Hanlon Creek Business Park 2015 Consolidated Monitoring Report

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Aquatic, Terrestrial and Wetland Biologists

Hanlon Creek Business Park
2015 Consolidated Monitoring Report

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Introduction

A consolidation of the monitoring on the Hanlon Creek Business Park (HCBP) Lands is required as a condition of approval of the *HCBP Environmental Implementation Report 2009* (EIR) prepared by Natural Resource Solutions Inc. Standard Operating Procedures for this monitoring can be found in a report titled *Hanlon Creek Business Park Consolidated Monitoring Program*, prepared by NRSI in 2010.

Pre-construction monitoring began in 2006 and continued for 4 years. Construction-phase monitoring began in 2010. Monitoring occurs either at specific times of the year, and certain components of groundwater and surface water occur year round. Annual reporting occurs according to the calendar year. A Rapid Assessment and Action Protocol (RAAP) is in place to address immediate monitoring concerns, with a focus on surface water temperature and turbidity.

Construction commenced in late 2009 and has continued each year and through 2015. Construction activity in Phase 1, Stage 2 lands included the operation of one commercial building and the construction of one commercial building on Hanlon Creek Boulevard. In Stage 3 lands activities included the operation of commercial buildings at 197 – 345 Hanlon Creek Boulevard and the construction of one commercial building at 28 Bett Court. Construction in Phase 2 lands in 2015 included the preliminary grading of Blocks 8, 9 and 26, the use of the Laird Road overpass and the construction of one commercial building at 104 Cooper Drive. Construction inspection in 2015 was conducted by Natural Resource Solutions Inc. (NRSI).

Performance monitoring in 2015 was conducted by Banks Groundwater Engineering Limited, AECOM and NRSI. Monitoring components included groundwater levels, temperature and water quality at 37 monitoring wells and 19 mini-piezometers; stream flow, temperature and water quality at 11 stream stations and within 3 stormwater management ponds; fish and benthic invertebrates at 5 stream stations; and vegetation, breeding birds and amphibians at 11 vegetation plots plus additional bird and amphibian stations.

Results

In 2015, groundwater levels are easily explained by the weather including the patterns of precipitation throughout the year. The highest groundwater levels observed in monitors equipped with data loggers occurred during the months of January, April, June, and December. These high levels correspond to thaw events in the winter and precipitation patterns the rest of the year. The lowest groundwater levels occurred in early March and September. These periods of low levels were considered normal, as groundwater elevations at all monitoring stations remained within the normal range throughout 2015.

During the months of January, February and March, groundwater levels at Core PSW and Downey Road PSW monitoring stations were somewhat lower than the typical range for the time of year, due to the lower-than-normal amounts of precipitation. However, despite the limited amount of precipitation, the slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at this location during the second half of March and early-April. Groundwater levels began a gradual decline in mid- April, with a brief increase June followed by a decline from July to early October. Groundwater levels rose in response to precipitation events in October and December. Most of the lowest levels observed in each monitoring well in 2014 occurred during late-August and early-September. At almost all locations where data loggers had been in place for more than three years, the 2015 summer levels were comparable to 2013 and 2014 summer levels, which were above the low levels observed during the drought in the summer of 2012.

Regarding site-wide patterns in groundwater elevations, the smallest fluctuations occurred in and adjacent to the core wetland and Hanlon Creek Tributary 'A'. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range of groundwater elevations in these areas. Groundwater elevations varied more widely over the year at perimeter locations where groundwater recharge to the medium- to coarse-grained deposits is most significant.

Altogether, climate had the greatest, if not the only, influence on groundwater levels across the HCBP in 2015. There were no apparent changes in groundwater levels that could be attributed to construction activities during 2015 within the HCBP.

Surface water baseflows in Tributary A in 2015 were lower than those in 2014 at all eight monitoring stations. Precipitation at the Elora Research Station in 2015 was slightly higher than the climate normal for the years 1971 to 2000 at Guelph Arboretum. In contrast, precipitation at the Waterloo Region International Airport Station was much lower than the climate normal.

The discharge from Pond 4 was observed to be near continuous again in 2015 causing elevated baseflow levels at HC-A(04), which is located a short distance downstream of Pond 4. The pond interacts with groundwater flowing in a northwesterly direction, and provides a more direct pathway for discharge to Tributary A. The continuous discharge has resulted in the observed elevated baseflows in Tributary A, and has also affected summer water temperatures in Tributary A. The bottom draw outlet ensures that the coolest water in the pond is being discharged, and the cooling trench also receives groundwater directly, further reducing discharge temperatures. Nevertheless, the resulting discharge temperature is greater than the stream temperatures in Tributary A in the summer.

During summer months of 2015, Tributary A stations HC-A(04) and HC-A(06), located downstream of the Pond 4 outlet, recorded high average temperatures and limited daily fluctuation due to the influence of the continuous discharge at Pond 4, as compared to HC-A(03) which is not impacted by pond discharge. Downstream stations on Tributary A which are more exposed such as HC-A(10), HC-A(12), HC-A(13) and HC-A(14), and those with a wider flow channel and shallower depths (HC-A(09)), show the highest daily variation in temperature as there is greater opportunity for solar radiation impact. Station HC-A(08) shows the lowest temperatures and daily temperature variation during the summer, indicating the presence of groundwater inputs in Tributary A1 where this station is located. Altogether, the temperatures in the summer of 2015 were determined to be above the preferred temperatures for Brook Trout.

Groundwater quality in 2015 was generally within the applicable Ontario Drinking Water Quality Standards (ODWQS) criteria for concentrations of the parameters analyzed, with some exceptions for nitrate, metals, sodium and hardness. Colour, turbidity, total dissolved solids and dissolved organic carbon (DOC) generally exceeded the respective ODWQS concentrations, and this is typical for these parameters in monitoring wells.

For surface water quality in 2015, the majority of the stream sites were within the ranges of the Provincial Water Quality Objectives (PWQO). The dissolved oxygen (DO) was below the PWQO minimum level at four stations; HC-A(04), HC-A(11), HC-A(06), and HC-A(10) on at least one occassion, which may be attributable to a below-average flow rate due to high temperatures and an extended period of no precipitation. The pH levels were more acidic than the PWQO guideline range at two of the stations and were more basic at four stations. Monitoring of turbidity at four stations occurred in 2015. Overall the turbidity levels at HC-A(14) (the most downstream station) are lowest while turbidity levels at station HC-A(06) appear to increase relative to rainfall events. Sediment accumulation and biofouling resulted in inaccurate readings for extended periods at two stations; HC-A(03) and HC-A(11).

Benthic invertebrate monitoring in 2015 showed increases in Ephemeroptera, Plecoptera and Trichoptera (EPT) richness at all five stations with taxonomic richness increasing at all but one station (BTH-005), which experienced a slight decline from 2014. Two stations (BTH-002 and BTH-005) resulted in sequential “Impact” determinations. This is the first sequential impact determination at BTH-005, while the ‘Impact’ determination is a fairly regular occurrence at BTH-002. An ‘Impact’ determination was also noted for the first time at BTH-001. The occurrence of ‘impact’ determinations at these stations suggests a change in the quality of the benthic community at these stations. The cause of these determinations is not clear at this point in time. Monitoring using the PMA analysis should continue with the intention of determining whether or not a ‘no impact’ determination is observed again at these stations. The sequential PMA impact determinations represent threshold exceedances at BTH-002 and BTH-005. Stations that have previously exceeded the PMA threshold (BTH-003 and BTH-004) showed ‘No Impact’ in 2015.

Fish monitoring in 2015 resulted in the capture of a total of 481 individual fish representing five different species. The total catch in 2015 represents a slight increase in the total numbers of fish from 2014 and a continued return to more ‘typical’ numbers at most stations following uncharacteristically high numbers in 2013. All five fish species captured in 2015 are known previously from the monitoring program and exhibit a cool-water thermal regime (Eakins 2015). No threshold exceedances occurred for fish in 2015.

Vegetation monitoring in 2015 showed largely stable vegetation conditions with only a few exceptions. A total of 140 vascular flora species were recorded in 2015 – slightly higher than what was observed in 2014. Twelve species were recorded for the first time in 2015; Spikenard (*Aralia racemosa ssp. racemosa*), Long-stalked Sedge (*Carex pedunculata*), Radiate Sedge (*Carex radiate*), Hay-scented Fern (*Dennstaedtia punctilobula*), Balsam Poplar (*Populus balsamifera*), Meadow Fescue (*Festuca pratensis*), Dudley's Rush (*Juncus dudleyi*), Bristle-leaved Sedge (*Carex eburnean*), Evergreen Wood Fern (*Dryopteris intermedia*), Basswood (*Tilia Americana*), Ninebark (*Physocarpus opulifolius*), and Philadelphia Fleabane (*Erigeron philadelphicus*). In 2015, Meadow Horsetail (*Equisetum pratense*) and Rough-leaved Goldenrod (*Solidago patula*), Clearweed (*Pilea pumila*), American Mountain-ash (*Sorbus americana*) and Hay-scented Fern were observed and are considered rare within Wellington County. None of the species observed are federally or provincially significant.

The coefficient of wetness continued to show that two plots (Plots 3 and 5) are upland sites while the remaining nine plots are in wetlands. Plot 1 continued to be the wettest plot, and Plot 3 continued to be the driest. In 2014, Plot 7 had exhibited a positive CW value (0.16) which is not indicative of White Cedar-Hardwood Swamp conditions. It is noted that the plot contains hummocks with upland plant species as well as a portion of watercourse. In 2015 this plot had a slightly wetter CW value (-0.10), more typical of what has been observed at Plot 7. Plots 16 and 18 demonstrated the continuation of a drying trend that is not explained by groundwater levels but may be a result of changes to surface hydrology.

The coefficient of conservatism (CC) values at three of the plots (Plots 3, 4, and 7) had average results between 4 and 5, which are consistently the highest values from year to year and can be interpreted as having plant species that are associated with a specific plant community but can tolerate moderate disturbance. Three of the plots (Plots 6, 9 and 16) had values between 2 and 3, which are the lowest values and indicate the presence of plant species that are more tolerant of disturbance.

The Natural Area Index (NAI) combines the CC with native species to provide a more stable assessment of the vegetation. NAI values were generally stable compared to recent years, increasing at some stations and decreasing at others. However, the values at many of the stations are low relative to the overall monitoring period. There are a variety of explanations, including the potential for the addition or subtraction of one species to have a substantial effect on the NAI value at a station with low diversity. It is also believed that the drought conditions in 2012 are likely to have a lingering effect on the NAI values for most of the stations.

The numbers of non-native species have remained stable throughout monitoring from 2006 to 2015, with 17 recorded within vegetation pots in 2015. For total numbers of species by category of plants, observations were made of 103 herbaceous plant species and 22 shrub species. The number and composition of trees was unchanged. Following monitoring in 2014 the scope of tree inventory work was reduced to collect only canopy closure data. No tree species are present within Plots 1, 6 and 9.

A total of 58 bird species were observed during breeding bird monitoring in 2015, with 49 species documented during the formal point counts. Of the 49 species, 19 exhibited possible breeding evidence, 25 exhibited probable, three were confirmed, and three did not show breeding evidence. The most abundant species observed during 2015 surveys were Red-Winged Blackbird (*Agelaius phoeniceus*), and by Song Sparrow (*Melospiza melodia*), comprising 14% and 10% of the observations during breeding bird point counts, respectively. These were followed by American Robin (*Turdus migratorius*) and American Goldfinch (*Spinus tristis*) at 7% each. These species are consistently the most abundant within the point counts.

In general, the diversity of bird species at each plot in 2015 was similar to those numbers documented between 2006 and 2011, with 2012 and 2013 appearing as exceptional years of high diversity across the study area. The 2015 abundance reflects the overall average since monitoring began in 2006. Similar to species diversity, breeding bird abundance showed a notable spike during the 2012 and 2013 monitoring years and 2015 data reflects abundance data observed between 2006 and 2011.

NRSI observed five species that are considered Threatened federally and provincially: Bobolink (*Dolichonyx oryzivorus*), Eastern Meadowlark (*Sturnella magna*), Barn Swallow (*Hirundo rustica*), Bank Swallow (*Riparia riparia*), and Chimney Swift (*Chaetura pelagica*). Eastern Wood-pewee (*Contopus* virens), a species listed as Special Concern federally and provincially, was also documented in 2015. Bobolink has been observed each monitoring year with probable breeding evidence documented in 2010 and 2012 through 2015. In 2015, Bobolink was observed within Plot 20 and in the vicinity of Plot 1 and 9. Eastern Meadowlark was observed showing probable breeding evidence in Plot 20 and was also observed in the vicinity of Plot 1. Barn Swallows were observed at four breeding bird plots within the Phase 3 lands (Plots 1, 9, 19 and 20). Based on breeding bird surveys, the species was documented showing confirmed breeding evidence with as many as four individuals present at Plot 19 on the June 29th survey. Suitable nesting habitat for this species is present at the Crawley farmhouse within Phase 3. Barn Swallow may also be nesting outside of the subject property in barns along Forestell Road or Downey Road and utilizing the subject property for foraging habitat. A single Bank Swallow was observed in suitable habitat at Plot 6. Suitable nesting habitat for this species may be provided by a large topsoil pile in the block adjacent to Plot 16. The SWM ponds present may provide suitable foraging habitat. A pair of Chimney Swifts were documented foraging above Plot 2. While suitable nesting and roosting habitat is not present within the study area, the fields and treed habitats provide foraging habitat. A single singing male Eastern Wood-Pewee was documented at Plot 3 and was also noted as an incidental at Plot 19. The open understorey habitat present at Plot 3 provides ideal habitat for this species which may also utilize other treed and edge habitats throughout the study area.

Five amphibian species were recorded during evening call count surveys in 2015; Spring Peeper (*Pseudacris crucifer crucifer*), Wood Frog (*Lithobates sylvatica*), American Toad (*Anaxyrus americanus*), Green Frog (*Rana clamitans melanota*) and Gray Treefrog (*Hyla versicolor*). Since 2006, the number of species recorded during the calling anuran surveys has fluctuated. The five amphibian species recorded calling in 2015 is above the annual average of 3.8 species recorded in previous years. Species recorded during surveys have fluctuated over the eight-year monitoring period, with as many as six species recorded during 2009 surveys and none recorded during the first preconstruction monitoring year (2006).

Issues

Water temperatures during summer months of 2015 continued to be elevated as a result of the effects of SWM Pond 4. While higher than average air temperatures and lower precipitation levels were noted in 2015 compared to 2014, which contributed to these elevated water temperatures, the influence of SWM Pond 4 continued to be evident in 2015. The evidence is focused on the stations on Tributary A that are the nearest to the SWM Pond 4 outlet. Water temperatures exceeded both 22°C and 24°C at the stations downstream of the SWM Pond 4 outlet while the station upstream of the outlet exhibited only a brief exceedance of 22°C and did not exceed 24°C in 2015. Thermal effects are evident in the proportion of the summer that the temperature was above 19°C, and by the thermal regime classifications in 2015 compared to pre-construction data. These elevated water temperatures are of concern based on the goal of maintaining a suitable thermal regime for Brook Trout, a cold water fish species that inhabit the Hanlon Creek system.

Two potential modes of impact by SWM Pond 4 were previously discussed in the 2013 and 2014 consolidated monitoring reports. The first mode is the water that is discharging to Tributary A through the SWM Pond 4 outlet; the second is the pond's effects on adjacent groundwater that may eventually discharge to Tributary A as groundwater.

Two benthic monitoring stations experience threshold exceedances in 2015. Station BTH-002 and BTH-005 produced an exceedance of the first benthic invertebrate threshold in 2015, such that they had sequential PMA-Analysis "Impact" determinations. Station BTH-002 had an 'Impact' determination for the fifth consecutive year, which resulted in another exceedance of the first threshold in 2015. The threshold exceedances observed at this station over the previous years would suggest an overall change in the quality of the benthic community and habitat. However, in 2015 there was an increase in EPT taxa, and the dominant and subdominant families from the sample were both species indicative of good water quality. Station BTH-005 also experienced an 'Impact' determination for the second consecutive year despite EPT richness being substantially higher in 2015 compared to 2014. Prior to 2015 there appeared to be a trend of decreasing EPT richness across the five benthic monitoring stations since 2008 and 2009 when EPT richness was highest. Possible reasons for the decreasing trend in EPT richness have included the drought conditions in 2012, and the continuous discharge from SWM Pond 4 beginning in late 2011. However, assessing the results by station does not make a clear or consistent connection with SWM Pond 4.

Two fish monitoring stations experienced a threshold exceedance in 2015. Station EMS-001 exhibited a 50% reduction in the number of taxa. This occurred due to a decrease from four taxa to two, which appears to be a return to a more 'typical' number of taxa and similar to what was observed under pre-construction conditions. Station EMS-003 exhibited a 50% reduction in the number of fish captured. This occurred due to the decrease in total catch from 10 fish in 2014 to 5 fish in 2015. The catch totals at EMS-003 have been consistently low since monitoring began in 2006. As a result it has a greater likelihood of exhibiting threshold exceedances and is of little concern at this time.

Multiple vegetation plots had threshold exceedances in 2015. Herbaceous cover exceeded the threshold positively in Plot 2, while Plot 3 fell below the threshold. While increases in herbaceous species in Plot reflect a positive change in recent years the cover in 2015 is still well below the pre-construction average. Herbaceous cover in this plot is primarily influenced by the presence of Ostrich Fern which, which experienced a reduction during extremely dry monitoring years in 2011 and 2012. It is anticipated that if the site continues to receive higher levels of precipitation during the spring months, herbaceous cover at Plot 3 will continue to increase.

Herbaceous species diversity positively exceeded the pre-construction threshold in both Plot1 and 2, while Plot 5 fell below the threshold. Plot 5 has a low number of species, and is susceptible to a threshold exceedance due to small changes. The exceedance is not cause for immediate concern.

The canopy cover at Plot 8 continued to be below the threshold based on pre-construction cover, and is still anticipated to recover from construction of the crossing of Hanlon Creek Boulevard over Tributary A.

Although Coefficient of Wetness (CW) is not used as a specific threshold for the vegetation monitoring, it is noteworthy that the CW values have shown a drying trend between 2011 and 2015 at Plots 16 and 18. These plots are located in close proximity to recent development (Block 9 and Block 10) and Hanlon Creek Boulevard. It appears that fluctuations in groundwater levels would have little to no effect on the soil wetness in the wetlands because their elevations have never been above the ground surface of the wetlands. Groundwater levels in the vicinity of Plots 16 and 18 do not show a trend that matches the declining trend in CW values. However, ponded surface water in the plot may be drying up earlier. Monitoring of vegetation and groundwater should continue at these plots in order to better understand the impacts which may be occurring within these features. In addition, the presence and depth of surface water should be monitored in some manner each spring.

An associated threshold exceedance is the decline in amphibian abundance at two stations in 2015. A decrease of two calling codes was observed for Spring Peeper in Plots 12 and 14. Spring Peeper was only documented for the first time in Plot 14 in 2014. Plot 12 is now separated from the larger natural area by the Laird Road overpass and associated curbs. As an isolated feature Spring Peepers may have relocated to larger and more suitable habitats in the vicinity or the localized population may have disappeared following several years of drier conditions which may have limited successful reproduction.

Thresholds were reached for breeding bird species diversity and breeding bird abundance in 2015. Breeding bird species diversity was below the threshold at Plot 11 as a total of 11 bird species identified was the lowest that has been seen since sampling began in 2009. Recent years have seen the installation of roads and servicing around the site, replacing a series of hedgerows that were originally present to the north. Given that Plot 11 does not provide core forest habitat, species which require larger tracts of forest would not be expected at this location and this area is not likely to support a high diversity of bird species. The exceedance at Plot 11 has been attributed to a natural fluctuation in bird species diversity in 2015.

Plots 1, 3, 6, 9 and 11 were all below the threshold for breeding bird abundances in 2015. None of these are of immediate concern. Breeding bird abundance was generally average to below average for the majority of plots in 2015, although bird numbers experienced an increase at the majority of plots between 2014 and 2015.

Corrective Measures Undertaken

No corrective measures were undertaken in 2015. The RAAP group met on several occasions regarding temperature exceedances including one site visit by the RAAP team in August following an exceedance at HC-A(06), and an additional visit by AECOM to confirm site conditions following an exceedance at Station HC-A(03).

The temperature effects continued at SWM Pond 4, and the corrective measures undertaken in 2012 were again monitored for effectiveness in 2015. The corrective measures undertaken in 2012 included:

1) raising the outlet of the cooling trench at Pond 4 (removed in early 2013),
2) raising the weir level at the pond outlet at Pond 4, and
3) planting of aquatic vegetation throughout the shallow areas of the pond as well as planting vines and herbaceous species in and around the cooling trench at Pond 4.

The decision to wait on implementing additional corrective measures was based on the fact that the vegetation planted in 2012 can take several years (5+) to become well established and mature in order to function as intended. The 2015 monitoring year was the 4th year that the plantings have had to establish and a review of the plantings near the end of the growing season has indicated that they still haven't established enough to have a positive effect on the Pond 4 temperatures. Looking ahead, it will be necessary to undertake additional corrective measures to address the thermal impacts from SWM Pond 4.

The RAAP team identified four mitigation measures to be considered for implementation, including: the installation of a drainage tile along the east side of Pond 4, installation of a floating island, planting of live stakes along the edges of the cooling trench, and redirecting or bioengineering the cooling trench outlet. By the end of 2015 these mitigation measures were still under consideration and review and it is expected that decisions regarding this will be made in 2016.

While other issues have been identified through review of the monitoring results, there were no other clear cause-and-effect relationships that constituted problems to be rectified through corrective measures.

Recommendations

Based on the 2015 monitoring results, it is recommended that additional corrective measures be developed to address the effects of SWM Pond 4 on water temperatures in Tributary A. This may be an extension of vegetation-planting measures already taken, or new measures.

The need for additional monitoring requirements should be considered in conjunction with the development and implementation of the corrective measures.

It is also recommended that existing monitoring continue with diligent attention given to stream temperatures and the SWM Pond 4 mitigation measures put in place to date, using the RAAP as prompted by any stream temperature or turbidity exceedances.

As a new monitoring item, surface water should be monitored at Plots 16 and 18 and adjacent roads, swales and development blocks in order to determine whether surface hydrology has been altered in a manner that is affecting Plots 16 and 18.

The frequency of terrestrial monitoring should be reviewed to determine if some or all of the plots should be monitored at a reduced frequency.

Along with the above recommendations, the groundwater, surface water, fish, benthic invertebrate, vegetation, breeding bird and amphibian monitoring should continue in 2016 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

Conclusions

Monitoring at the Hanlon Creek Business Park in 2015 was successful in providing useful information to describe environmental conditions on site, detect issues and develop solutions.

Elevated stream temperatures and the contributing temperature impacts from SWM Pond 4 continued to be the most prominent issue in 2015. As such, monitoring in 2016 should give particular attention to this issue through the continued monitoring of nearby wells and the effectiveness of the planted vines and aquatic vegetation. The RAAP group should carefully review any stream temperature threshold exceedances. Additional corrective measures should also be developed to mitigate the effects on stream temperatures, including additional monitoring as required to inform such measures.

The decline in CW at vegetation Plots 16 and 18 represents another issue to be investigated further, and surface water and groundwater monitoring should continue to be investigated in the nearby monitoring wells.

1.0 Introduction

The monitoring program associated with the Hanlon Creek Business Park (HCBP) is an integration of a series of monitoring requirements arising from recommendations made in the Consolidated Environmental Impact Study (NRSI 2004), the Draft Plan Conditions (OMB 2006), and review comments from agencies during the various stages of the planning process. A consolidation of the monitoring on the HCBP Lands was required as a condition of approval of the *HCBP Environmental Implementation Report 2009* (EIR) prepared by Natural Resource Solutions Inc. (NRSI 2009). The City of Guelph Environmental Advisory Committee (EAC) recommended approval of the EIR, with a list of conditions that should be met prior to registration of the plans for Phases 1 and 2. Condition 8 states:

> *That a comprehensive and consolidated monitoring program, which specifies frequency, location, protocols, timing, thresholds, and specific contingency measures be submitted and approved by the City of Guelph and the GRCA [Grand River Conservation Authority].*

To meet the above condition, a document titled *Hanlon Creek Business Park Consolidated Monitoring Program* (NRSI 2010) was created as a reference document containing the standards that are to be followed in carrying out the Consolidated Monitoring Program. Refer to that document for detailed information on the framework of the monitoring program and the Standard Operating Procedures for each monitoring component. The Standard Operating Procedures provide detailed methodologies such that the performance monitoring can be carried out consistently over the years of monitoring.

A consolidation of the monitoring on the Hanlon Creek Business Park (HCBP) Lands is required as a condition of approval of the *HCBP Environmental Implementation Report 2009* (EIR) prepared by Natural Resource Solutions Inc. Standard Operating Procedures for this monitoring can be found in a report titled *Hanlon Creek Business Park Consolidated Monitoring Program*, prepared by NRSI in 2010.

Pre-construction monitoring began in 2006 and continued for 4 years. Construction-phase monitoring began in 2010. Monitoring occurs either at specific times of the year, and certain components of groundwater and surface water occur year round. Annual reporting occurs according to the calendar year. A Rapid Assessment and Action Protocol (RAAP) is in place to address immediate monitoring concerns, with a focus on surface water temperature and turbidity.

This report integrates the information from all monitoring components for the 2015 calendar year. In 2010, pre-grading and servicing activities began within Phase 1 of the HCBP. Phase 2 pre-grading and servicing began in 2011. Building and site construction on individual blocks commenced following completion of servicing, and has continued in 2015. Construction-phase monitoring began in 2010 following four years of pre-construction monitoring.

Individual reports from each discipline are appended, and the results are summarized in Section 2.0. The consolidated reporting began in 2009. Natural Resource Solutions Inc. (NRSI) has prepared this consolidated report each year with support from Banks Groundwater Engineering Limited (hydrogeology), and AECOM (surface water).

1.1 Study Area

The Hanlon Creek Business Park comprises the lands between Downey Road and the Hanlon Expressway, and between Forestell Road and the south end of the Kortright subdivision along Teal Drive (Map 1). Prior to development, lands within Phases 1 and 2 were a mix of agricultural fields, meadow, woodland, forest and Provincially Significant Wetlands (PSW) consisting of swamp, marsh and thicket, while Phase 3 was primarily agricultural field and cultural meadow, with small wetlands. The core area of natural features was designated as natural heritage lands to be retained in their pre-development state. The agricultural fields and associated hedgerows, and small isolated habitats were designated for roads and development blocks.

The creek, wetlands and forested uplands in the HCBP are part of the much larger Hanlon Creek watershed. The central wetlands in the HCBP are part of the Hanlon Swamp Wetland Complex and therefore are considered provincially significant. In addition, a small wetland in the southwestern portion of the HCBP, next to Downey Road, is part of the provincially significant Speed River Wetland Complex.

This area encompasses a headwater tributary of Hanlon Creek. The tributary within the HCBP was designated as Tributary A in the Hanlon Creek Watershed Study (Marshall Macklin Monaghan Limited 1993). All of Hanlon Creek is designated as a cold-water stream to be managed for Brook Trout (*Salvelinus fontinalis*) (GRCA and MNR 1998).

1.1.1 Construction Activity

Construction commenced in late 2009 and has continued each year through to 2015. Construction activity in 2015 within Phases 1 and 2 is outlined below and highlighted on Map 2.

Phase 1, Stage 2

- Operation of commercial building – 500 Hanlon Creek Boulevard (Fusion Homes)
- Construction of commercial building – 501 Hanlon Creek Boulevard (Compass)

Phase 1, Stage 3

- Operation of commercial buildings – 197-345 Hanlon Creek Boulevard (Wurth Canada, Graniteworx, etc.)
- Construction of commercial building – 28 Bett Court (MF Property Management Inc.)

Phase 2

- Construction of commercial building – 104 Cooper Drive (Ontario One Call)
- Preliminary grading of Blocks 8, 9 and 26 completed in 2014
- Laird Road overpass has been in-use since 2014

No construction activity occurred within Phase 3 in 2015.

1.2 Monitoring Requirements and Components

A total of seven discrete monitoring requirements were identified during the planning process for the HCBP. The requirements are each rooted in one or more of the various stages of the process, including the Consolidated EIS (NRSI 2004), the Draft Plan Conditions (OMB 2006), the Environmental Implementation Report, and review comments from agencies pertaining to the design, mitigation and restoration of features in the Business Park.

The seven discrete monitoring requirements are as follows:

1. **Performance of Stormwater Management Systems:** Monitoring of hydrogeology, creek flows and temperatures, aquatic biota and wetlands, arising from the Draft Plan Condition #12 to provide baseline information on interactions and as input to the design of stormwater management facilities that discharge to Tributary A, as well as post construction monitoring of performance of the ponds (especially thermal impacts).
2. **Groundwater and Wetlands for the HCBP:** Monitoring arising from the Draft Plan Condition #12 of hydrogeology and wetlands at strategic locations to provide baseline information on spatial distribution and interactions of groundwater/wetlands such that block-level infiltration targets can be assessed.
3. **Groundwater and Wetlands for the Mast-Snyder Gravel Pit:** Monitoring of hydrogeology and wetlands in the western portion of lands south of Laird Road (Speed River PSW) to monitor changes in groundwater and wetlands stemming from concerns over potential impacts of the proposed neighbouring Mast-Snyder Gravel Pit.
4. **Permit Conditions and EIR Recommendations:** Monitoring arising as conditions from permit applications/review as well as impact predictions specifically arising from recommendations out of the EIR process.
5. **Success and Naturalization of Restoration Areas:** Monitoring of success and naturalization processes of restoration areas within buffers, swales and stormwater management areas, arising from agency comments and restoration planting warranty.
6. **Wildlife Movement:** Monitoring of wildlife movement throughout the Business Park, with a focus on movement and mortality associated with Laird Road and Hanlon Creek Boulevard (Road 'A').
7. **Construction Monitoring:** Monitoring arising from the Draft Plan Condition #10, which states that an environmental inspector is to carry out the construction monitoring during grading, servicing, and building construction.

There are eight performance monitoring components and two construction monitoring components that occur on the HCBP property, and they are each being conducted to serve one or more of the requirements listed above. Pre-construction performance monitoring occurred over a number of years to establish baseline conditions. Most of the monitoring activities have been in effect annually beginning in 2006. Groundwater monitoring began in 1999. Some construction inspection occurred in 2009 associated with the Hanlon Creek Boulevard (Road ‘A’) culvert directional service installation under the Hanlon Expressway, and borrow pit operations in the southeast corner of the Business Park. In 2010, construction-phase monitoring began which included the monitoring of grading and servicing construction activities.

The City of Guelph, as the developer representative, is responsible for this monitoring. The duration of the responsibility to monitor has been defined for each of Phases 1 and 2 as the time when 75% of the area of the individual phase is built, plus an additional two years. It is anticipated that this timeframe will also apply to Phase 3.

1.2.1 Performance Monitoring

The performance monitoring components are indicated as follows, with the past years of monitoring indicated in parentheses.

- Groundwater (most years from 1999 to 2015; quarterly from 2006 to 2015)
- Stream Temperature and Flow (annually from 2006 to 2015)
- Fish (annually from 2006 to 2015)
- Benthic Invertebrates (annually from 2006 to 2015)
- Vegetation and Soils (annually from 2006 to 2015)
- Breeding Birds (annually from 2006 to 2015)
- Amphibians (annually from 2006 to 2015)
- Salamanders (2009 and 2010 only)

1.2.2 Construction Monitoring

Construction monitoring is tied to the specific undertaking. Generally, construction monitoring must occur to ensure compliance with the conditions of various permits, including permit(s) from the Grand River Conservation Authority (GRCA) under Ontario Regulation 150/06 and the Letter of Advice from GRCA that constitutes approval under Section 35 of the *Fisheries Act*. Construction monitoring also serves as a means to avoid contravention of other regulations, such as Section 36 of the federal *Fisheries Act* pertaining to deleterious substances. In the specific case of the HCBP, the need for construction monitoring also stems from Condition 10 from the Ontario Municipal Board

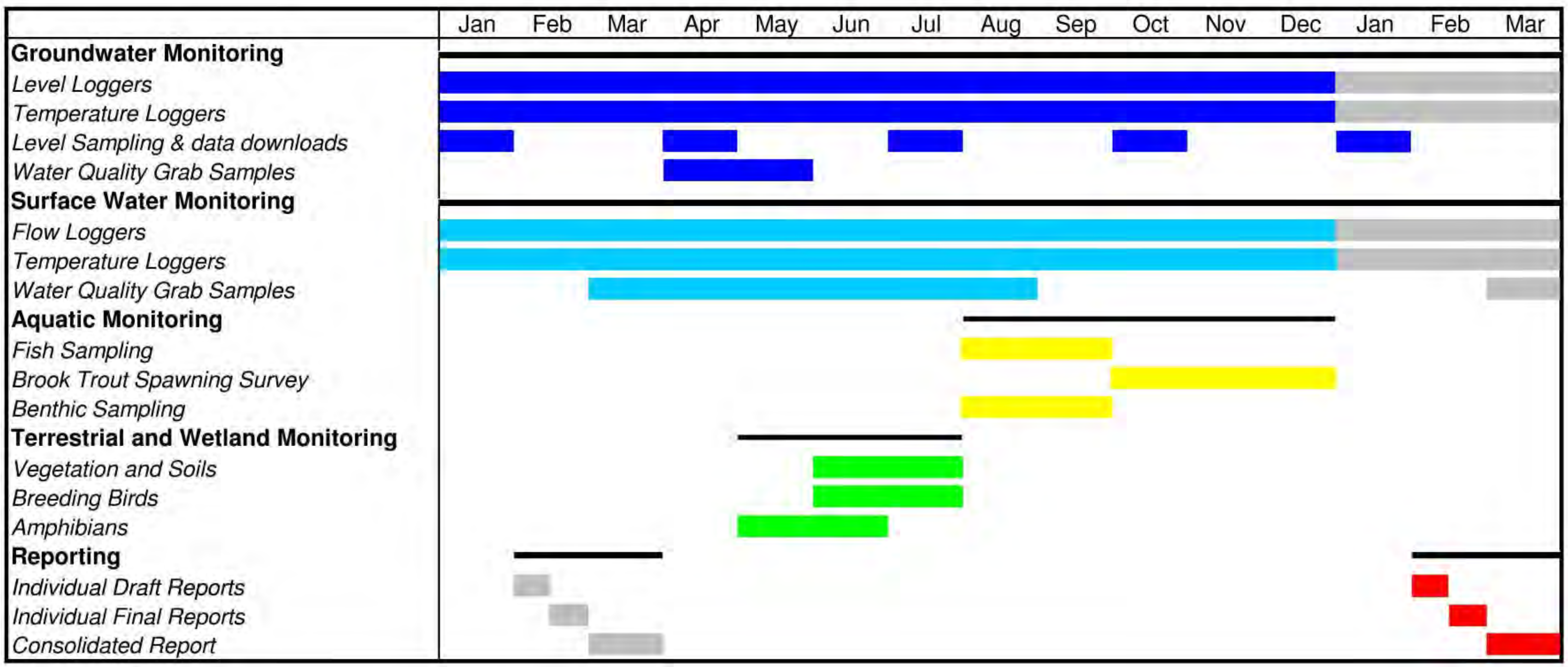
(OMB) hearing for the HCBP Draft Plan (June 2006). The condition states that an environmental inspector is to carry out the construction monitoring during grading, servicing, and building construction.

No construction inspection reports are available from 2015 as construction activity was limited.

1.3 Annual Schedule of Activities

Table 1 provides the general annual timeline of performance monitoring activities, which approximates the schedule of the 2015 monitoring. The specific dates of monitoring activities in 2015 are provided in the appended individual reports. Each colour represents an individual monitoring component (Groundwater Monitoring – dark blue, Surface Water Monitoring – light blue, Aquatic Monitoring – yellow, Terrestrial and Wetland Monitoring – green). The timeline for Reporting is represented by red.

Table 1. General Annual Schedule of Performance Monitoring Activities



2.0 Monitoring Results

2.1 Climate Data

Climate data provided by the Region of Waterloo International Airport Station (WMO ID 71368) was utilized for groundwater monitoring due to its proximity to the HCBP site and availability of total daily precipitation and maximum daily air temperature data. For assessment of surface water monitoring data, climate information was used from the Guelph Turfgrass Institute and the Elora Research Station, provided by the University of Guelph. In 2015, at the request of the City of Guelph, a tipping bucket rain gauge (model TB3) was installed by AECOM on the roof of the Clair Road Emergency Services Centre near the Hanlon Creek Business Park. Due to the lack of data gathered in 2015, it was not used in this year's monitoring report.

The precipitation is important for reporting and interpreting both the groundwater and surface water monitoring results. This includes trends preceding the monitoring year, and patterns during the monitoring year.

From 2003 to 2015, there has generally been lower-than-normal precipitation resulting in a cumulative negative departure from monthly normals. Fluctuations have occurred during this time, including an increase from July 2013 to January 2015, but the overall trend is a negative departure from normal. This does not necessarily translate into analogous reductions in groundwater or streamflow. Instead, groundwater levels are strongly correlated with precipitation during the previous 18 months. During the same period, cumulative departure from the average of the preceding 18-months illustrates periods of decrease and increase in precipitation. The year 2007 stands out as a year of substantial decrease in precipitation, followed by an increase in precipitation from mid-2008 to early 2010. Smaller fluctuations have occurred since that time followed by a significant rise from July 2013 to January 2015. This 18-month increase represents the second highest level since monitoring began in 2003.

Precipitation recorded at the Elora Research Station in 2015 was slightly above the Canadian Climate Normal (1971-2000) at the Guelph Arboretum. At the Elora Research

Station, total precipitation for 2015 was 927.7mm, compared to a normal of 923.3mm known for the Guelph Arboretum.

At the Region of Waterloo International Airport Station, much less precipitation was observed. The total precipitation in 2015 was666.8mm, compared to a 45-year average of about 879mm and a normal of 916.5mm. This is much lower than average, and a very substantial difference from the records at the Elora Research Station. A possible explanation is a high degree of patchiness in rainfall amounts on the landscape in the surrounding area. Instrument error at one or both of the stations is another possibility.

The University of Waterloo Weather Station is a third source of precipitation data. It indicates total precipitation in 2015 to be 814.2mm, which is also less than the normals and averages for weather stations in the area surrounding the HCBP, but more than the observation at the Region of Waterloo International Airport Station.

Substantial variation in precipitation occurred during 2015, beginning with precipitation levels well below-normal for January to March and then only slightly below normal for April and May. Precipitation was above normal in June and was equal to the normal levels in August; however, July exhibited precipitation levels well below normal once again. The greatest monthly difference observed for 2015 was noted in July. Precipitation levels were once again below the monthly normal for September, above the normal level for October, and then below normal for November and December.

The air temperatures from May to September were noted to be warm in the spring and fall and cool during the summer months. The average air temperatures in May and September were roughly 3 degrees higher in 2015 than the Canadian Climate Normals from 1971 to 2000 at the Guelph Arboretum. They were also among the highest average air temperatures documented for those months during the monitoring period since 2007. In September the daily average temperature of 17.0°C was the highest that has been observed at the site with the second highest occurring in 2007 at 15.8°C. Average air temperatures were slightly cooler than the Normals in June, July, and August.

2.2 Groundwater Levels and Flow

During the 2015 monitoring period there were 37 functioning monitoring wells and 19 mini-piezometers located across the HCBP site. Two of the mini-piezometers (13D and 14D) were installed along Hanlon Creek Tributary A immediately downstream of stormwater management (SWM) Pond 4 in June 2013. These were required to provide additional monitoring data related to the effects of SWM Pond 4 on Tributary A, and they have remained in place through 2015. To evaluate the response to spring thaw and precipitation at selected groundwater monitors, data loggers were installed to record groundwater levels on a more frequent basis, with installation at some stations beginning in 2007. In the year 2015, groundwater elevations were recorded using data loggers in 38 of the 56 groundwater monitoring stations. Table 2 in the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix I) lists the monitoring wells and mini-piezometers where the 38 data loggers were in operation for all or part of 2015. In addition, groundwater quality samples were collected from a total of 36 monitoring wells that were available for sampling in 2015. These were the same wells that were sampled in 2014. The locations of the groundwater monitoring stations are shown on Map 3 including new, existing, proposed, and abandoned stations as of December 2013.

The resulting groundwater level monitoring data is tabulated and plotted on graphs in the appendices of the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix I). Those results are summarized and discussed below.

<u>Long-Term and Medium-Term Observations of Groundwater Levels</u>

Groundwater levels are interpreted to have been elevated in the early to mid-1990s, followed by a decline from 1997 to 2007. These trends are based on climate data beginning in 1971. On-site groundwater monitoring began in 2003, and since that time precipitation has generally continued to decline.

In 2007, the effects of below-average precipitation were expressed in groundwater levels in July and November, when precipitation was the lowest observed from 1971 to 2015.

In late 2010 and early 2011, groundwater levels declined and approached the low levels observed in 2007. This is attributable to below-average annual precipitation in late 2009, through most of 2010, and into February 2011.

In 2012, groundwater levels at many monitored locations on-site during the summer and fall were the lowest recorded since monitoring began in 2003. The total precipitation in 2012 was 684 mm, which was the fourth lowest recorded amount from 1971 to 2015.

The periods of low groundwater levels are contrasted by higher levels during the intervening periods. Annual precipitation in 2003, 2006, 2008, 2011, and 2013 was above average. This appears to have influenced groundwater levels in the spring of 2004 and 2007, the spring and fall of 2008, in the last five months of 2011, and from spring to fall in 2013.

General Observations in 2015

In 2015, groundwater levels are easily explained by the weather including the patterns of precipitation throughout the year. The highest groundwater levels observed in monitors equipped with data loggers occurred during the months of January, April, June, and December. The high levels in January were a continuation of the levels experienced at the end of 2014 and prior to a reduction that was noted in February and March as a result of well-below normal precipitation levels and extended below-freezing temperatures. The high levels in April were in response to the slow melt of the retained snow-pack and ground frost which helped to raise levels in late March and early April, despite the limited amount of precipitation between January and February. In June, high levels were in response to the above-normal amounts of precipitation. The high levels in December groundwater occurred despite lower-than-normal amounts of rainfall in November and December. This high level may have resulted after precipitation events greater than 25mm in October. Although total precipitation amounts in November and December were below normal, such precipitation events can lead to increases in groundwater levels.

The lowest groundwater levels occurred in early March and September resulting from below normal precipitation levels in prior months. These periods of low groundwater levels were considered normal, as groundwater elevations at all monitoring stations remained within the normal range throughout 2015.

Site-Wide Patterns in 2015

The groundwater elevation data from the 38 groundwater monitoring stations throughout 2015 continued to exhibit the downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Groundwater discharge conditions have also been confirmed at the Downey Road PSW.

The greatest range in groundwater elevations occurred around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant. The smallest fluctuations occurred in and adjacent to the core wetland and Hanlon Creek Tributary 'A'. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range of groundwater elevations in these areas.

Graphs illustrating hydraulic gradients and groundwater elevations are included in the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix I).

2015 Monitoring of Groundwater Levels in the Core PSW

Groundwater levels in 2015 were monitored at 14 monitoring wells and 10 mini-piezometer stations within or near the Core PSW (Table 2, Map 3).

Table 2. Monitoring Wells and Mini-Piezometers Within or Near the Core PSW

Monitoring Wells		Mini-Piezometers	
MW103	MW119A	PZ-1	PZ-12
MW104	MW121A	PZ-2	PZ-13
MW105	MW122A	PZ-4	PZ-14
MW111	MW127	PZ-7	
MW116A	MW129	PZ-8	
MW117A	MW130A	PZ-10	
MW118A	MW131	PZ-11	

In 2015, the observed groundwater levels and temperatures in the monitoring wells and mini-piezometers responded to precipitation and maximum daily air temperatures. This confirms the inherent relationship of the wetlands to the shallow groundwater system. The hourly recording of groundwater levels at mini-piezometer locations also indicates subtle fluctuations during each 24-hour period, likely associated with diurnal cycles of evapotranspiration in the wetland. While responsiveness is apparent, the range of groundwater levels in mini-piezometers is more subdued than in those at other locations on the HCBP site. This reflects the relatively constant groundwater elevations in the wetland area, usually with only minor perturbations observed relative to precipitation and/or temperature changes.

During the months of January, February and March 2015, groundwater levels declined and the respective graphs for each monitor indicate levels that were somewhat lower than the typical range for this time of year for each of these locations. As noted previously, combined snow and rainfall through January, February and March was well below the normal amount of precipitation for this period. However, despite the limited amount of precipitation, the slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at this location during the second half of March and early-April. Groundwater levels began a gradual decline in mid-April, which is earlier than most years, and continued to decline through May. June rainfall caused levels to rise again, before declining through July to early October. Groundwater levels rose in response to precipitation events in October and December.

The graphs of each of the Core PSW groundwater monitors listed in Table 2 show that below-normal precipitation during 2015 caused groundwater levels to decline to the third-lowest late-summer/early-fall levels at some locations. The lowest levels observed in 2015 varied from location to location, but most occurred during late-September or early-October. At almost all locations where data loggers had been in place for more than three years, the 2015 summer levels were comparable to 2013 and 2014 summer levels, which were above the low levels observed during the drought in the summer of 2012. At many Core PSW monitoring stations, groundwater levels rose in response to precipitation in early-October and December.

Groundwater levels in the three mini-piezometer monitoring locations (i.e. from north to south PZ-4D, PZ-2D, and PZ-1D) that are located in the Core PSW, were below the normal range for most of 2012. During 2013 through 2015, groundwater levels were within the range of prior years. The recorded groundwater elevations for PZ-4D, PZ-2D, and PZ-1D are presented in Graphs G13, G20, and G22 within the appendices of the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix I).

Similarly, groundwater levels recorded in streambed mini-piezometers (i.e. from north to south PZ-10D, PZ-8D, PZ-11D, PZ-7D) were below the level of the creek and the streambed for part, if not most, of 2012. Groundwater levels during 2013 through 2015 were within the range observed in prior years, where data is available. The recorded groundwater elevations for PZ-10D, PZ-8D, PZ-11D, and PZ-7D are presented in Appendix I.

Altogether, climate had the greatest, if not only, influence on groundwater levels within the Core PSW in 2015. There were no apparent short-term and/or longer-term changes in groundwater levels that could be attributed to construction activities during 2015 within the HCBP (i.e. there were no abnormal changes in groundwater elevations that would have suggested otherwise). As of the end of 2015, six lots in Phase 1 had been developed and another five were at various stages of development. The first lot in Phase 2 was also being developed. The remainder of the graded portion of the site consisted of paved roadways, vegetated stormwater management swales and ponds, gravel-surfaced trails, and barren soils across most vacant lots. Based on the observed responses of groundwater levels to rainfall events and above-normal total monthly precipitation during June and October, it is evident that infiltration was occurring across the site.

<u>2015 Monitoring of Groundwater Levels in the Downey Road PSW</u>

Groundwater levels in 2015 were monitored at two stations at the Downey Road PSW. These include monitoring well MW003, which is located on the north edge of the PSW, and mini-piezometer nest PZ-9, which is located in the centre of the PSW (Map 3).

During the months of January, February and March 2015, groundwater levels declined and were somewhat lower than the typical range of between 326.0 and 326.5 m amsl for this time of year for this location. As noted previously, combined snow and rainfall through January, February and March was only about 38 mm, which is about 139 mm below the normal amount of precipitation for this period. However, despite the limited amount of precipitation during this period, the slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at this location during the second half of March and early-April. Groundwater levels began a gradual decline in mid-April, which is earlier than most years, and continued to decline through May. June rainfall caused levels to rise again, before declining through July to early October. Groundwater levels rose in response to precipitation events in October and December.

The responses to precipitation events and spring thaw, or lack thereof, observed in this monitor during the period 2007 to 2015, have demonstrated the local sensitivity of the shallow groundwater system, which is associated with the coarse-grained nature of the overburden deposits within and above the uppermost aquifer. The below-normal precipitation during 2015 caused groundwater levels to decline to the third-lowest late-summer/early-fall levels at this location since data logger monitoring began in 2007.

As noted above, two mini-piezometers were installed in the Downey Road PSW. PZ-9S was installed to a depth of about 0.5 m and PZ-9D to a depth of about 1.0 m below ground level. Graph F2, Appendix I presents the groundwater elevations recorded in mini-piezometer PZ-9D, for the period March 2007 to December 2015. Groundwater levels for this pair of shallow and deeper mini-piezometers have illustrated the upward hydraulic gradient that exists in this PSW.

It is noted that responses to precipitation and temperature are apparent in PZ-9D, similar to MW003, confirming the infiltrative capacity of the medium- to coarse-grained deposits on this site and the inherent relationship of the wetlands to the shallow groundwater system. Each year, groundwater levels naturally decline to an elevation that is below ground level in the wetland, typically during June or July.

A small upward hydraulic gradient is also evident at various times when groundwater levels in MW003 are higher when compared with levels in the adjacent PZ-9D.

<u>2015 Monitoring at Perimeter Locations</u>

Groundwater levels in 2015 were monitored at nine monitoring wells around the perimeter of the site. These included stations MW125, MW126, MW128, MW124, MW107, MW132, MW135, MW133, and MW134 (Map 3).

Groundwater elevations vary more widely over the year at perimeter locations in comparison to the Core PSW locations. The perimeter groundwater monitoring stations responded to spring thaw and the above-normal precipitation during June and October 2015, similar to the monitoring stations described in the previous two sections. There were no apparent short-term and/or longe-term changes in groundwater levels at perimeter monitoring stations that could be attributed to construction activities during 2015 within the HCBP.

2.3 Surface Water Levels and Flow

As part of the surface water monitoring program in 2015, water depth (level) was measured at 10 stations on Tributary A and Tributary A1. The station names are HC-A: 03, 04, 06, 08, 09, 10, 11, 12, 13 and 14. In addition, one station (SR-01) was located on an unnamed tributary on the west side of Downey Road across from the Downey Road PSW. Flow rating curves were developed to provide continuous flow data. In addition to the continuous flow monitoring, baseflow measurements were taken at eight stations on Tributary A between August and December, 2015. The resulting surface water data is presented in the tables and figures in the surface water monitoring report prepared by AECOM (Appendix II). Those results are summarized and discussed below.

As per GRCA requirements, monitoring was also completed at each of the stormwater management facilities, which included SWM ponds 1, 2, and 4. Monitoring of these locations included three components: inflow and discharge flow rates, water temperature, and water quality sampling. Inflow and discharge are discussed below while water temperature and water quality are discussed in Sections 2.4 and 2.5, respectively. Inflow and discharge flow rates were computed based on water level loggers placed in each facility's inlet and outlet structures. The locations of loggers within each SWM Pond are provided in Table 2. Refer to Figure 4 for all monitoring station locations.

Table 3. Stormwater Management Pond Monitoring Stations

SWMF	Station	Data Collected	Date installed	Location
Pond 1	HC-P1(01)	Temperature	September 2011	In pond close to bottom
	HC-P1(02)	Temperature	September 2011	In pond near mid-depth
	HC-P1(03)	Temperature	September 2011	In pond at surface
	HC-P1(04)	Temperature, Depth	September 2011	Inlet
	HC-P1(05)	Temperature, Depth	September 2011	Inlet
	HC-P1(06)	Temperature, Depth	June 2011	Outlet
	HC-P1(07)	Temperature	June 2011	Cooling trench outlet
	HC-P1(08)	Temperature	June 2011	Cooling trench outlet
Pond 2	HC-P2(01)	Temperature	April 2011	In pond close to bottom
	HC-P2(02)	Temperature	April 2011	In pond near mid-depth
	HC-P2(03)	Temperature	April 2011	In pond at surface
	HC-P2(04)	Temperature, Depth	April 2011	Inlet
	HC-P2(05)	Temperature, Depth	August 2012	Inlet
	HC-P2(06)	Temperature, Depth	June 2011	Inlet
	HC-P2(07)	Temperature, Depth	April 2011	Outlet
Pond 4	HC-P4(01)	Temperature	October 2011	In pond close to bottom
	HC-P4(02)	Temperature	November 2011	In pond near mid-depth
	HC-P4(03)	Temperature	November 2011	In pond at surface
	HC-P4(04)	Temperature, Depth	August 2012	Inlet
	HC-P4(05)	Temperature, Depth	October 2011	Outlet
	HC-P4(06)	Temperature	October 2011	Cooling trench outlet

Operational issues were experienced in 2015 at several surface water monitoring stations. Winter stream conditions and equipment malfunctions produced data gaps in the continuous monitoring data at eight stations. The resulting data gaps in logger files are given in detail in the surface water monitoring report prepared by AECOM (Appendix II).

A plot showing the creek flow at eight surface water stations as well as precipitation data collected at the Elora Research Station for the 2015 monitoring period is shown in Figure 1. Baseflow measurements for 2015 are shown in Figure 2, and a summary of baseflow monitoring from 2008 to 2015 is provided in Table 4.

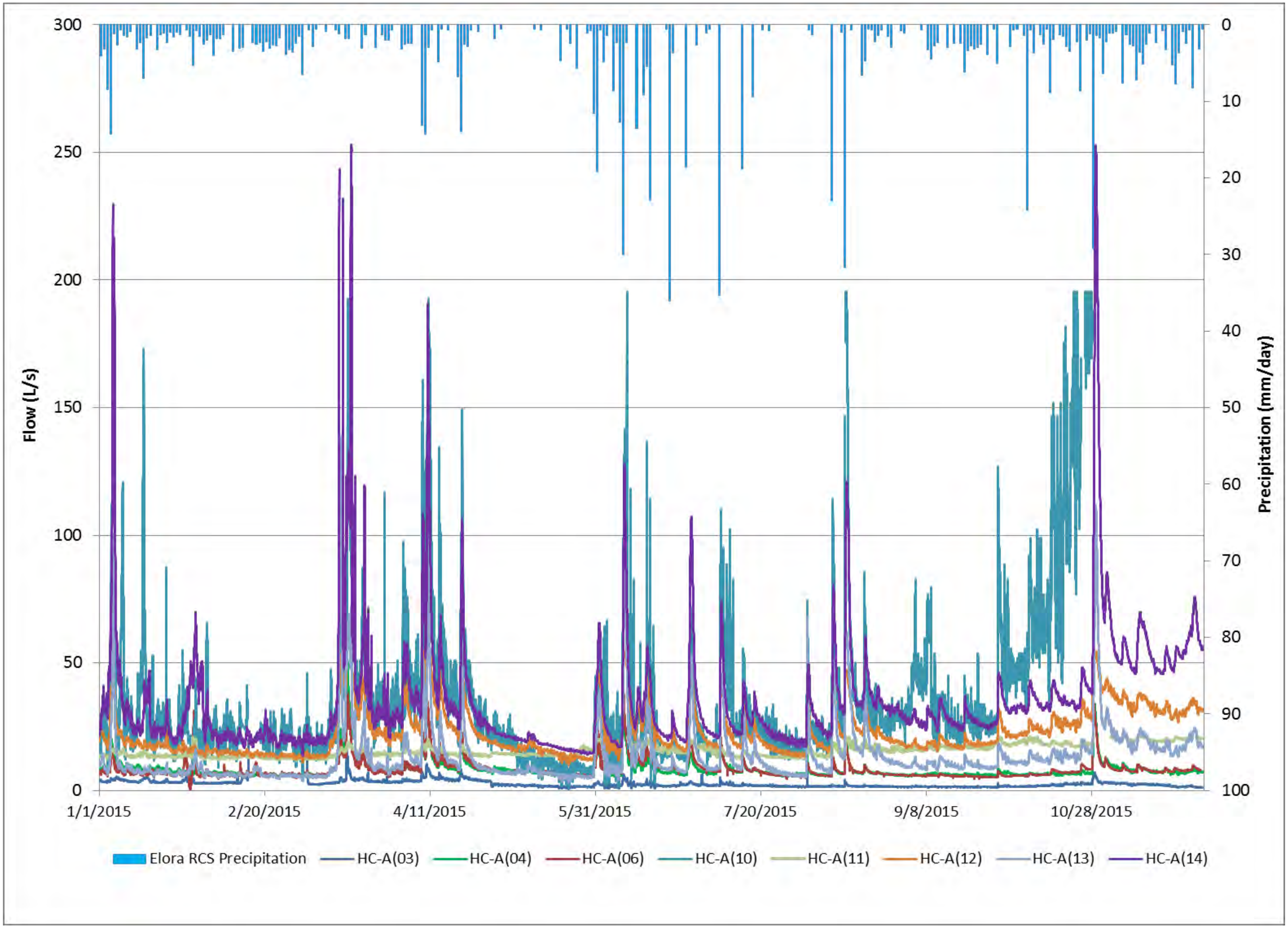


Figure 1. Tributary A and A1 Flow and Precipitation Monitoring – Continuous for Eight Stations, January to December 2015

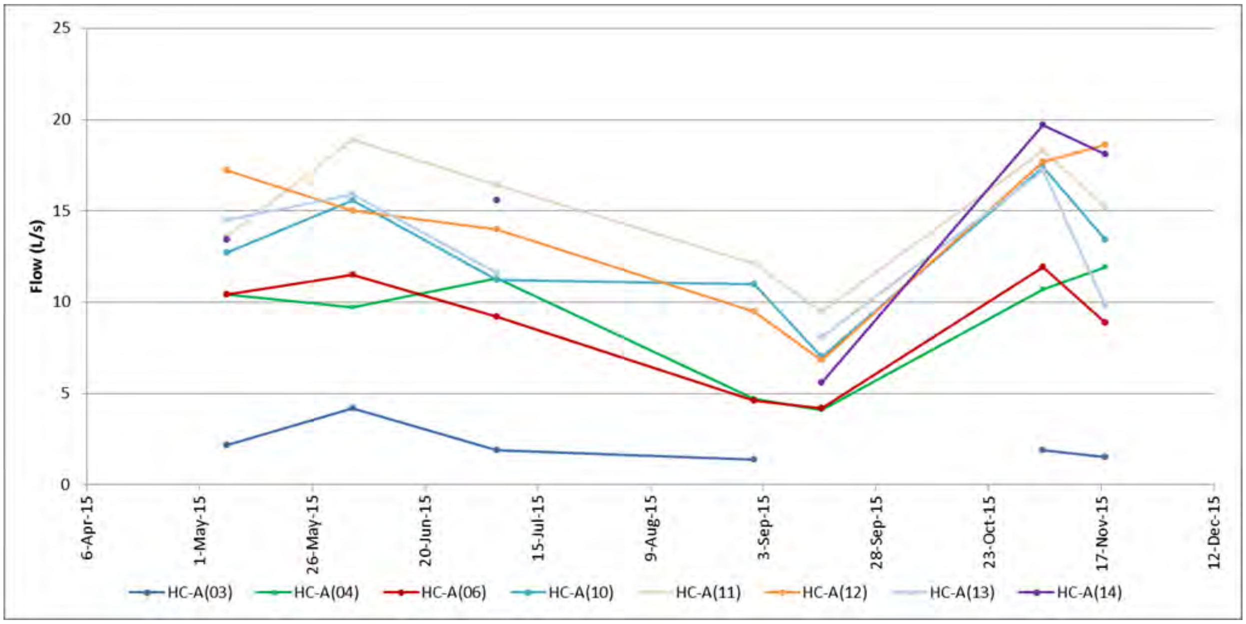


Figure 2. 2015 Hanlon Creek Tributary A Baseflow Measurements

Table 4. Hanlon Creek Baseflow Monitoring – 2008 to 2015 Summary (L/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08) Tributary	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2008 Min	n/a	3.5	2.7	2.1	3.8	7.7	n/a	n/a	n/a	0.9
2009 Min	n/a	3.9	1.2	3.0	4.2	5.0	n/a	n/a	n/a	1.8
2010 Min	n/a	0.4	0.4	-7.3	1.1	0.8	n/a	n/a	n/a	0.9
2011 Min[2]	2.8	5.5	0.8	1.5	n/a	2.4	4.6	5.0	2.8	1.5
2012 Min	0.1	3.2	3.1	0.5	n/a	1.3	0.7	1.7[1]	0.6[1]	0.7[1]
2013 Min	1.2	8.2	5.5	n/a	n/a	6.4	2.7	12.5	3.4	3.4
2008 Max	n/a	11.3	10.7	10.0	9.4	16.8	n/a	n/a	n/a	12.1
2009 Max	n/a	14.9	25.6	22.1	18.7	56.3	n/a	n/a	n/a	53.8
2010 Max	n/a	2.9	4.9	12.3	6.7	22.2	n/a	n/a	n/a	1.2
2011 Max[2]	47.4	56.6	50.0	5.9	n/a	31.5	46.0	31.9	18.2	48.0
2012 Max	2.5	10.5	14.6	7.4	n/a	13.2	45.6	17.6	36.6	20.7
2013 Max	4.4	16.8	10.3	n/a	n/a	16.9	16.0	21.7	15.8	15.7
2014 Max	3.6	15.4	16.9	n/a	n/a	27.7	27.3	33.1	30.0	28.2
2015 Max	4.2	11.9	11.9	n/a	n/a	17.4	18.9	18.6	17.2	19.7
2008 Average	n/a	6.0	9.3	9.0	8.5	20.5	n/a	n/a	n/a	15.8
2009 Average	n/a	7.8	10.7	9.3	10.6	21.3	n/a	n/a	n/a	19.7
2010 Average	n/a	1.6	2.0	2.4	3.6	7.1	n/a	n/a	n/a	5.0
2011 Average[2]	14.6	21.7	20.2	2.7	n/a	19.3	20.6	18.0	20.5	17.2
2012 Average	1.1	6.1	7.5	3.1	n/a	8.0	14.4	10.6	10.9	9.1
2013 Average	2.7	11.2	7.9	n/a	n/a	10.4	10.4	16.1	8.0	9.9
2014 Average	2.6	12.3	14.0	n/a	n/a	19.3	21.1	26.1	21.0	17.2
2015 Average	2.2	9.0	8.7	n/a	n/a	12.6	14.9	14.4	12.9	14.5
Notes	[1] Hanlon Creek was noted to be dry or flows were below the measurement threshold flow at stations HC-A(03),HC-A(12), HC-A(13) and HC-A(14) [2] Baseflows were influenced by construction activities									

Baseflows in Tributary A in 2015 were lower than those in 2014 at all 8 monitoring stations. The lower average baseflows that were noted in 2015 occurred in spite of total precipitation in 2015 (927.7mm at Elora Research Stn.) that was higher than in 2014 (776.7mm). Precipitation in 2015 was also slightly higher than the climate normal of 923.3mm for the years 1971 to 2000 at Guelph Arboretum.

The discharge from Pond 4 was observed to be near continuous again in 2015 causing elevated baseflow levels at HC-A(04), which is located a short distance downstream of Pond 4. The pond interacts with groundwater flowing in a northwesterly direction, and provides a more direct pathway for discharge to Tributary A. It remains the understanding that groundwater is the predominant source of the pond's continuous discharge. The continuous discharge has resulted in the observed elevated baseflows in Tributary A, and has also affected summer water temperatures in Tributary A. The effect on water temperatures is discussed in Section 2.4.

Baseflow levels at station HC-A(04) were slightly higher than those at HC-A(06) in 2015 (on average 0.3 L/s higher). Prior to construction of Pond 4 in 2011, average baseflows from 2008 to 2010 ranged from 1.6 to 7.8 L/s at HC-A(04). In 2014 and 2015, average baseflows were 12.3 and 9.0 L/s (Table 4), reflecting the increase in baseflow that is attributed to continuous discharge of water from Pond 4.

The continuous discharge from Pond 4 has occurred since the construction of its outlet in 2011. Within that time, the average baseflows during the years 2011 and 2012 did not reflect the continuous discharge from Pond 4. Average baseflows at HC-A(04) were especially elevated during most of 2011 due to dewatering for the construction of the outlet and cooling trench for Pond 4, which was a unique condition for that year. In 2012 there were drought conditions, causing the average baseflows at HC-A(04) to be consistent with pre-2011 baseflows in spite of the continuous discharge that occurred that year. Without the continuous discharge, the baseflows in 2012 would have been much lower. Thus, the continuous discharge and resulting contribution to baseflows have been occurring for more than three years, beginning in late 2011 when construction of the cooling trench and outlet was completed.

Farther downstream, the reach between HC-A(09) and HC-A(10) receives input from a small groundwater-fed tributary (Tributary A1) that flows through a cedar-hardwood mixed, swamp which helped it remain a gaining reach. HC-A(10) and HC-A(11) have historically been groundwater discharge areas and this was the case for 2015. HC-A(12), HC-A(13) and HC-A(14) were all areas of ground water recharge or losing reaches again in 2015.

2.4 Water Temperature

2.4.1 Groundwater Temperature

Groundwater temperatures were recorded using data loggers in 38 groundwater monitoring stations across the Hanlon Creek Business Park during 2015. Temperature monitoring has been conducted since 2007 at four PSW monitoring locations (MW003, PZ-9D, PZ-2D, and PZ-7D), all of which are representative of shallow groundwater conditions within the site. The groundwater temperature results are given in the 2015 technical memorandum prepared by Banks Groundwater Engineering (Appendix I) and discussed as follows.

Temperature ranges for each of the four PSW locations were as follows:

- MW003 – similar to previous years ranging from a low of 4.9°C in the second week of April to a high of 11.6°C in late-October
- PZ-9D – ranged from a low of 2.1°C in the second week of April to a high of 14.6°C in mid-September
- PZ-2D – ranged from a low of 4.0°C in mid-April to a high of 12.6°C in mid-September
- PZ-7D – ranged from a low of 4.2°C in early-March to a high of 11.5°C in early- to mid- September.

The temperature range of groundwater at greater depths in this general area tends to fluctuate in a narrower range, typically between 5 and 10°C. It is therefore apparent that the temperatures in the shallower groundwater regime in the vicinity of these four monitors are influenced by seasonal variations in air temperature and solar radiation.

These data are interpreted to be representative of the temperature of groundwater discharging to the wetlands and creeks in these locations.

Monitoring well MW119A is located adjacent to and down-gradient from SWM Pond 4. Groundwater temperatures recorded in monitoring well MW119A during 2015 ranged from a low of 5.2°C at the start of April to a high of 14.9°C in mid/late-September, similar to 2014. This is also comparable to the ranges observed from 2008 to 2010. The high temperature of 14.9°C in 2015 was below the highest temperature recorded, which was 17.5°C on September 5, 2012. Prior to construction of SWM Pond 4 in late 2010, the highest groundwater temperature at this monitor was 15.0°C in early-September 2010. Prior to that, the years 2008 and 2009 had reached a maximum of approximately 13°C in September.

The bottom of SWM Pond 4 is below the shallow groundwater surface and as a result the un-lined pond is in direct contact with the local groundwater system. A portion of the water in the pond is interpreted to discharge from the pond as groundwater in a north-westerly direction, flowing into the ground adjacent to the pond. Therefore, water in the pond warmed by solar radiation during the summer months in 2015 appears to have increased the late-summer groundwater temperature by as much as 3°C in the area down-gradient (north-west) of the pond.

Additional monitoring of groundwater temperatures down-gradient of SWM Pond 4 was initiated in June 2013. A pair of shallow mini-piezometers (PZ-13D and PZ-14D) were installed on the east and west bank of Tributary 'A', and equipped with data loggers (refer to Figure 1). The piezometers were located a short distance down-stream from surface water monitoring station HC-A(04). The groundwater temperatures recorded in PZ-13D up to September 27, 2015 when the data logger failed and in PZ-14D up to the end of October 2015 are presented in Graph G24a within the appendices of the technical memorandum prepared by Banks Groundwater Engineering (Appendix I).

Also included in this graph are the groundwater temperatures recorded in MW119A and MW131. MW131 is located about 130 m up-gradient of SWM Pond 4. It is apparent from comparison with the MW131 graph that the groundwater temperatures at PZ-13D and possibly PZ-14D, which reached a maximum of just less than 14°C in mid-

September, was likely influenced by the warmer shallow groundwater flow affected by SWM Pond 4. MW119A, located downgradient of the SWM Pond 4, had late-summer temperatures that were 3°C warmer than concurrent temperatures at MW131. The groundwater temperature at PZ-14D may have been influenced by solar radiation during summer months on the adjacent, up-gradient field. Graph 24a also shows that temperatures in PZ-13D and PZ-14D returned to below those recorded in MW131 by late-October each year. This issue is discussed further in Section 5.1.2.

2.4.2 Surface Water Temperature

Surface water temperatures were measured in Tributary A and Tributary A1 using data loggers at 11 stream stations and in numerous locations within SWM Ponds 1, 2 and 4. The results are given in the surface water monitoring report prepared by AECOM (Appendix II), and are summarized and discussed as follows.

A plot of the continuous temperature monitoring throughout the year 2015 is provided in Figure 3. During the winter months (January to March) of 2015, temperatures at all stations appear to have been at or around freezing (0°C) for most of the winter indicating that a large portion of Tributary A periodically experienced frozen conditions. Additionally, stations HC-A(03), HC-A(04), HC-A(06), HC-A(08), HC-A(10), HC-A(11) and SR-1 had temperatures fluctuate below zero degrees indicating that loggers may have been exposed to air temperatures during the winter months.

Stations HC-A(08), HC-A(03), HC-A(04), and HC-A(06) show trends of consistent temperatures above 0° during sub 0° air temperature conditions. This indicates these stations are likely most impacted by groundwater input. Conversely stations HC-A(14) and HC-A(09) record the coldest temperatures and are least impacted by groundwater inputs. These trends are consistent with over-winter observations made since the implementation of the monitoring program before the construction of the ponds.

During summer months, stations HC-A(04) and HC-A(06), located downstream of the Pond 4 outlet, recorded high average temperatures and little daily fluctuation due to the influence of SWM Pond 4's continuous discharge compared to HC-A(03), which is not impacted by pond discharge. Downstream stations which are more exposed such as

HC-A(10), HC-A(12), HC-A(13) and HC-A(14); and those with a wider flow channel and shallower depths (HC-A(09)) show the highest daily variation in temperature as there is greater opportunity for solar radiation impact. Station HC-A(08) shows the lowest temperatures and daily temperature variation during the summer, indicating the presence of groundwater inputs in Tributary A1 where this station is located.

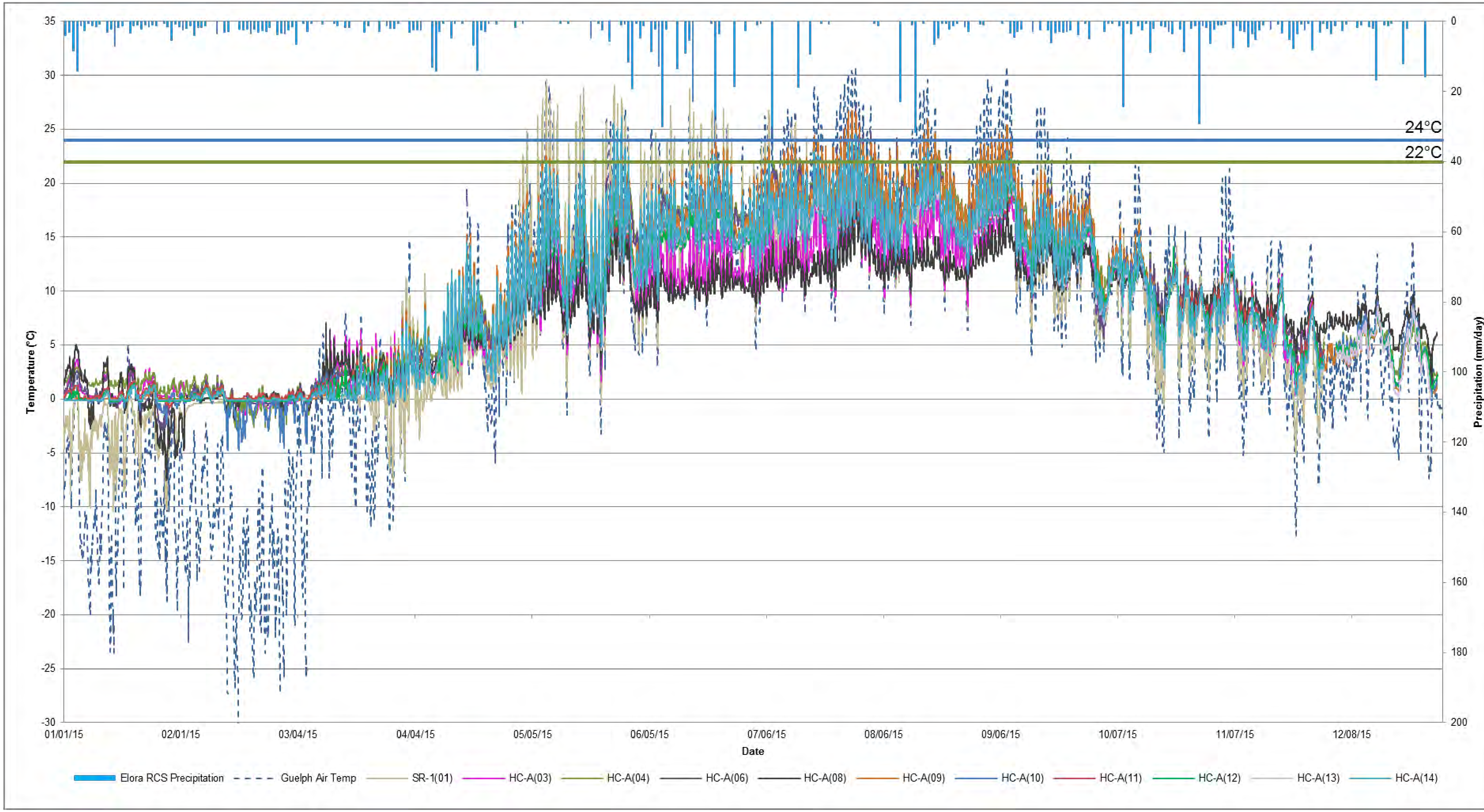


Figure 3. Tributary A and A1 Temperature Monitoring – Continuous Temperature for 11 Stations, January to December 2015.

The surface water temperatures were higher in 2015 compared to 2014. Compared to other years of monitoring, results for 2015 were generally normal to somewhat warm. Stations HC-A(04) and HC-A(06) are the notable exceptions, as they continued to have higher temperatures due to the influence of the continuous discharge from SWM Pond 4.

The generally normal to warm water temperatures in 2015 are attributable to the observed air temperatures and lower precipitation in the summer of 2015. Daily average air temperatures from May to September 2015 were slightly below climate normals for June, July, and August and were well above for May and September. In comparison to 2014 averages, the air temperature was high in 2015 for all months (May, July, August, and September) except June when they were almost 2°C cooler. Altogether, this resulted in the warmer surface water temperatures in 2015.

Table 5 shows the thermal regime classifications for Tributaries A and A1 from 2006 to 2015 using the methods developed by Stoneman and Jones (1996) and revised by Chu (2009). The 2015 classifications show similar conditions to those in 2014 and other previous years. Comparing 2014 and 2015 results, station HC-A(03) shifted from cool-cold to cool, station HC-A(4) shifted from cool to cool-warm and stations HC-A(10) and HC-A(13) shifted from cool-warm to cool. The other stations remained the same. The 2012 classifications reflect the drought conditions that year. Several stations have exhibited changes in thermal regime with four stations showing a warmer thermal regime (HC-A(04), HC-A(06), HC-A(09), and HC-A(10)) and two showing a cooler thermal regime (HC-A(11) and HC-A(12)). The remaining four stations showed little to no change.

Table 5. Temperature Classification Summary

	Based on C. Chu et al. (2009)								Based on Stoneman and Jones (1996)		Overall Change in Thermal Regime
Station	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	
HC-A(03)	Cool	Cool-Cold	Cool-Cold	Cool	Cool	n/a	n/a	n/a	n/a	n/a	None
HC-A(04)	Cool-Warm	Cool	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cold	Cold	Cold-Cool to Cool-Warm
HC-A(06)	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cool	Cool	Cool to Cool-Warm
HC-A(08)	Cold	Cold	Cold	Cool-Cold	Cold	Cold	Cold	Cold	Cold	Cold	None
HC-A(09)	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	n/a	Cool	Cold	Cool	Cool to Cool-Warm
HC-A(10)	Cool	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Cold	n/a	Cool-Cold	Cool	Cool	Cool to Cool-Warm
HC-A(11)	Cool	Cool	Cool	Cool-Warm	Cool	Cool	Cool-Warm	Cool	Warm	Warm	Cool-Warm to Cool
HC-A(12)	Cool	Cool	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	Cool-Warm to Cool
HC-A(13)	Cool	Cool-Warm	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	None
HC-A(14)	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool	Cool	n/a	n/a	None

Comparing 2015 results to pre-construction years (2006 to 2010), it is evident that there is some warming that is likely attributable to the effects of SMW Pond 4. Stations HC-A(04), HC-A(06), HC-A(09) and HC-A(10) were warmer in 2015. Further downstream, station HC-A(11) was cooler in 2015 compared to pre-construction condition, which may reflect the cooling effect of the removal of the online pond in conjunction with building the Hanlon Creek Blvd crossing of Tributary A in 2009. Station HC-A(14) was one category warmer in 2015 compared to pre-construction conditions (i.e. cool-warm in 2015 as opposed to cool in 2008 and 2009). Stations HC-A(12) and HC-A(13) did not exist prior to construction. Beginning in 2011, the results for those stations suggest that the only influence has been the warmer climate conditions in 2012. Altogether, the majority of the stations with warmer thermal regimes occur in the section of Tributary A that is most likely to be influenced by SWM Pond 4.

2.4.2.1 Suitability of Temperature for Brook Trout

Studies suggest that the upper temperature tolerance limits for Brook Trout are in the range of 22.3°C (Eaton et al 1995) to 25.4°C (Wehrly et al 2007). Optimum water temperature for growth during the summer is suggested to be in the range of 10 to 19°C (Hokanson et al 1973). . In general, water temperatures observed throughout the summer months in 2015 were above the preferred temperatures documented for Brook Trout in the *Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F* (AECOM, 2009). Water temperatures were noted to exceed 19°C and threshold exceedances of 22 and 24°C were also observed between May and September. Temperature exceedances of 19°C and up to 24°C may limit Brook Trout presence within certain areas of the creek during the summer months where water temperatures are elevated above their preferred range. However, these exceedances are not likely to eliminate the potential presence of Brook Trout altogether since fish are mobile and will move upstream or downstream in search of cooler water temperatures to use as refugia (Power 1980). Further, although no Brook Trout have been captured at the HCBP fish monitoring stations, the presence of other coolwater and coldwater species such as White Sucker (*Catostomus commersonii*) and Mottled Sculpin (*Cottus bairdii*) indicate that species preferring those thermal regimes are able to persist. Similar to previous years, stream temperatures in 2015 exceeded the preferred summer temperature range for Brook Trout, which is between 10 and 19°C. Table 6 shows that all stations had periods of time when temperatures were above 19°C in July and August. Stations HC-A(04) and HC-A(06) were influence by the continuous outflow from SWM Pond 4, and spent the majority of the time in July and August above 19°C. In contrast, station HC-A(03) is located immediately upstream of the SWM Pond 4 outflow, and had significantly less time when the stream temperature was above 19°C. Station HC-A(09) also had substantial time when the temperature was above 19°C. Station HC-A(08) is located on Tributary A1 which is typically colder. This station had only minor exceedances of 19°C in 2015. Downstream of the confluence of Tributary A and Tributary A1 at HC-A(10) and HC-A(11), the combined flows had some time above 19°C, but the results were clearly influenced by the colder water from Tributary A1. Moving downstream through stations HC-A(12), HC-A(13) and HC-A(14), the time above 19°C increased, reflecting the loss of water to the ground known to occur in this reach, and exposure to the sun that occurs early in the summer before the herbaceous vegetation is fully grown in this area. In 2015, every monitoring station along Tributary A and A1 experienced at least some time when temperatures were above the preferred summer temperature range for Brook Trout. Only two stations, HC-A(03) and HC-A(08) experienced values, specifically hours and percent of time over 19°C, that were within the modeled values.

Autumn temperatures are also very important to Brook Trout as they relate to spawning, which typically occurs between the middle of October and the end of November in southern Ontario. Witzel and MacCrimmon (1983) observed that stream temperatures were most commonly between 6 and 8°C while Brook Trout were spawning in the fall in southern Ontario streams. During the spawning period water temperatures were within the 6 to 8°C preferred range at the HCBP, indicating that water temperatures were suitable for Brook Trout spawning.

Table 6. Summer (July to August) 2015 Temperature Summary

Station	Modeled Values[1]	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)	SR-1(01)
Summer (July-August) average maximum (ºC)	14.5 - 19.9	18.0	20.9	21.6	14.5	22.3	19.7	19.5	18.7	18.9	20.4	21.1
Summer (July-August) average (ºC)	12.5 - 14.5	14.6	19.5	18.9	12.6	19.2	16.9	17.1	16.9	17.0	17.6	16.9
Summer (July-August) average minimum (ºC)	9.0 - 12.0	11.8	18.2	16.3	11.3	16.8	14.8	15.2	15.3	15.3	15.1	12.8
Maximum 3-day mean (ºC)	14.0 - 19.0	17.3	21.7	21.4	16.2	22.0	19.3	19.4	19.2	19.2	20.2	19.8
Maximum 7-day mean (ºC)	13.0 - 17.0	16.7	21.5	21.1	15.5	21.3	18.9	18.9	18.6	18.6	19.6	19.0
Maximum 7-day mean of daily maximums (ºC)	15.0 - 23.5	21.1	22.8	25.4	19.1	25.5	21.3	21.0	21.2	21.2	23.3	23.1
	Temperature Exceedance over 19°C for July and August											
Hours over 19°C	0 - 130	84	920	753	4	742	260	259	184	199	431	364
Percent of Time over 19°C	0 - 9%	6%	62%	51%	0%	50%	17%	17%	12%	13%	29%	24%
Frequency of Exceedance over 19°C (Days)	0 - 27	19	55	57	5	58	44	43	25	28	49	52
Average Duration of Event Over 19°C (h)	3 - 6	4.0	21.9	10.5	0.6	14.6	5.7	5.9	7.4	7.1	9.0	5.4
Maximum duration of event over 19ºC (h)	<<130	8.8	183.3	110.8	1.0	112.0	11.8	12.8	15.8	15.8	34.8	35.5
	Temperature Exceedance over 22°C for July and August											
Hours over 22°C		0	97	107	0	224	13	3	3	3	59	62
Percent of Time over 22°C		0%	7%	7%	0%	15%	1%	0%	0%	0%	4%	4%
Frequency of Exceedance over 22°C (Days)		1	16	24	0	38	6	1	1	1	14	21
Average Duration of Event Over 22°C (h)		0.3	5.2	3.4	0	3.9	1.4	1.8	1.4	1.4	2.9	2.1
Maximum duration of event over 22ºC (h)	<<130	0.25	18.75	10.25	0.00	14.25	3.75	3.25	2.50	2.50	8.50	7.25
	Temperature Exceedance over 24°C for July and August											
Hours over 24°C	0 -3.2	0	0	15	0	48	0	0	0	0	3	12
Percent of Time over 24°C	0 - 0.21%	0.00%	0.00%	0.99%	0.00%	3.19%	0.00%	0.00%	0.00%	0.00%	0.22%	0.79%
Frequency of 24°C Exceedance (Days)		0	0	8	0	10	0	0	0	0	1	6
Average Duration of Event Over 24°C (h)		0	0	1.64	0	4.75	0	0	0	0	3.25	1.68
Maximum duration of event over 24ºC (h)	<3.2	0	0	4.3	0	7.5	0	0	0	0	3.3	4.3

[1] Modeled range referees to the results of the Hanlon Creek Business Park Stream Temperate Impact Report Continuous Modeling with HSP-F (AECOM, 2009)

[2] Red text denotes exceedances of the modeled range

Maximum temperatures were also reviewed and provide further evidence that the temperatures in 2015 were not suitable for Brook Trout. The HCBP Consolidated Monitoring Plan established two thresholds for Brook Trout; the first is a single temperature exceedance of 22.0°C, and the second is any single temperature exceedance of 24.0°C. The highest number of exceedances of these thresholds since monitoring began occurred in the year 2012. Comparatively fewer exceedance events occurred in 2015, yet exceedences of both thresholds were still observed (Table 6).

Temperatures in excess of 22°C are not suitable for Brook Trout. Station HC-A(09) exceeded 22°C for 224 hours in July and August, which is 15% of this time period, and stations HC-A(04) and HC-A(06) exceeded 22°C for 97 hours and 107 hours, respectively or 7% of the time period (Table 6). Generally, the largest exceedances have been observed at station HC-A(09), resulting from the wide channel and shallow water depths. Overall, stations HC-(A)09, HC-A(06) and HC-A(04) have had greater number of hours above 22°C since the construction of Pond 4 and HC-(A)09 has also had a greater number of hours above 24°C. Improving the thermal conditions upstream by addressing the SWM Pond 4 issues will likely result in reducing temperature at these three downstream stations.

For comparison, station HC-A(03), located just upstream from these stations but outside of the impact from Pond 4, only experienced one minor exceedance of 22°C in 2015. Station HC-A(14) also exceeded 22°C for a total of 59 hours or 4% of the time period. It has been typical for station HC-A(14) to exceed both thresholds because of loss of water and exposure to the sun in this part of Tributary A. Other stations on Tributary A had lesser periods of time above 22°C in July and August. While the resulting time periods for those stations are a modest proportion of July and August, temperatures above 22°C are not suitable for Brook Trout, and adverse effects can occur even if the temperatures are not lethal. Only station HC-A(08) had temperatures that remained below 22°C. This is a result of the groundwater discharge to Tributary A1.

Temperatures above 24°C can be lethal for Brook Trout, and three stations had temperatures above 24°C during July and August 2015. Station HC-A(09) exceeded 24°C on ten occasions, with an average of 4.75 hours and totaling 48 hours (Table 6). Station HC-A(06) exceeded 24°C on eight occasions for 15 hours and HC-A(14) exceeded 24°C on one occasion for 3 hours. The RAAP team normally meets whenever temperatures exceeded 24°C at telemetry stations to discern the cause and try to address it. A discussion of the RAAP team's activity in 2015 is provided in Section 4.0.

2.4.2.2 Stormwater Management Pond Temperature

In addition to the monitoring of stream temperatures, monitoring was conducted at the constructed stormwater management facilities, which included SWM Pond 1, SWM Pond 2, and SWM Pond 4 (Map 4). Temperature was measured at each pond's inlet, at three depths near the bottom-draw outlet, at the outlet of the pond, and at the outlet of the cooling trench (where applicable).

SWM Pond 1

The loggers in the inlet channels (HC-P1(04,05)) were often exposed to solar heating and air temperatures due to low water levels in the channels. This resulted in temperature records with extreme daily fluctuations. Within the pond thermal stratification was evident, demonstrated by the bottom and mid temperatures converging during the mixing caused by a storm event, and then diverging again the following day (Figure 4). The surface temperature had the greatest diurnal temperature fluctuation during the summer. Outflows from Pond 1 were not recorded for July and August as the logger had been vandalized or taken from the site. The logger was subsequently locked inside the catch basin for protection. For 2015 however, conclusions regarding the function of the cooling trenches at pond 1 cannot be determined. Pond water levels were not high enough during the second half of the monitoring season to trigger a pond discharge event. In 2014, the cooling trenches demonstrated steady to declining temperatures through the storm event with cooling trench 1 generally maintaining lower temperatures than cooling trench 2.

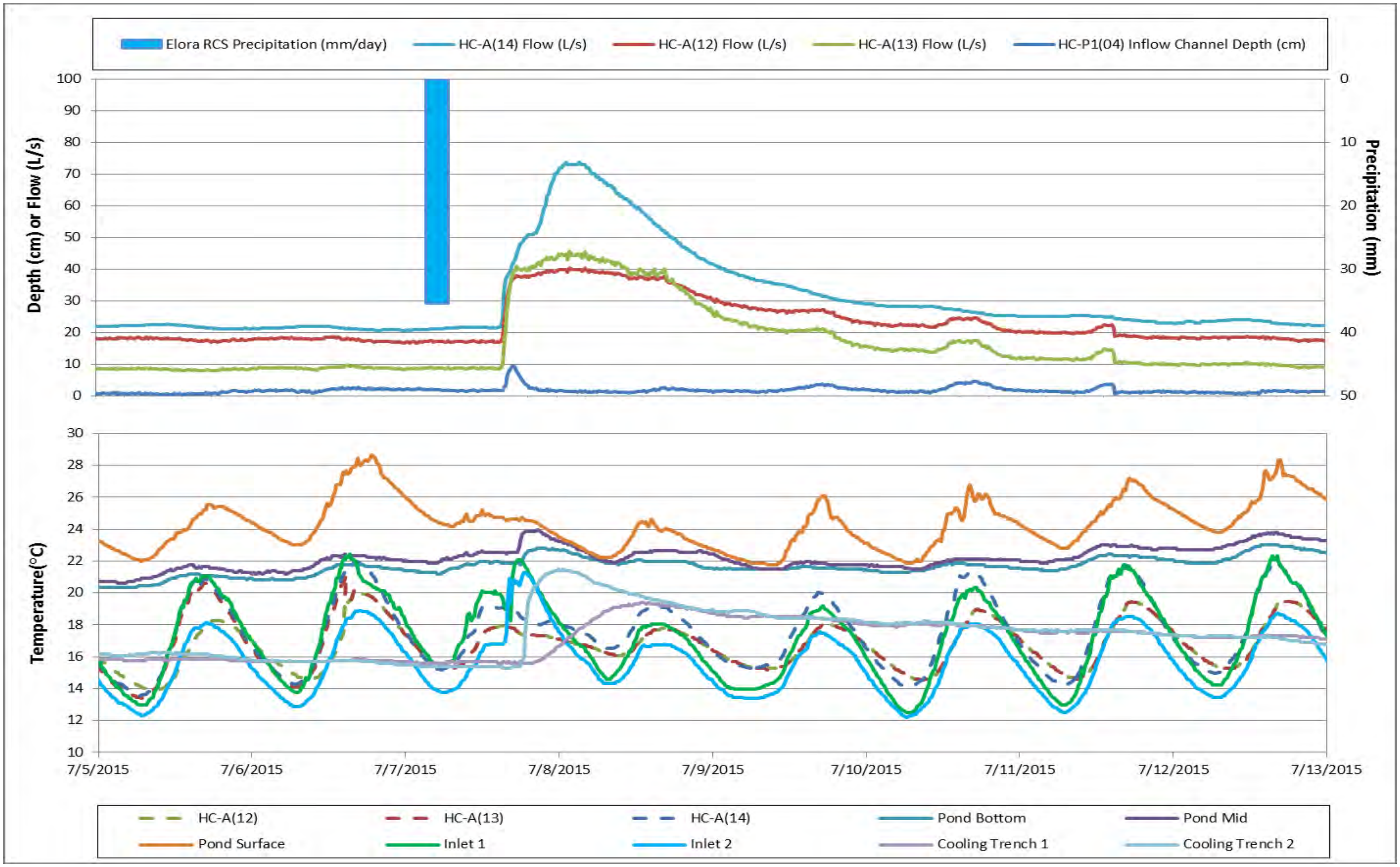


Figure 4. SWM Pond 1: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting the pond; precipitation; measured temperatures on Tributary A upstream (HC-A(12)) and downstream (HC-A(13, 14)) of Pond 1.

SWM Pond 2

The thermal stratification was evident with the mid temperature generally remaining more stable than the surface temperature (Figure 5). No data was available for the bottom of the pond in 2015 due to logger malfunction. At HC-P2(04), inflow rates to the pond at the 655 mm inlet pipe could not be estimated as the logger is significantly influenced by tail water conditions throughout the monitoring season. Additionally, flow was not calculated for HC-P2(05) due to faulty logger data. Due to an impediment to flow in the upstream channel, flow in this drainage swale only occurred during large storm events. Pond 2 was only found to be discharging for short durations in 2015.

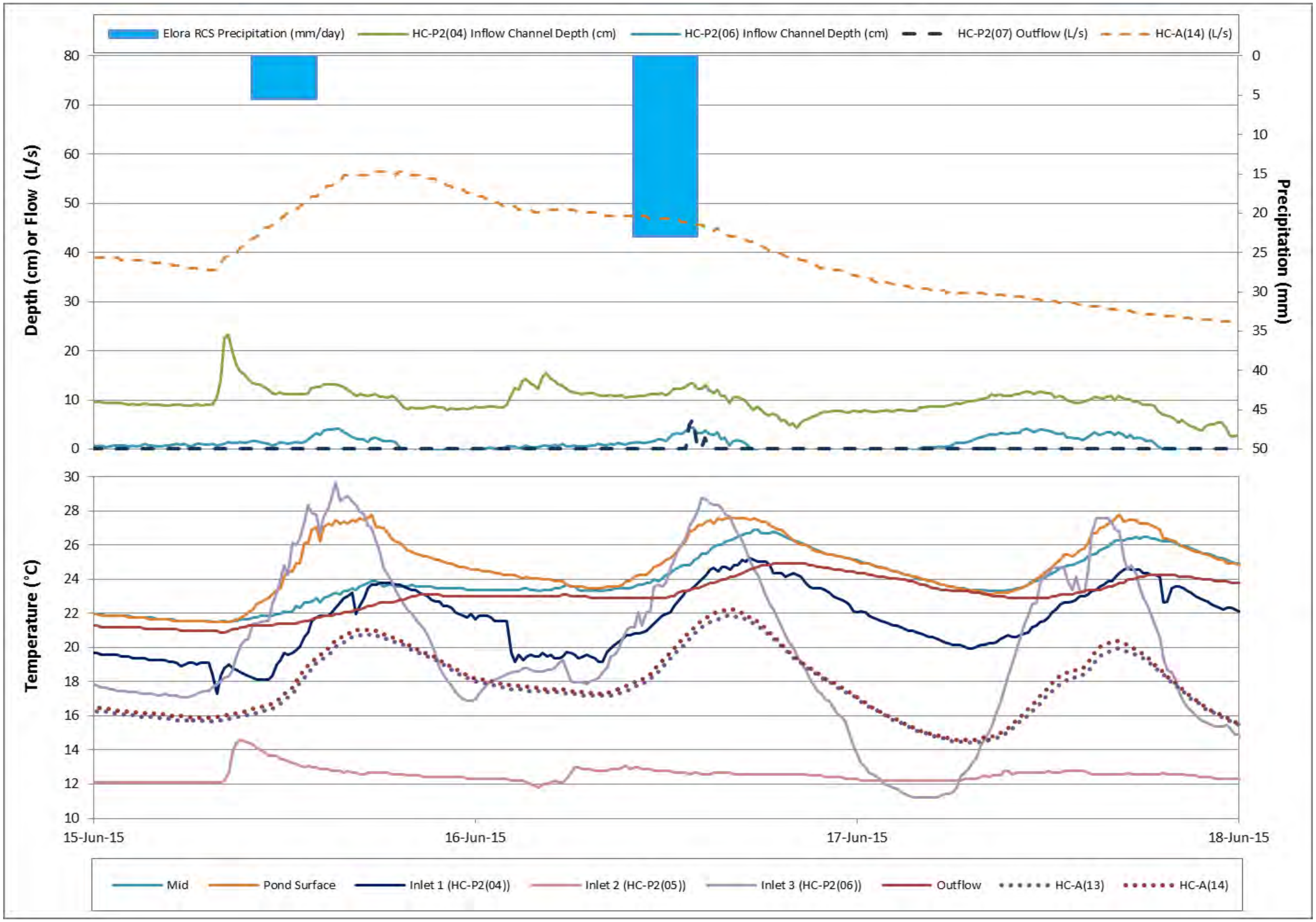


Figure 5. Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(13)) upstream and downstream (HC-A(14)) of Pond 2.

SWM Pond 4

As discussed in Section 2.3, SWM Pond 4 continued to discharge continuously, augmenting flow in Tributary A.

Pond temperatures were not able to be accurately analyzed due to the lack of data for the pond surface (HC-P4(03)). In previous years the pond temperatures have been strongly stratified during the summer, with bottom temperatures that that had much less temperature fluctuation than surface temperatures. In 2015 the bottom temperatures and mid-level temperatures remained similar in August with bottom temperatures elevating slightly above mid-level temperatures daily. Figures 6 and 7 demonstrate how the cooling trench maintained lower temperatures than the pond, yet were higher than upstream water temperatures in Tributary A at station HC-A(03). The resulting water temperatures downstream in Tributary A at station HC-A(04) are strongly influenced by the pond's discharge through the cooling trench. During the summer, the maximum daily temperatures recorded at HC-A(04) were typically 2 to 4 degrees cooler than temperatures recorded at HC-P4(05), and . This demonstrates that the cooling trench is generally functioning as intended, although the continuous discharge is increasing stream temperatures in Tributary A.

It appears that during dry periods the cooling trench was receiving water as outflows from the pond (outflow) combined with direct reception of groundwater. This explains why, during a dry period, the cooling trench water temperatures were midway between the pond outflow temperature and the upstream Tributary A temperatures at station HC-A(03) (Figure 7). The upstream temperatures in Tributary A appear to have been strongly influenced by groundwater. The daily minimum temperatures were consistent with groundwater temperatures at up-gradient monitoring wells MW 131 and MW 122A, which reached a maximum of nearly 14°C in the summer of 2015. The diurnal fluctuation in stream temperatures is interpreted to represent solar radiation and warm air temperatures that increased stream temperatures above groundwater temperatures during daylight hours. The pond outflow temperatures were considerably higher than the stream and groundwater temperatures. The fact that the cooling trench temperatures were in between suggests that they were a result of a mixture of pond outflow water and groundwater.

Cooling trench performance during a storm event further demonstrates how the mixing of SWM Pond 4 outflow (the water entering the cooling trench from the pond) and groundwater occurs. In response to a storm, the cooling trench temperatures were closer to pond outflow temperatures (Figure 6). This can be attributed to the greater volume of pond outflow, which has the greater influence on cooling trench temperature. Following the storm event, the cooling trench temperature gradually returned to a more balanced blend of groundwater and pond outflow, trending in a manner consistent with the pond outflow volumes.

With the possible exception of a few hours after a storm, it appears that the cooling trench performed largely as a mixing chamber, with the rock doing only a little to absorb heat from the outflow water. The cooling trench temperature responded very quickly to the inundation of outflow (Figure 6). . It appears that while the cooling trench at SWM Pond 4 did have a generally cooling effect on the continuous flow discharged to Hanlon Creek Tributary A, it had a limited ability to mitigate outflow temperatures during storm events.

In September 2012, aquatic vegetation was planted in the pond and the outlet weir was raised to reduce the constant discharge from SWM Pond 4. Raising the weir height did not stop SWM Pond 4 from continuously discharging from 2013 to 2015. Plantings of vines and other flora was completed at the end of 2012 on the cooling trench in an attempt to shade the exposed rock. The plants did not mature sufficiently from 2013 to 2015 to cover the cooling trench. Minor improvement in the amount of vegetation taking root along the cooling trench was noted, although the affect remains minor. These design features may provide additional cooling to the ponds discharge in future summer seasons. However, it will most likely be necessary to implement other measures to further mitigate the effects on stream temperatures. Options for other mitigation measures are being discussed with the City and the GRCA.

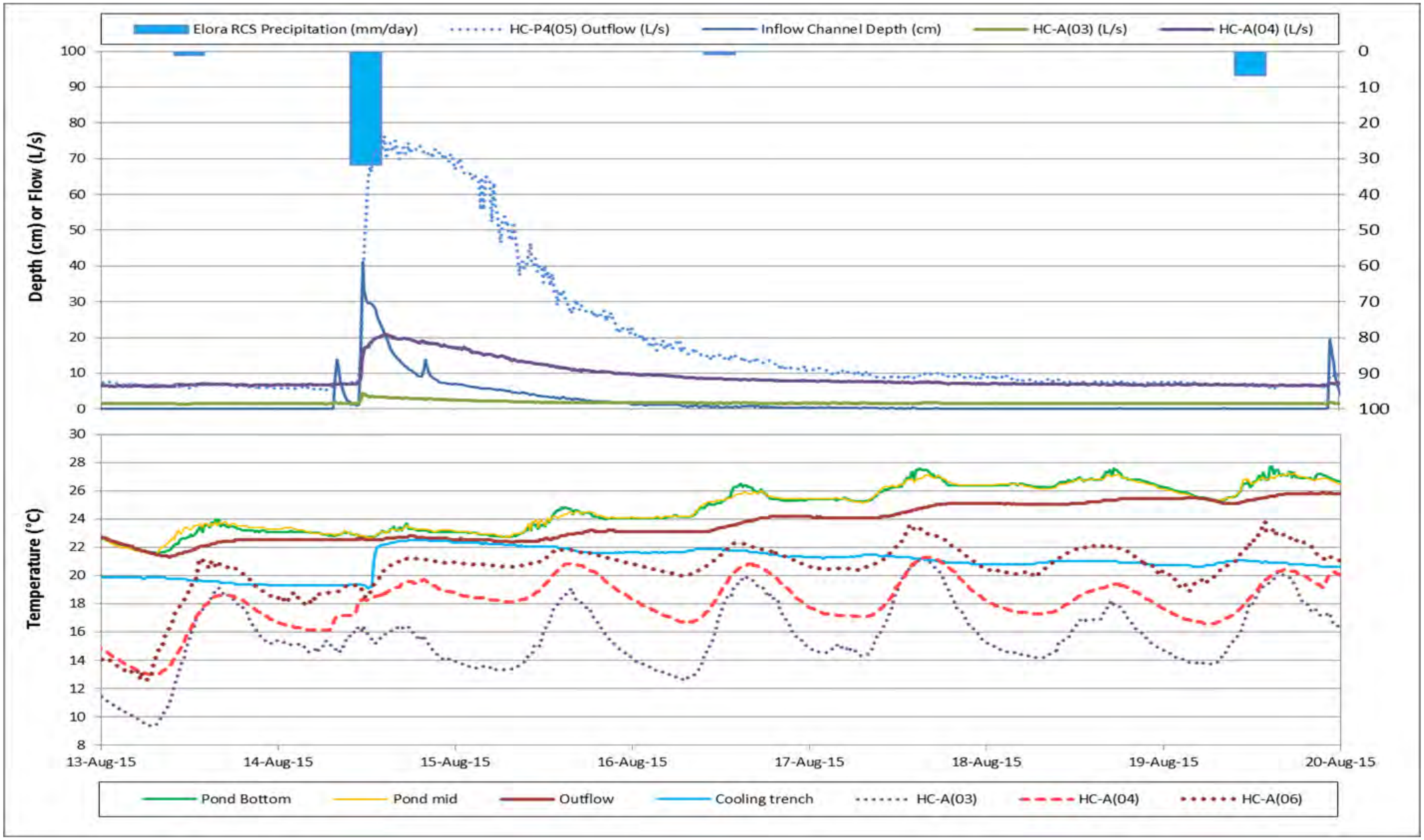


Figure 6. SWM Pond 4: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(03)) upstream and downstream (HC-A(04, 06)) of Pond 4 during a wet period.

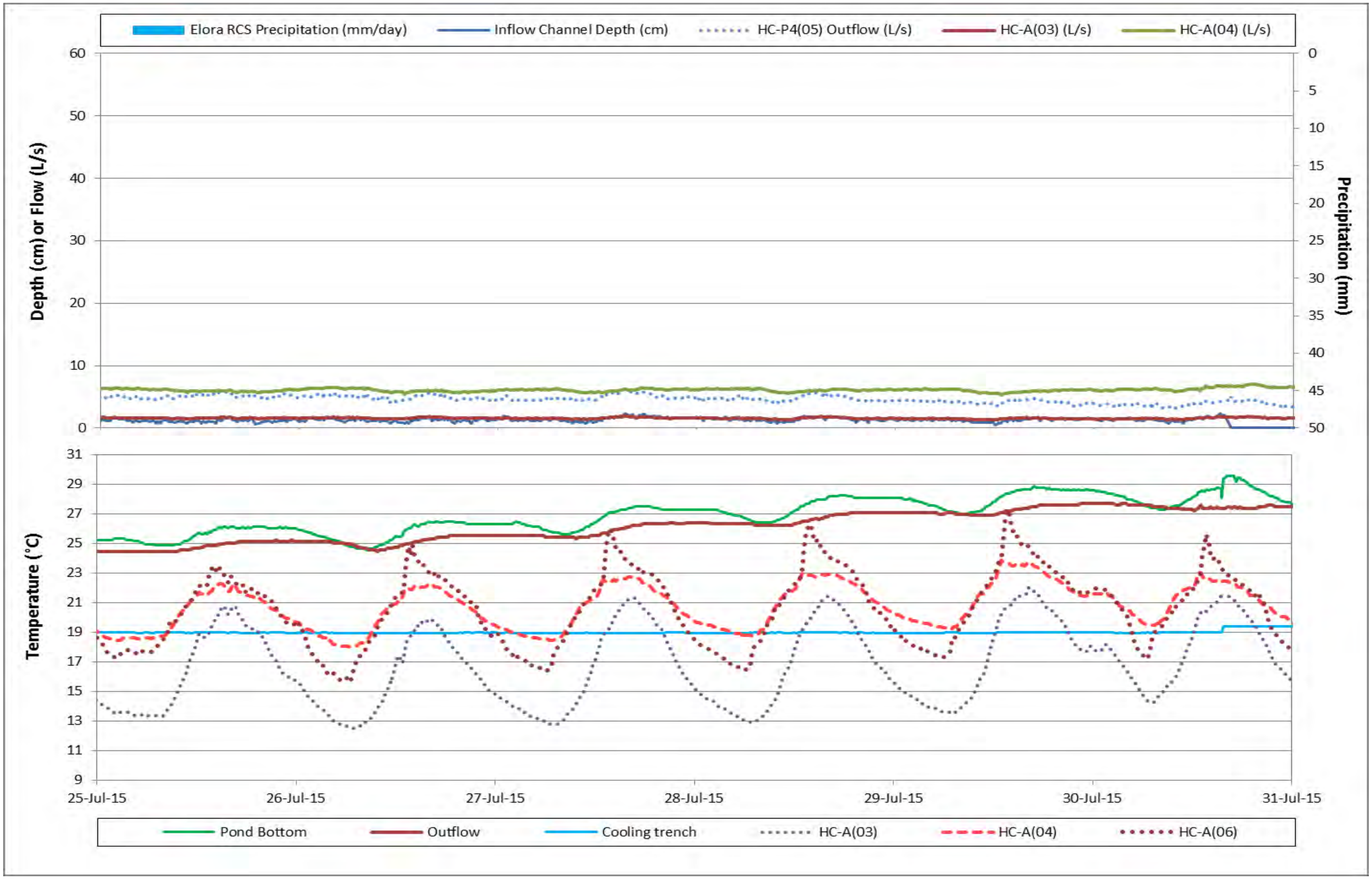


Figure 7. Pond 4: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(03)) upstream and downstream (HC-A(04, 06)) of pond 4 during a dry period.

2.5 Water Quality

2.5.1 Groundwater Quality

The groundwater quality results are given in the 2015 technical memorandum prepared by Banks Groundwater Engineering (Appendix I) and discussed as follows.

Water samples were taken from 36 monitoring wells in April 2015. Each sampling period the wells are purged prior to sampling the equivalent of three casing volumes. The samples are also field-filtered with a 45 micron in-line filter. The groundwater at the HCBP can be characterized as basic (pH>7) and, based on the reported calcium and magnesium concentrations, as hard. Since 2003, the concentrations of the parameters analyzed have generally been below the applicable Ontario Drinking Water Quality Standards (ODWQS) criteria, with the following exceptions during the 2015 monitoring period (refer to Appendix I for specific exceedances):

- Nitrate (as N) concentrations exceeded the ODWQS of 10.0 mg/L on at least one occasion in six monitoring wells
- Aluminum concentrations exceeded the ODWQS of 0.1 mg/L on at least one occasion in 24 monitoring wells
- Cadmium concentrations exceeded the ODWQS of 0.005 mg/L on at least one occasion in 11 monitoring wells
- Iron concentrations exceeded the ODWQS of 0.3 mg/L on at least one occasion in 32 monitoring wells
- Lead concentrations exceeded the ODWQS of 0.010 mg/L on at least one occasion in 22 monitoring wells
- Manganese concentrations exceeded the ODWQS of 0.05 mg/L on at least one occasion in 37 monitoring wells
- Sodium concentrations exceeded the ODWQS of 20 mg/L on at least one occasion in 37 monitoring wells
- Hardness concentrations exceeded the ODWQS of 100 mg/L in all monitoring wells.

Colour, turbidity, total dissolved solids, and DOC exceeded the respective ODWQS concentrations in most of the monitoring wells. This observation is typical for monitoring wells that cannot be developed to a sediment-free condition. Therefore, it cannot be concluded that these four parameters are naturally above the respective ODWQS. Improved filtering of samples at the time of collection since 2009 has resulted in reduced levels of some parameters.

2.5.2 Surface Water Quality

2.5.2.1 In-Stream Water Quality

During each field visit an YSI multi-parameter probe (556R) was used to collect dissolved oxygen, pH, and specific conductivity conditions at each site. These results are shown graphically in Figures 8, 9 and 10, respectively. The majority of the sites were within the ranges of the Provincial Water Quality Objectives (PWQO). In the event that water quality samples were collected and the pH probe was not functioning, then the pH was determined by lab analysis.

During some of the baseflow monitoring events, dissolved oxygen (DO) was found to be below PWQO guidelines. This occurred at station HC-A(04) on four occasions (Jul. 14, Aug. 20, Sept. 1, Sept. 19), at station HC-A(11) once (Aug. 20), at station HC-A(06) once (Sept. 16) and at station HC-A(10) once (Sept. 16). Lower DO levels observed on September 16 could be attributed to below average flow rates, high temperatures and an extended period of no precipitation.

Stations HC-A(03), (04), (06) and (10) all recorded pH levels above the PWQO guidelines on May 7th. Stations HC-A(03) and (04) also recorded pH levels below PWQO standards (Figure 9). Overall the pH levels to have been decreasing since 2012.

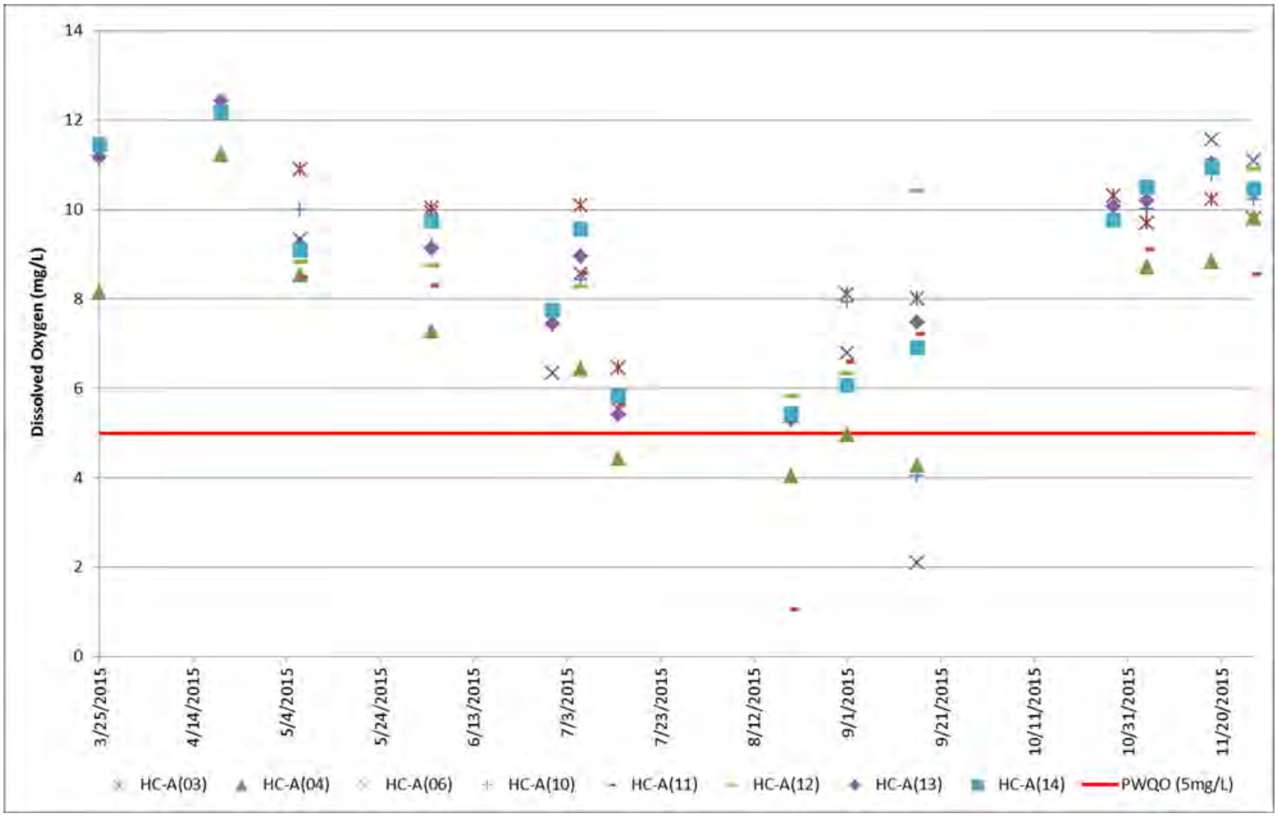


Figure 8. YSI Dissolved Oxygen Readings from 8 Monitoring Stations on Tributary A

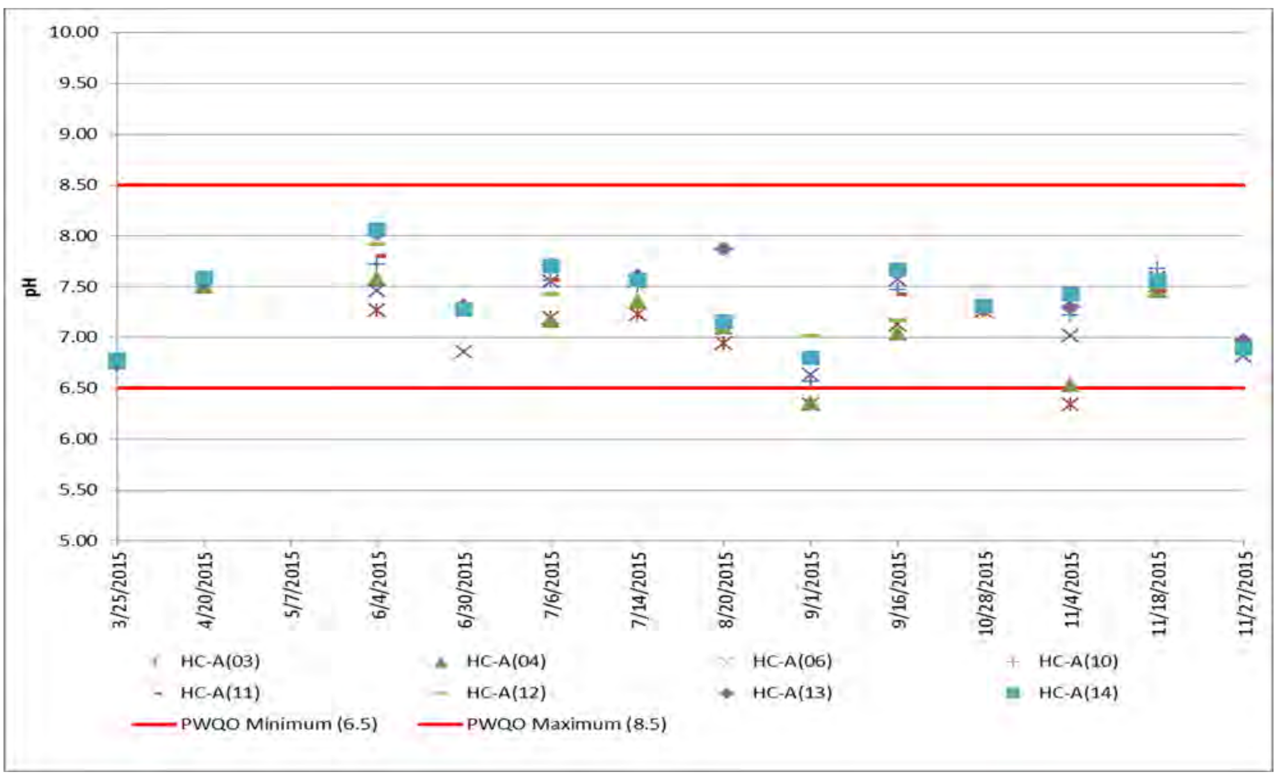


Figure 9. YSI pH Readings from 8 Monitoring Stations on Tributary A

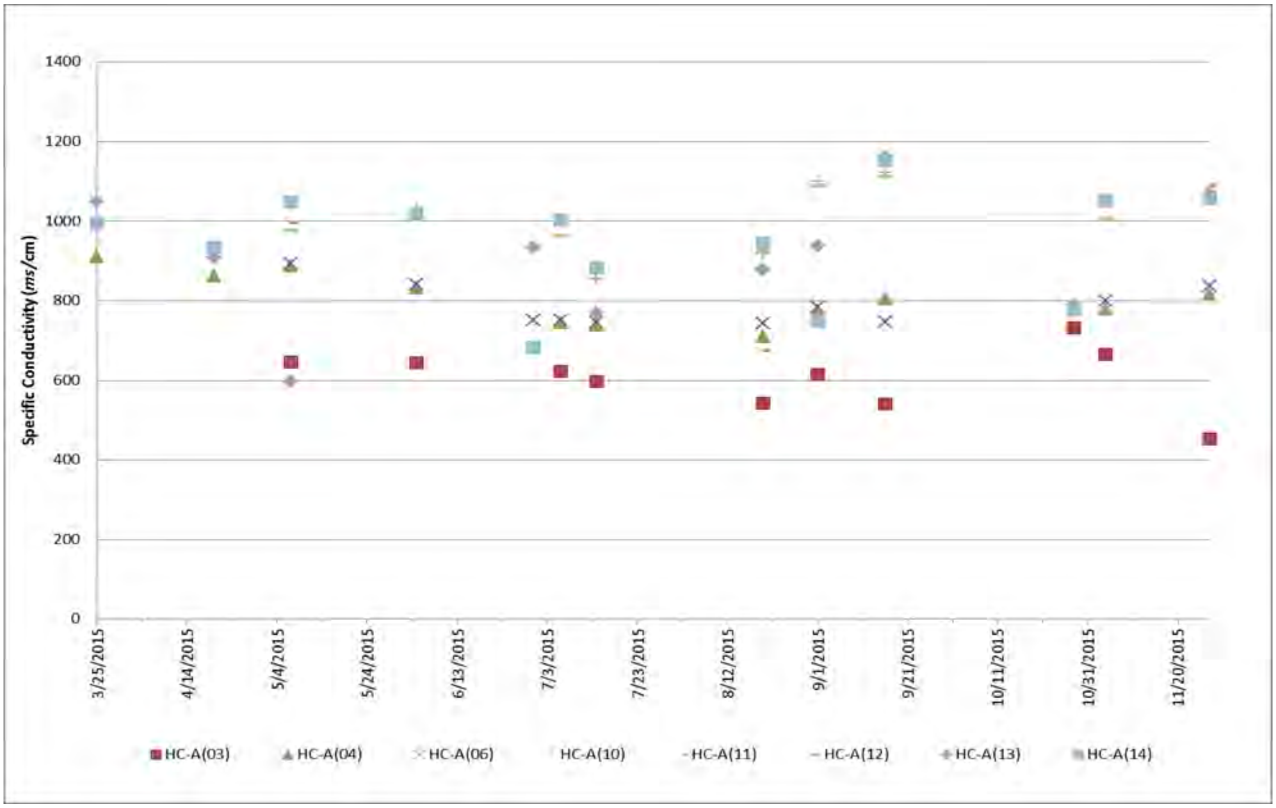


Figure 10. YSI Specific Conductivity Readings from 8 Monitoring Stations on Tributary A

In 2015, four turbidity monitoring stations were installed along Hanlon Creek at stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14). Some issues were encountered with the turbidity data. It appears that loggers at HC-A(03) and HC-A(11) were buried under sediment for extended periods causing the sensor to record maximum turbidity levels. During site visits turbidity sensors were checked and cleaned however sediment buildup in between visits occurred. There is also potential that biofouling and vegetation growth in the stream interfered with the sensor readings. The data shows overall the turbidity levels at the most downstream station are lowest. Turbidity levels at station HC-A(06) appears to increase relative to rainfall events. Due to fouling occurring at stations HC-A(03) and HC-A(11) no conclusions can be made regarding turbidity conditions at these locations.

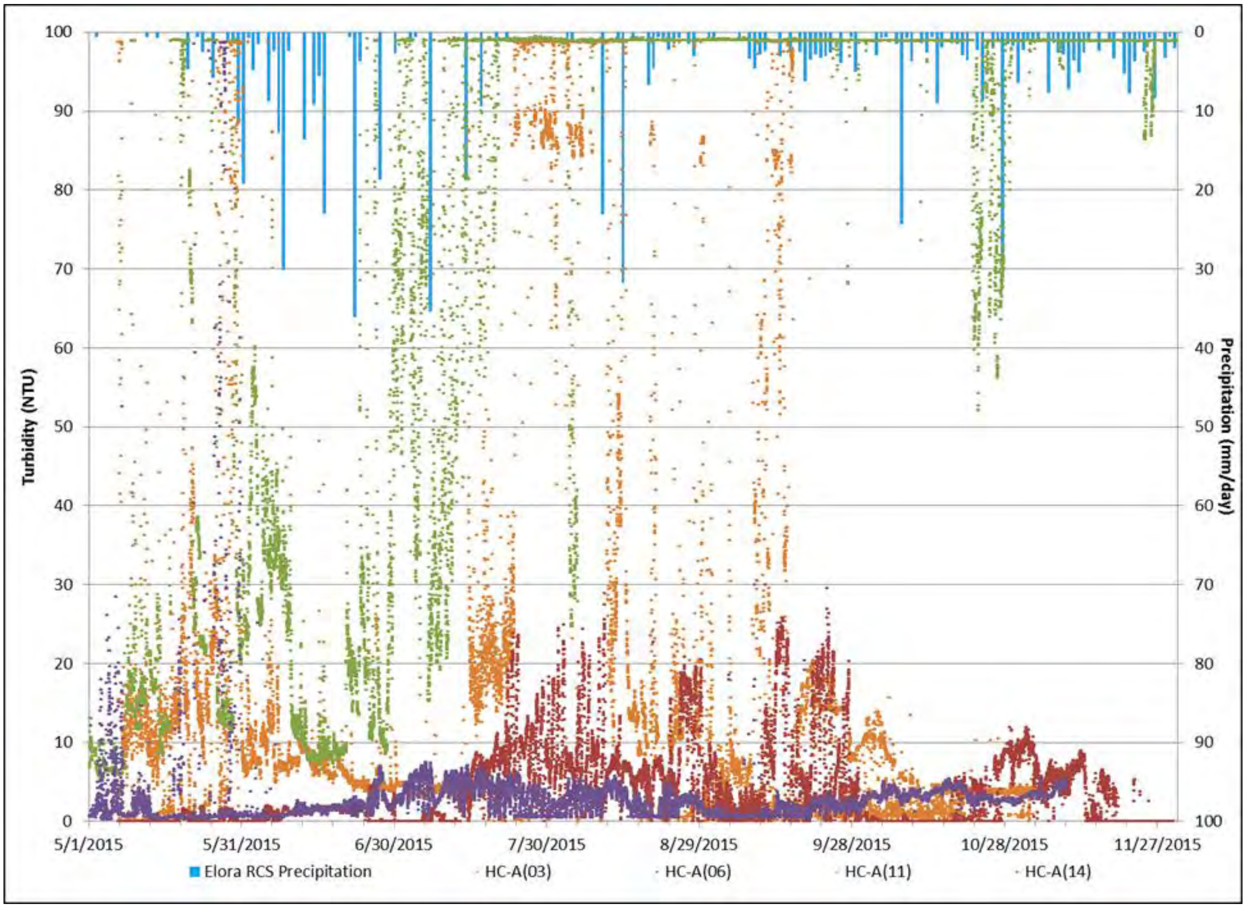


Figure 11. In-stream Turbidity Measurements for 2015

2.5.2.2 Stormwater Management Pond Water Quality

To establish the performance efficiency of the SWM facilities and to satisfy the MOE Certificate of Approval, the water quality sampling program consists of grab samples at the inlet, outlet and downstream of each pond. Parameters that were analyzed in 2015 included:

- CBOD (5)
- Total Suspended Solids
- Total Phosphorus
- Dissolved Phosphorus
- Metals (total and dissolved, lead, zinc and copper)
- Escherichia coli
- Nitrate as N
- Chloride

The Consolidated Monitoring Program included the following water quality sampling requirements:

- One sample per season (Winter and Fall) within one hour commencement of a storm event;
- Five wet weather samples collected during summer months (June-September);
- One sample collected during the snowmelt freshets (Spring);
- Three dry samples taken 72 hours after a wet weather event

Eight wet weather samples were collected over the course of the 2015 monitoring season. Both the winter and spring freshet samples were collected. Five wet weather samples were collected between May and October 2015. The remaining wet weather sample was taken during the month of November. One dry sample was taken during the spring, summer and fall (three total). From May to October, water levels at Pond 1 and 2 were too low prior to a rainfall event to result in stormwater being discharged from the outlet into Hanlon Creek Tributary A. Therefore, samples taken at Pond 1 and 2 were not taken during discharge events. As a result, the only interactions between these SWM facilities and Hanlon Creek Tributary A would have occurred though ground water interactions. Samples collected during non-discharge periods in the summer months were taken directly from the SWM facilities. As such, the water samples did not necessarily represent the water flowing into Hanlon Creek Tributary A. Pond 4 was discharging during the summer months and stormwater samples were collected from the pond outlet. The tabular results of the water quality sampling have been included in Appendix E of the surface water report (Appendix II of this report).

Water quality sampling results are presented as a number of exceedances as compared to the PWQO in Table K of the surface water report (Appendix II). A number of water quality parameters were typically higher in the SWM facilities with lower concentration in Hanlon Creek. E.Coli concentrations exceeded the recommended PWQO guidelines for recreational use for both wet weather and dry weather sampling events. Total phosphorus showed an overall reduction in phosphorus levels as the water moved though the pond. The instream phosphorus levels exceeded the PWQO during both wet and dry weather sampling events. However; this is not uncommon for streams in the Grand River watershed (GRCA, 2012). Nitrate, total suspended solids, copper and lead all showed higher concentrations entering the SWM facilities with concentrations decreasing in the outlet samples. Aluminum, cadmium, copper, iron, lead, vanadium and zinc exceeded PWQO in the SWM facilities. However, instream levels did not exceed PWQO guidelines for aluminum or vanadium. Copper, iron, lead and zinc exceeded PWQO guidelines for both wet weather and dry weather sampling events at various inlet, outlet and instream stations (see Table 7). Zinc concentration in both the SWM facilities and instream exceeded PWQO.

In 2011, the Canadian Council of Ministers of the Environment (CCME) set standards for Chloride exposure indicating increased risk of harm to aquatic life after long term exposure to concentrations above 120 mg/L and short term exposure to concentrations above 640 mg/L (CCME 2011). Chloride concentrations were typically higher at pond outlets and in-stream locations, compared to samples taken at pond inlets. However, inlet chloride levels sharply increased during winter sampling. Short term exposure targets were exceeded at pond inlets HC-P1(04,05), HC-P2 (04,05) and HC-P4(05) during winter sampling events.

Table 7. Number of Guideline Exceedances per Water Quality Sampling Location

Analyte	**Units**	**LOR[1]**	PWQO		CCME		Guelph Storm Sewer By-Law			Number of Exceedances for Wet Weather Sampling Events											Number of Exceedances for Dry Weather Sampling Events			Tota
			Lower Limit	**Upper Limit**	**Short Term**	**Long Term**	**Lower Limit**	**Upper Limit**	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4 (04)	HC-P4 (05)	HC-A (04)	HC-A (13)	HC-A (14)	HC-A(04)	HC-A(13)	HC-A(14)	
Dissolved Oxygen(DO)	mg/L	0.05	5	-	-	-	-	-	2	2	1	2	0	2	1	1	0	0	0	0	1	0	0	12
pH	pH units	0.1	6.5	8.5	-	-	6	9	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	4
Chloride	mg/L	2	-	-	120	640	-	-	4	3	8	1	5	5	1	3	8	8	8	8	3	3	3	71
Total Phosphorus	mg/L	0.003	-	0.02	-	-	-	-	6	7	8	8	6	7	8	7	1	4	6	7	2	2	0	79
E. Coli	CFU/100mL	10	-	100	-	-	-	-	3	4	2	8	4	3	4	6	1	4	5	5	1	1	1	52
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	-	-	7	8	8	8	8	8	8	8	4	8	8	7	3	3	3	99
Arsenic (As) - Total	Mg/L	0.001	-	0.005	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	-	-	0.001	0	1	0	1	2	0	0	1	0	1	0	0	1	0	0	7
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	-	-	0	2	0	1	0	0	0	2	0	0	0	0	0	0	0	5
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	-	-	0.01	8	7	3	8	8	6	7	8	2	4	4	5	2	2	2	76
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	-	-	1	6	1	7	3	2	3	7	0	1	0	1	1	1	0	34
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	-	-	0.05	0	5	1	6	2	1	4	7	0	1	0	0	1	1	0	29
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	-	-	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	3
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	-	-	0.05	0	5	0	4	3	0	0	4	0	8	0	0	3	0	0	27
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	-	-	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	-	-	0	0	0	5	3	4	7	4	0	0	0	0	0	0	0	23
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	-	-	7	7	2	8	8	2	5	7	0	0	0	0	0	0	0	46
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	-	-	0	0	0	0	0	0	0	1	0	6	0	0	3	0	0	10

Notes: 1 Limit of reporting (LOR)
- 8 Wet weather grab samples and 2 dry weather grab samples were collected
- Exceedances based upon the PWQO limits, Chloride exceedances were based upon the CCME short term level.

2.6 Aquatic Habitat and Biota

Aquatic monitoring was conducted for the benthic invertebrate and fish community within Tributary A and Tributary A1 of Hanlon Creek. Monitoring in 2015 was conducted at five different sites, each with a benthic invertebrate sampling station and a quantitative fish sampling station. Aquatic habitat information was collected at each station. Brook Trout spawning surveys were conducted on three separate occasions in fall 2015 along sections of Tributary A and Tributary A1. Locations of the ten sampling stations are shown on Map 5, along with the Brook Trout spawning search area.

To assess the benthic invertebrate community, several indices were calculated to provide a characterization of the community at each station and to allow for comparisons across years. The indices calculated for 2015 include the Percent Model Affinity (PMA) index, which generates Percent Similar Community (PSC) values. Values that are higher than the critical PSC value indicate no impact, while values that are lower than the critical PSC value indicate impact at that station. Other indices were taxonomic richness, Ephemeroptera, Plecoptera and Trichoptera (EPT) richness, and percent dominant taxon.

To assess the fish community, multi-pass electrofishing surveys were conducted. This involved isolating a section of stream using nets and electrofishing that section multiple times until there was a decline in the number of fish captured in subsequent passes with the electrofisher. Following the identification and enumeration of the catches, population estimates were calculated for the five monitoring stations using a maximum likelihood constant P method (Schnute 1983).

Detailed results from the aquatic monitoring program are provided in the 2015 aquatic monitoring report prepared by NRSI (Appendix III) and are summarized and discussed in Sections 2.6.1 and Section 2.6.2 below.

2.6.1 Benthic Community

The benthic invertebrate index results are shown on Figures 12 (taxa richness), 13 (EPT Taxa Richness) and 14 (Proportion of dominant taxon), and in Table 8 (PMA analysis).

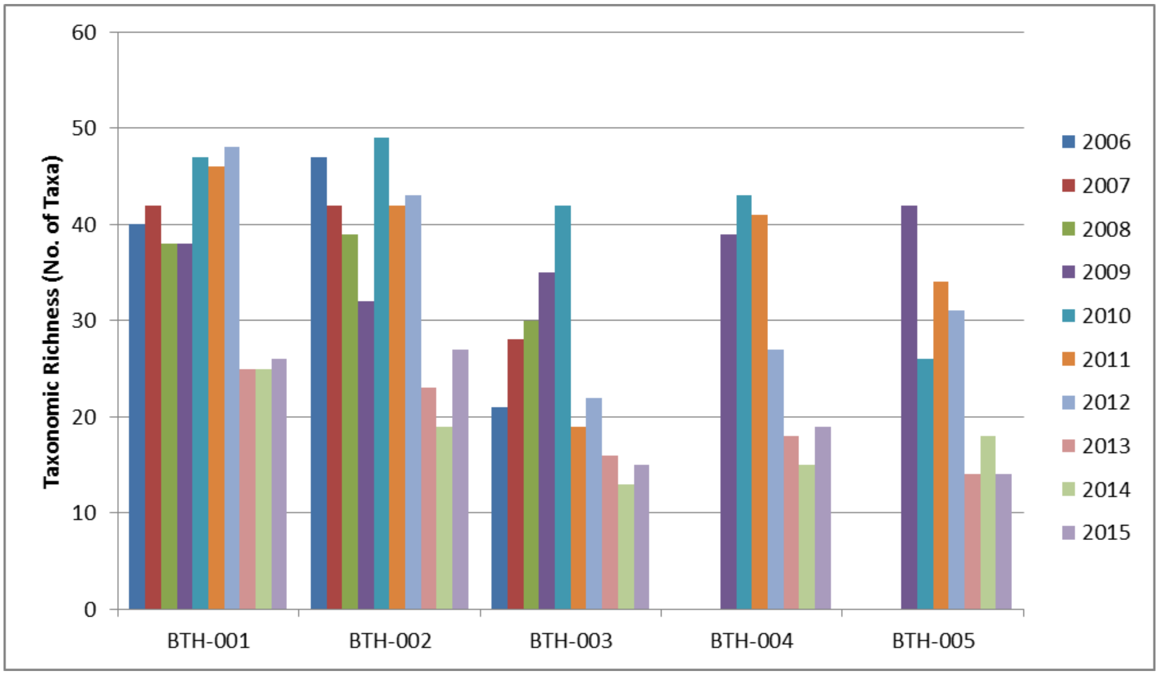


Figure 12. Benthic Invertebrate Taxonomic Richness for the Years 2006 to 2015

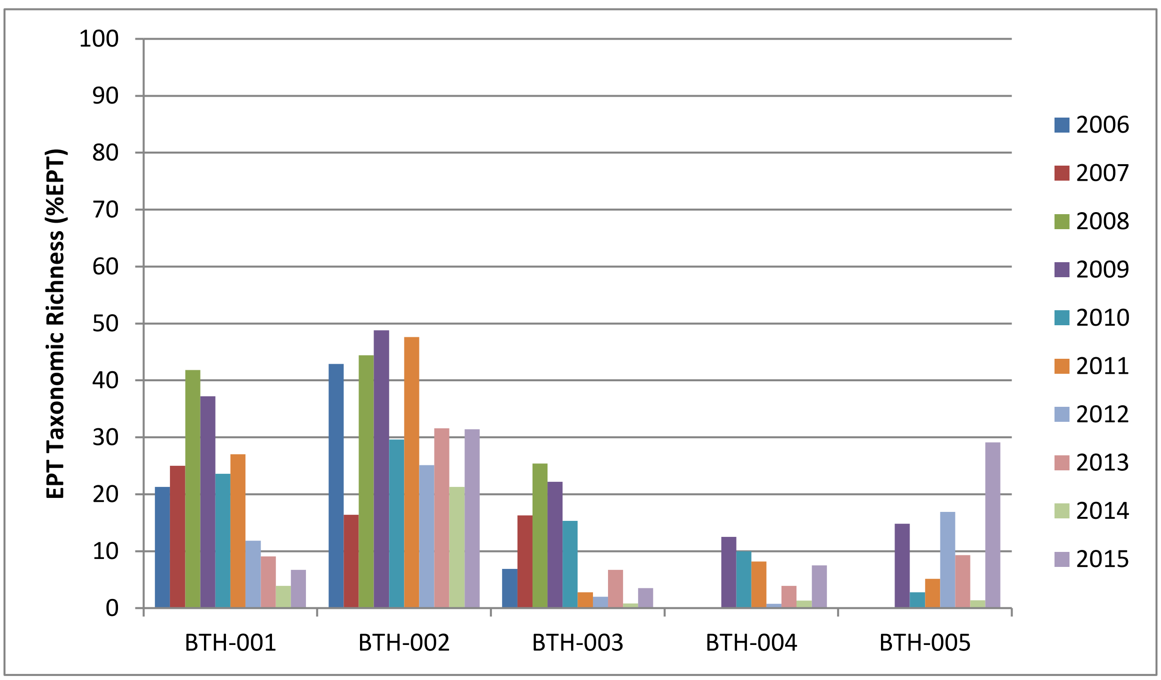


Figure 13. Benthic Invertebrate EPT Taxa Richness for the Years 2006 to 2015

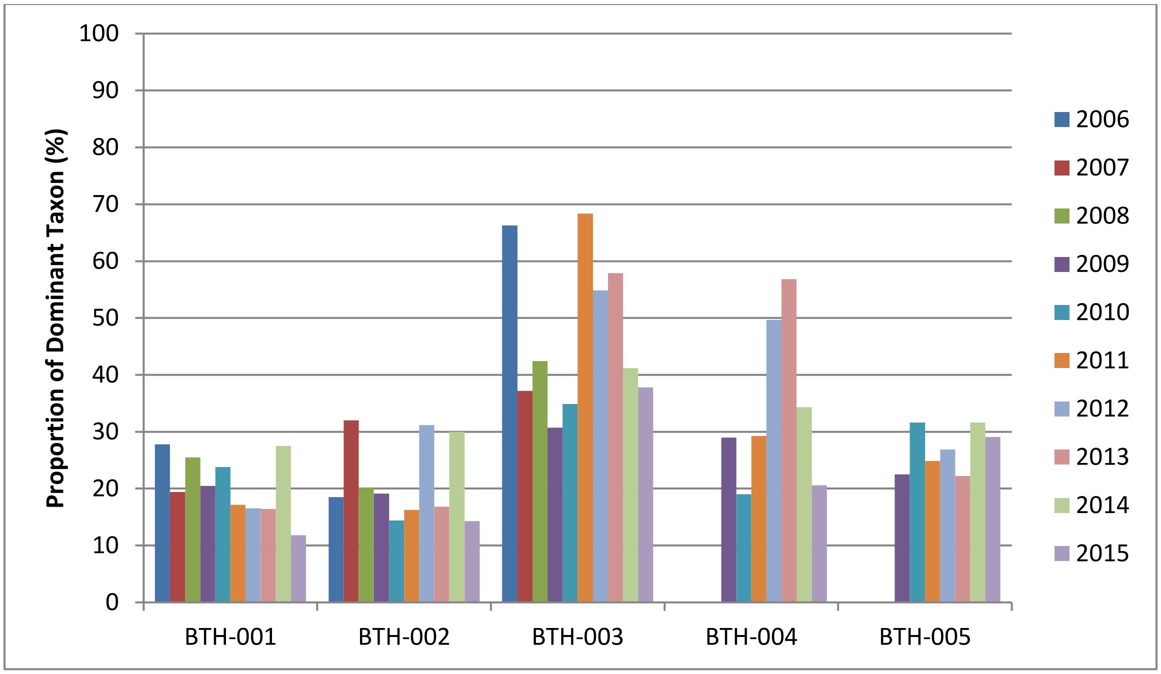


Figure 14. Benthic Invertebrate Proportion of Dominant Taxa for the Years 2006 to 2015

Table 8. Percent Similar Community Values and Impact Determination

Station	Result	2006	2007	2008	2009	2010	2011	2012	2013	2014	Critical PSC	2015 Sample PSC	2015
BTH – 001	Impact										42.12	41.35	X
	No Impact	X	X	X	X	X	X	X	X	X			
BTH – 002	Impact	X		X	X		X	X	X	X	50.7	38.36	X
	No Impact		X			X							
BTH – 003	Impact							X	X		42.12	49.26	
	No Impact	X	X	X	X	X	X			X			X
BTH – 004	Impact	-	-	-				X	X	X	42.12	49.78	
	No Impact	-	-	-	X	X	X						X
BTH – 005	Impact	-	-	-						X	42.12	16.55	X
	No Impact	-	-	-	X	X	X	X	X				

<u>Station BTH-001</u>

Taxonomic richness at station BTH-001 has varied from 25 to 48 over the 10 years of monitoring. Between 2006 and 2012 the taxa richness at this station remained fairly consistent with an increase observed in 2010. The highest taxa richness occurred in 2012 with a high of 48 (Figure 12). In 2013 a decline was noted with numbers dropping from 48 to 25, the lowest that had been observed to date. Taxonomic richness in 2014 remained low with a richness of 25, which was found for a second straight year. In 2013 it was determined that this low taxa richness was largely a function of the level of identification of Chironomids, which changed between 2012 and 2013 from genus to sub-family level. This appears to have continued into 2014 and 2015, resulting in a similarly low richness. The changes experienced between 2012 and 2013 as well as the low taxonomic richness in 2014 and 2015 have been discussed in detail in Section 4.1.3 of Appendix III. No consistent trends have been established at BTH-001 as it relates to taxonomic richness.

The EPT richness at BTH-001 has varied greatly between 2006 and 2015. Pre-construction values ranged from a low of 21.3% in 2006 to a high of 48.1% in 2008, which appeared to be uncharacteristically high for this station (Figure 13). Following 2008 the EPT richness has declined to below 10% with the lowest EPT richness (3.9%) occurring in 2014. The EPT richness increased slightly to 6.7% in 2015 but overall remains lower than what had been observed during pre-construction monitoring. Threshold exceedances occurred at this station for three consecutive years (2012, 2013, and 2014).

The dominant taxon in 2015 belonged to the family Sialidae of the order Megaloptera (Alderfly). Species belonging to this family may be associated with a variety of substrates and current types and are exclusively predatory (Merritt *et al*. 2008). The conditions at station BTH-001 are consistent with this generalized habitat description providing silt, sand and gravel substrates, as well as moderately abundant detritus and woody debris. Sialidae are considered to be indicative of very good water quality with only slight organic pollution (Mandaville 2002). This species represented 11.8% of the total number of individuals within the sample (Figure 14) and dominated the sample for the first time in 2015. Several subdominant species were observed, comprising between 8.0 and 9.0% of the sample. These species represented three distinct families including Amphipods (*Gammarus pseudolimnaeus* - 8.7%), Isopods (*Caecidotea intermedius* - 8.3%), and Coleopterans (*Optioservus fastiditus* - 8.3%). These species have all historically comprised a large proportion of the samples at this station and have dominated the samples during different years from 2010 to 2012. Species of Dipterans (true flies) have also previously comprised large proportions of the samples at BTH-001, and did again in 2015. Species of *Chironominae* (*Chironomus sp.*), a subspecies of

Chironomidae, and Tabanidae (*Chrysops sp.*) both comprised 7.5% of the sample. In total, Dipteran species accounted for 37.8% of the overall sample, the highest of any of the benthic families in 2015. Dipteran species previously dominated the samples in 2006, 2007, 2013, and 2014. Previously observed dominant taxa have also included a species of caddisfly (Trichopteran) of the family Hydropsychidae in 2008 and 2009.

The PMA index showed 'impact' in 2015 as the calculated PSC value of 41.4 was slightly lower than the critical PSC value of 42.12. This is the first year since monitoring began in 2006 that results have shown an 'impact' determination for the PMA index (Table 7). A decrease in EPT species at this site between 2012 and 2014 indicated a potential change in conditions, and continued low EPT richness combined with the PMA impact determination in 2015 suggests that impact is occurring.

<u>Station BTH-002</u>

Taxonomic richness at station BTH-002 was 27 in 2015. Results show an increase following two consecutive years of decreasing taxa richness in 2013 and 2014, during which the lowest-to-date taxa richness of 19 was observed (Figure 12). This metric experienced a steep decline in the taxonomic richness between 2012 and 2013 from 43 to 23. The result in 2013 was likely a function of the level of identification of the benthic invertebrates, which changed from 2012 to 2013 and continued in 2014 and 2015. This change is discussed in detail in Section 4.1.3. When considering the change in the level of identification used, it appears that taxonomic richness has continued to be fairly consistent at BTH-002.

The EPT richness was 31.4% in 2015, an increase from 21.3% in 2014 and similar to what was observed in 2010 and 2013 (Figure 13). This metric has shown no obvious increasing or declining trends. EPT richness has frequently been high (above 40%) with large declines noted in 2007 (16.4%), 2010 (29.6%), and most recently in 2012. Further to this, it has never experienced declining richness values over consecutive years. The lowest levels in EPT richness at BTH-002 were seen during a pre-construction year in 2007 indicating that the observed declines in EPT taxa are within the natural variations of the station.

The dominant taxa at station BTH-002 in 2015 was *Optioservus fastiditus*, a species belonging to the family Elmidae (riffle beetle) from the order Coleoptera. Species belonging to this family occur primarily in well-aerated streams and are indicative of very good water quality. They are considered to be collector-gatherers or scrapers feeding mainly on algae and detritus (Elliott 2008, Mandaville 2002). These characteristics are consistent with the habitat found at this site, which is mainly cobble and gravel riffles. Some finer sediment was observed in addition to the presence of small amounts of woody debris and detritus. This is the first year that this species has dominated the sample at BTH-002 comprising 14.3% of the sample. In 2014 *Gammarus pseudolimnaeus*, a species of Amphipod, was the dominant taxa and represented 30.0% of the total number of individuals in the sample (Figure 14). *G. pseudolimnaeus* had been the dominant taxa at this station since 2012. The result for % dominant taxon has generally been lower at this station over the years of monitoring with 2007, 2012 and 2014 being relatively high (32.0%, 31.2% and 30.0%, respectively). The dominant taxonomic group has changed several times at BTH-002 including *Sialis sp.* (Megaloptera) in 2006, *Micropsectra sp.* (Diptera) in 2007 and 2008, *Cheumatopsyche spp.* (Trichoptera) in 2009, and *Leuctra spp.* (Plecoptera) in 2010 and 2011. In 2013 two species dominated the sample including *G. pseudolimnaeus* and *Diplectrona modesta*, a species of Trichoptera. EPT species were well represented within the sample again in 2015 including *Cheumatopsyche spp.* (Trichoptera) which was the subdominant species. The proportion of *Sialis sp.* was also relatively high within the sample.

The PMA index in 2015 showed ‘impact’ for the fifth consecutive year. Results since pre-construction monitoring began in 2006 have been inconsistent up until 2011 with results showing no reliable trend of ‘impact’ or ‘no impact’. Since 2011 results have consistently indicated ‘impact’, which has been the most common result, with ‘no impact’ observed only two out of ten years of monitoring (2007 and 2010) (Table 7). The prolonged continuation of the ‘impact’ determinations suggests that some change has occurred. Monitoring using the PMA analysis should continue with the intention of determining whether or not a ‘no impact’ determination is observed again, at least on occasion.

The predominance of the ‘impact’ result should not be construed to mean that station BTH-002 is in poorer condition than the other stations. This station is the only station that uses the cobble/gravel model community for PMA index, and it was chosen based on the habitat characteristics of the station. Because of this difference, comparisons among the other four stations using the PMA index are not valid. The monitoring program is intended to provide temporal comparison within stations.

Station BTH-003

Taxonomic richness at station BTH-003 was 15 in 2015. This was a slight increase from 13 in 2014 (Figure 12). Taxa richness has experienced a general decrease that began in 2011, which followed an exceptionally high year in 2010 where the richness was 42. The results in 2014 were the lowest that had been recorded at this site since sampling began. This result is likely a function of the level of identification of certain groups of the benthic invertebrates, which changed between 2012 and 2013 and continued through to 2015. This change is discussed in detail in Section 4.1.3. Over the 5 years of monitoring prior to 2011 species richness had increased steadily by 50%, beginning in 2006 with a measure of 21 and increasing to 42 in 2010. The results observed in 2011 and 2012 appeared to be a return to the degree of taxonomic richness that was observed during pre-construction monitoring. While the results in 2015 remain below pre-construction numbers, it can be explained by the change in the level of identification of some groups between 2013 and 2015. The high richness in 2010 included many taxa in the family Chironomidae. There were numerous individuals in that family in 2015, but they were only identified to the subfamily. This accounts for much of the reduction in taxa richness.

The EPT richness was 3.5% in 2015, an increase from a historic low of 0.8% in 2014 (Figure 13). This value is higher than what was observed in 2011, 2012, and 2014. Results have varied throughout the years with an increasing trend observed during the first three years of monitoring and a decreasing trend between 2008 and 2014. The EPT richness values seen between 2011 and 2014 show levels that are lower than results from pre-construction monitoring, with the exception of 2013 which saw an increase to pre-construction levels. The decrease experienced between 2013 and 2014 resulted in the exceedance of threshold number three in 2014.

The dominant taxon in 2015 was *Gammarus pseudolimnaeus*, which comprised 20.1% of the total sample (Figure 14). This marks the fourth consecutive year that *G.*

pseudolimnaeus has been the dominant species at BTH-003 comprising between 37.8% and 68.4% of the samples. *G. pseudolimnaeus* prefers soft substrates and the shallow areas of both lotic and lentic environments. The preference of this species for depositional areas explains its abundance at station BTH-003 as this station occurs in a slow-flowing, groundwater-fed headwater tributary with abundant detritus and underlying substrates dominated by silt and clay. *G. pseudolimnaeus* are indicative of very good water quality (Mandaville 2002). Prior to 2012, the dominant taxon was *Micropsectra* spp., a Dipteran species that had previously been the dominant taxon throughout all six years of pre-construction monitoring. In 2015 a variety of Chironomid species comprised the majority of the subdominant group including several species belonging to the *Chironominae* and *Prodiamesinae* subfamilies. The proportion of *Sialis sp.* was also relatively high within the sample.

The PMA analysis showed 'no impact' in 2015, which is consistent with the result from 2014. This is a change from 2012 and 2013, both of which showed 'impact' (Table 7). Prior to 2011 the results suggested that habitat and/or water quality conditions at station BTH-003 were generally improving as evidenced by a consistent increase in species diversity (taxonomic richness) and a similarly consistent result of 'no impact'. Results in 2011 and 2012, however, suggested a change in the habitat conditions at this site leading to results that are similar to those observed in 2006. This was demonstrated through a decrease in taxonomic richness and EPT taxa richness, and a large increase in the proportion of the dominant taxon, *Micropsectra* spp in 2011, and *G. pseudolimnaeus* in 2012 and 2013. However, since this change was consistent with pre-construction monitoring results in 2006, it was attributed to natural variation. Results in 2015 show similar levels to 2014 in terms of taxa richness, EPT richness, and dominant taxa; however EPT richness was noted to increase suggesting an improvement in water quality.

<u>Station BTH-004</u>

This was the seventh consecutive year of sampling conducted at this station, which began in 2009. Taxonomic richness at Station BTH-004 was 19 in 2015, a slight increase from 15, which was observed in 2014 and was the lowest taxa richness observed to date (Figure 12). The highest taxa richness to date was 43 in 2010 although results in 2009 and 2011 were similarly high. A decrease in taxa richness at

BTH-004 began in 2010 and continued to 2014. The most noteworthy decrease was in 2012, which was a substantial decrease compared to results from 2009 to 2011. Beginning in 2013 this decline was likely a function of the level of identification of the benthic invertebrates, which changed between 2012 and 2013 and has continued into 2015. After accounting for this factor, it can be concluded that taxonomic richness has been stable with the exception of the year 2012.

The EPT richness was 7.5% in 2015, an increase from 1.3% in 2014 (Figure 13). This result is similar to the high EPT richness values observed between 2009 and 2011 and is a substantial increase from the previous three years of monitoring. The EPT richness values at BTH-004 have been relatively low in relation to the other four monitoring stations with the highest proportion of EPT taxa (12.5%) occurring in 2009.

The dominant taxon at BTH-004 in 2015 was *Gammarus pseudolimnaeus*, consistent with Stations BTH-003 and BTH-005. The preference of this species for shallow, depositional areas that offer soft substrates and detritus is generally consistent with the habitat characteristics of BTH-004, which is comprised exclusively of fine substrates including silt and sand. Woody debris and detritus are also present throughout the site. This species represented 20.6% of the total sample in 2015 (Figure 14) and was the dominant taxa at this site for the fourth consecutive year, although its proportion within the sample has decreased by over 35.0% since 2013. Prior to 2012, the dominant taxa was identified as *Caecidotea intermedius*, a species of aquatic sowbug, which dominated the sample in 2010 and 2011. Both *C. intermedius* and *G. pseudolimnaeus* inhabit shallow waters where detritus is present and are likely to coexist in such habitat. In 2015 *C. intermedius* once again comprised a large proportion of the sample along with *Sialis sp.*, however the subdominant species was *Paratendipes* sp., a genus of Dipteran belonging to the *Chironominae* sub-family.

The PMA analysis showed ‘no impact’ at station BTH-004 in 2015 (Table 7). This signifies a change following three consecutive years of ‘impact’ determinations which resulted in two years of threshold exceedances at this station. Prior to this the PMA analysis had shown ‘no impact’. The ‘no impact’ result is most likely a function of the higher proportion of EPT taxa richness, which was similar to the EPT richness during previous years that showed ‘no impact’ determinations (2009, 2010, and 2011).

Station BTH-005

This was the seventh consecutive year of sampling conducted at this station, which began in 2009. Taxonomic richness at Station BTH-005 was 14, which was the lowest observed at the HCBP in 2015 (Figure 12). This is a slightly lower taxa richness than what was observed in 2014 (taxa richness = 18) but the same as 2013. These results continue to be considerably lower than what was generally observed at this station prior to 2013. A threshold exceedance was observed in 2013 following a decrease from 42, the highest value that has been noted at this site, to 14, the lowest that has been observed. This exceedance was determined most likely to be a function of the level of identification of certain groups of the benthic invertebrates, which was adjusted between 2012 and 2013.

In 2015 the EPT taxonomic richness experienced a substantial increase at BTH-005. The richness increased from 1.4%, the lowest that has been observed at this station, to 29.1%, the highest observed at this station (Figure 13). This was the second highest EPT richness value across all stations at the HCBP in 2015, second only to BTH-002 at 34.1%. The EPT richness values at BTH-005 have fluctuated since 2006 with no obvious trends observed. The highest results have been observed in 2009, 2012 and 2015 while low results were observed in 2010, 2011, and 2014.

The dominant taxon at BTH-005 was *Gammarus pseudolimnaeus* in 2015, consistent with what was observed at BTH-003 and BTH-004. *G. pseudolimnaeus* represented 29.1% of the total sample in 2015 (Figure 14). The habitat preferences of this species are consistent with the habitat characteristics of BTH-005, which is largely comprised of silt and sand along with detritus and some woody debris. This was the dominant species in 2014 at this station as well. Prior to 2014 the dominant taxa had been *Caecidotea* sp., which includes a variety of sowbug species (Asellidae spp.). In 2014 and 2015 this species continued to comprise a large proportion of the sample. In 2015 the subdominant species was a species of Trichoptera (caddisfly) belonging to the family *Hydropsychidae*. Both the dominant and subdominant species observed at BTH-005 in 2015 are indicative of very good water quality (Mandaville 2002).

The PMA analysis indicated ‘impact’ in 2015 for the second year in a row and for the second time since sampling began that this result has been seen (Table 7). Between 2009 and 2013 results had consistently shown ‘no impact’. Overall the results suggest an improvement in the conditions at BTH-005, primarily due the large increase in EPT species at the station. Nevertheless, the two consecutive years of PMA ‘impact’ result has caused a threshold exceedance, which is discussed in Section 5.2.

2.6.2 Fish Community

During 2015 construction-phase aquatic monitoring a total of 481 individual fish were captured representing five different species: Blacknose Dace (*Rhinichthys obtusus*), Brook Stickleback (*Culaea inconstans*), Central Mudminnow (*Umbra limi*), Creek Chub (*Semotilus atromaculatus*), and White Sucker. The total catch in 2015 was higher than but generally similar to the 454 fish that were captured during 2014 sampling. This is the second highest catch to be recorded since sampling began in 2006, with the highest occurring in 2013 with an uncharacteristically high catch of 735 fish. Prior to 2013 and 2014 the total catches ranged from 92 in 2006 to 260 in 2012. All five fish species captured in 2015 are known previously from the monitoring program and have been captured frequently over the years. All species exhibit a cool-water thermal regime (Eakins 2015). Population estimates are provided in Figure 15, and results are discussed below. Similar to previous years, no Brook Trout were captured during 2015 fish community sampling.

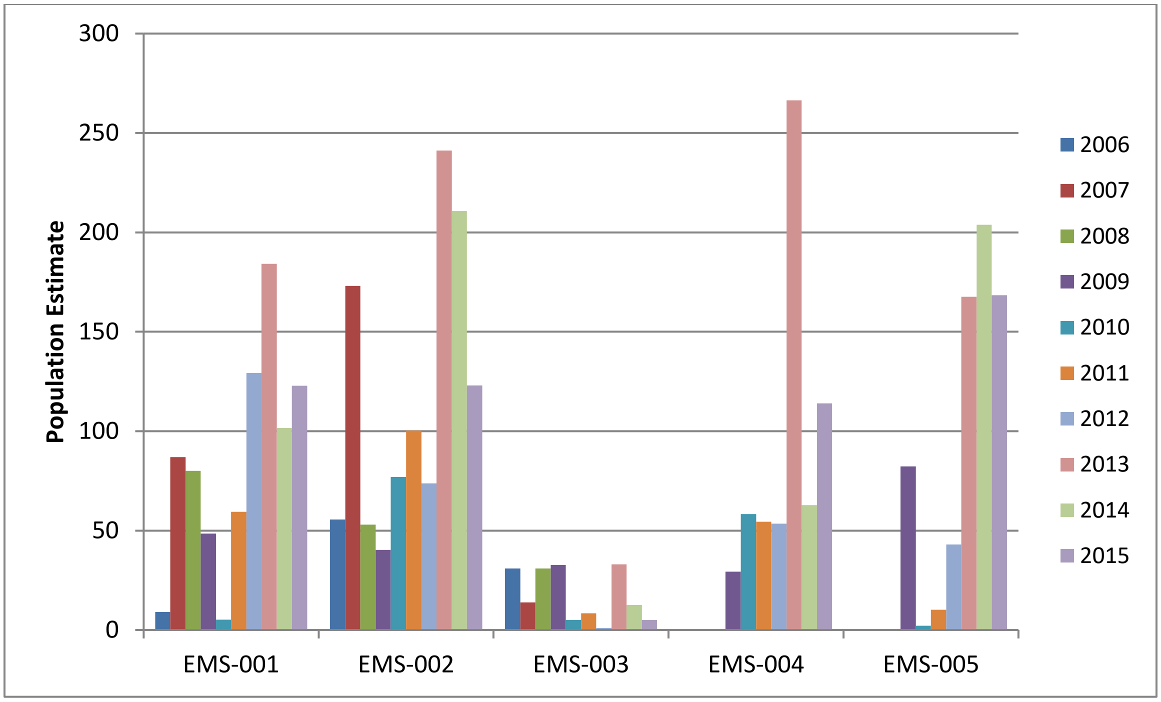


Figure 15. Population Estimates at Electrofishing Stations for the Years 2006 to 2015

<u>Station EMS-001</u>

Electrofishing in 2015 resulted in the capture of two species; Blacknose Dace and Creek Chub. A combined total of 116 individual fish were captured through a total of three passes. Brook Stickleback and Central Mudminnow have typically been captured here every year but were absent in 2015. Fathead Minnow (*Pimephales promelas*), Northern Redbelly Dace (*Chrosomus eos*), and White Sucker have also been previously captured at this station.

Fish population estimates at this station have varied greatly between 2006 and 2015, and have generally been higher during construction-phase monitoring beginning in 2010 than they were during pre-construction monitoring prior to 2010. The population estimate increased slightly from 102 in 2014 to 123 in 2015. This followed 2013 during which the fish population was estimated to be 184, the highest that has been observed to date at BTH-001. This was attributed to increased baseflows following a year of above-average precipitation. The lowest population estimate was observed in 2010, which was estimated at 5. This result was similar to the low population estimate observed in 2006.

Station EMS-002

Electrofishing in 2015 resulted in the capture of three fish species and a combined total of 114 individual fish in a total of three passes. The species captured were Blacknose Dace, Brook Stickleback, and Creek Chub. Blacknose Dace and Brook Stickleback have been captured at this station every year while creek chub have been captured sporadically. Central Mudminnow and White Sucker have also been previously captured throughout the years at this station. Mottled Sculpin, a coldwater species was captured at this site in 2011 and Pumpkinseed (*Lepomis gibbosus*), a warmwater species was captured in 2014. These species have not been captured a second time.

The estimated fish population at EMS-002 has exhibited no obvious trend since sampling began in 2006. The estimated numbers have experienced a great deal of variation with the lowest estimate occurring in 2009 (approximately 40) and the highest estimate of approximately 241 in 2013. In 2015 this estimate decreased but continued to remain above most of the previous years.

Station EMS-003

Electrofishing in 2015 resulted in the capture of two fish species and a combined total of 5 fish over four passes. The species captured were Blacknose Dace and Brook Stickleback. Electrofishing results at this station indicate a low diversity of species relative to the other stations as only the two species captured in 2015 have been consistently captured here since 2007. Three species were captured in 2006, which also included Creek Chub.

Population estimates at EMS-003 have been consistently low relative to the other stations within the HCBP study area. The estimate calculated in 2015 shows a decrease from 2014 and is similar to some of the lower population estimates that were observed at this station between 2010 and 2012. Overall, the pre-construction population estimates have been generally higher than during-construction, with the exception of 2013.

Station EMS-004

Electrofishing took place at this site for the first time in 2009 and it has been sampled every year since. Electrofishing in 2015 resulted in the capture of four fish species and a combined total of 92 individual fish in three passes. The species captured included

Backnose Dace, Brook Stickleback, Central Mudminnow, and Creek Chub. These four species have been consistently captured over the previous years of monitoring. White Sucker has also been previously captured at this station in 2013.

Fish population estimates remained relatively consistent at EMS-004 between 2009 and 2012 ranging from approximately 29 to 58. In 2013 the population estimate increased substantially to 266, the highest estimate recorded at any of the five stations since sampling began in 2006. In 2014 the numbers decreased to more typical levels before increasing again to 114 in 2015.

Station EMS-005

Electrofishing took place at this site for the first time in 2009 and has been sampled every year since. Electrofishing in 2015 resulted in the capture of three fish species and a combined total of 154 individual fish over three passes. The species captured included Blacknose Dace, Brook Stickleback, Central Mudminnow, Creek Chub, and White Sucker. Prior to 2013, this station typically contained between two and three species. In 2013, seven species were captured including Fathead Minnow and Northern Redbelly Dace. Blacknose Dace has been captured during every year of sampling at this station. Brook Stickleback, Central Mudminnow and Creek Chub have also been captured regularly throughout previous years of monitoring.

The population estimate at station EMS-005 in 2015 was 168, a slight decrease from 2014 when the estimate was 204. This marks a decline following four consecutive years of increasing estimates that started in 2010 with a low of roughly 2. The population estimate at EMS-005 in 2015 was the highest observed across any of the five monitoring stations within the HCBP.

Brook Trout Spawning Survey

During the fall of 2015 Brook Trout spawning surveys were conducted along a section of Tributary A and along Tributary A1 (refer to Map 5) to document Brook Trout spawning activity. Throughout the surveyed reaches the habitat was variable from silt and muck to cobble and gravel. The majority of the site, and particularly along Tributary A1 and at the downstream extent of Tributary A was deemed to be unsuitable for Brook Trout spawning due to the presence of silt and muck. The most suitable areas for Brook Trout spawning were observed upstream and downstream of the Hanlon Creek Boulevard crossing. At this location, substrates were predominantly gravel and small cobble and the presence of groundwater infiltration was noted. Three spawning surveys were conducted throughout October and early November and no Brook Trout, or evidence of spawning activity was observed, which is consistent with previous years.

2.7 Terrestrial Habitat and Biota

Since 2006, the terrestrial and wetland monitoring program has focused on plot-based surveys to document breeding amphibians, breeding birds and vascular flora (herbaceous, shrubs and trees) as well as incidental wildlife throughout the property. Soils information was collected from each of the monitoring plots between 2006 and 2014.

For plot set-up and annual monitoring survey methods, the reader is referred to the HCBP Terrestrial and Wetland Monitoring Report (Appendix IV). In addition, the Standard Operating Procedures for the vegetation, breeding birds and amphibians are found in the *HCBP Consolidated Monitoring Program* (NRSI 2010). The monitoring stations are shown on Map 6 of this report.

Detailed results for the terrestrial habitat and biota are given in the 2015 terrestrial and wetland monitoring report prepared by NRSI (Appendix IV). The results are summarized and discussed below.

2.7.1 Vascular Flora

In 2015, a total of 140 vascular flora species were documented during the plot-based monitoring. Overall, 258 different species have been observed in the vegetation monitoring plots. In 2015, vegetation surveys documented 12 species not previously recorded (Table 9).

Table 9. Vegetation Species Not Previously Recorded at the HCBP

Common Name	Scientific Name	Plot Occurrence
Spikenard	*Aralia racemosa ssp. racemosa*	2
Long-stalked Sedge	*Carex pedunculata*	2
Radiate Sedge	*Carex radiate*	4
Hay-scented Fern	*Dennstaedtia punctilobula*	4
Balsam Poplar	*Populus balsamifera*	5

Meadow Fescue	*Festuca pratensis*	6
Dudley's Rush	*Juncus dudleyi*	6
Bristle-leaved Sedge	*Carex eburnean*	7
Evergreen Wood Fern	*Dryopteris intermedia*	7
Basswood	*Tilia Americana*	7
Ninebark	*Physocarpus opulifolius*	8
Philadelphia Fleabane	*Erigeron philadelphicus*	18

A total of 13 regionally significant species have been observed in the plots between 2006 and 2015. In 2015, Meadow Horsetail (*Equisetum pratense*) and Rough-leaved Goldenrod (*Solidago patula*), Clearweed (*Pilea pumila*), American Mountain-ash (*Sorbus americana*) and Hay-scented Fern were observed and are considered rare within Wellington County. None of the species observed are federally or provincially significant.

Refer to Map 6 for locations of vegetation monitoring stations, and the 2015 terrestrial and wetland monitoring report (Appendix IV) for a comprehensive list of the vegetation species observed from 2006 to 2015.

2.7.1.1 Floristic Indices

A common method for evaluating and assessing natural areas is using floristic composition. This method is based on the character of a region's flora. There are several floristic indices which can be used to describe the character of the vegetation in the plot. These include the Coefficient of Wetness (CW), the Coefficient of Conservatism (CC), and the Natural Area Index (NAI). All species (herbs, shrubs, and trees) from each plot are considered in these equations.

Coefficient of Wetness

The CW is based on wetland values given to each individual plant species. Values range from -5 to +5, where -5 indicates an obligate wetland species, and +5 indicates an obligate upland species. "0" is assigned to facultative species, those that are just as likely to be found in wetland or upland habitats. The CW values used are based on Oldham et al. (1995). Figure 16 shows the average wetness per plot, based on the wetness coefficients of all species found within a plot. All except two of the monitoring plots are located within wetland areas.

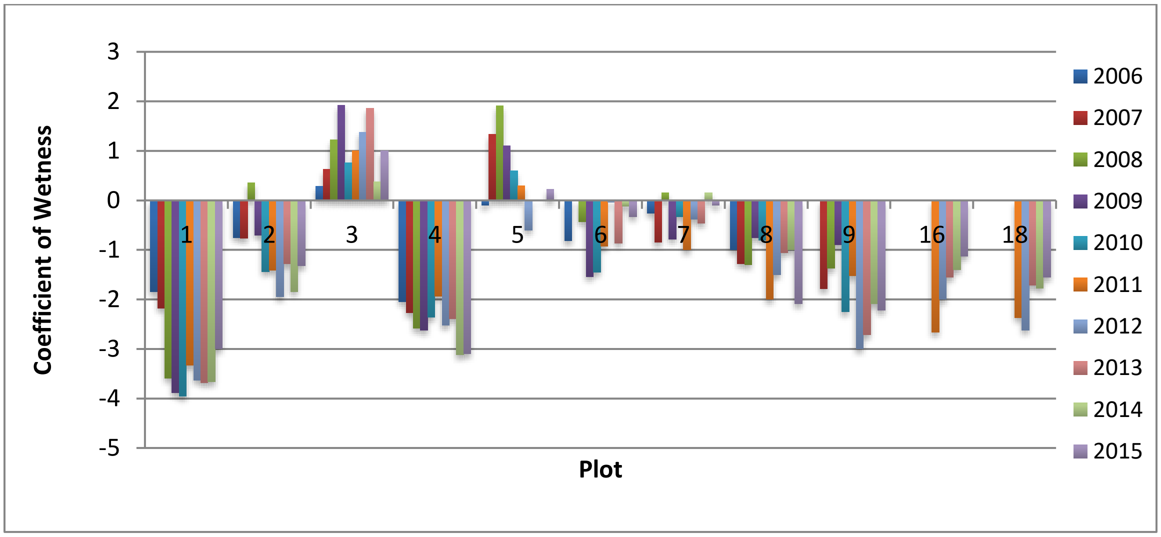


Figure 16. Coefficient of Wetness by Plot 2006 - 2015

Plot 1 has previously been documented as the wettest site during most years of monitoring. In 2015 Plot 4 was slightly wetter than Plot 1 with a CW score of -3.10, compared to -3.00 at Plot 1. Shallow, pooled water is regularly present throughout much of Plot 1 at the time of the vegetation survey and Plot 4 is comprised of saturated organic soils. Plot 3 (Sugar Maple forest) continued to exhibit the driest average CW value (1.00). Plot 5, which was the second plot with a positive CW value in 2015 (0.22) is situated within a Fresh-Moist Forest community which nears wetland conditions. Plot 3 and Plot 5 are the only two vegetation monitoring plots to occur within upland ELC communities. In 2014, Plot 7 had exhibited a positive CW value (0.16) which is not indicative of White Cedar-Hardwood Swamp conditions. It is noted that the plot contains hummocks with upland plant species as well as a portion of watercourse. In 2015 this plot had a slightly wetter CW value (-0.10). This plot showed the wettest CW value in

2011 at -1.00 and has generally been between 0.00 and -1.00 during most monitoring years, with the exception of 2009 and 2014. Plot 8, which is situated almost entirely within Tributary A (to the north of Hanlon Creek Boulevard) had an average CW value of -2.09 in 2015 which is the wettest value recorded in this plot to date. The remaining plots are located within swamp or marsh habitat.

At Plot 16 and Plot 18, CW values have shown a drying trend between 2011 and 2015, with the most pronounced decrease in CW values occurring between 2011 and 2013. These plots are located in close proximity to recent development (Block 9 and Block 10) and the Hanlon Creek Boulevard (Maps 2 and 6 in Appendix IV). Both of these plots were added in 2011 to monitor any changes within the wetland community due to the potential dewatering required as part of the City of Guelph SW Quadrant Class EA.

Plot 16 has consistently contained limited herbaceous vegetation, and is located in a wetland that is physically separate from the core PSW but considered part of the Hanlon Swamp Wetland Complex. Groundwater levels at Plot 16 do not correspond to the drying trend in CW values. Contour mapping shows that its elevation ranges from 324m to 325m above mean sea level (amsl). Monitoring well MW103 is located adjacent to this wetland where ground elevation is approximately 324m amsl. The continuous data logger has recorded groundwater elevations ranging from a low of just over 322.0m amsl in 2012 to 323.5m amsl in the spring of 2013 (Appendix I). This demonstrates that the ground water is near the surface, yet the continuous data logger at MW103 has not measured levels at or above the ground surface since its installation in the summer of 2010. In 2015, the level at MW103 remained similar to or slightly lower than in 2013 and 2014 reaching a high of only 323.1m in April, compared to a high of just over 323.4m in 2014. Since 2012, groundwater levels at MW103 appear to be similar to or higher than levels from 2010 to 2012. Thus, groundwater levels in the vicinity of Plot 16 do not show a trend that matches the trend in CW values.

Plot 18 has contained a diversity of species with good coverage of the 10x10m plot. It too is located in a small wetland that is physically separate from the core PSW but considered part of the Hanlon Swamp Wetland Complex. Similar to Plot 16, groundwater levels at Plot 18 do not correspond to the drying trend in CW values. Contour mapping shows that its elevation is +/- 324m amsl. Monitoring Well MW118A is located approximately 80m south of this wetland and occurs where the ground elevation is also at an elevation of approximately 324m amsl. The continuous data logger has recorded groundwater elevations ranging from a low of just over 322.5m amsl in August 2011 to a high of just over 323.9m amsl in February 2009. In 2015, there was a low elevation of just over 322.9 in July and a high of just over 323.5m amsl in June. These conditions are similar to what was observed in 2014, although the maximum elevation was slightly lower than, and the minimum slightly higher than, what was noted in 2014. Since installation of the monitor in the summer of 2008, the groundwater at MW118A seemed to be highest in 2009, lowest in the summers of 2011 and 2012, and moderate in 2013 and 2014. This demonstrates that the ground water at MW118A can be near the surface, but often ranges from 0.5 to 1.0m below surface, and even lower at times. The low groundwater levels in the summers of 2011 and 2012 may be associated with the drying trend in CW values at Plot 18; however, the results between 2013 and 2015 do not demonstrate dry conditions that would easily explain the continued drying trend.

Plot 9 (cattail marsh) had shown decreasing CW values, indicating a trend of becoming wetter; however values between 2013 and 2015 have demonstrated a return to values observed prior to 2012 when the average CW was -3.00. This plot is located in a reed-canary grass marsh and was originally added to the monitoring program to track changes as a result of the Mast-Snyder Gravel Pit to the west of the subject property. The Mast-Snyder Gravel Pit project has not been initiated; therefore, trends being observed within Plot 9 are likely attributed to natural fluctuation in precipitation from year to year. Additionally, the observation of certain species in one monitoring year (but not the next) can influence these values, such as Dark Green Bulrush (*Scirpus atrovirens*), that was observed in 2012 but has not been recorded since. With a CW of -5, species such as this would impact the overall CW value for the plot; conversely, the observation of a species with a high CW value among low CW species would influence the overall average. Plots which contain a low diversity of species are more susceptible to data fluctuations as the addition or removal of a single species can significantly impact calculations. As the average CW does not account for abundance and only provides an analysis of the overall species list, outlier species can inflate average CW values for low diversity plots.

Overall, 8 of 11 vegetation monitoring plots exhibited a drier CW value in 2015 over 2014 value. In many cases these plots have shown a slight drying trend over the past several monitoring years.

Coefficient of Conservatism

Species conservatism is the degree of faithfulness a plant displays to a set of environmental conditions. The quality of a natural area is reflected in the number of conservative species found within a certain habitat (Wilhem and Ladd 1988 *In* Oldham et al. 1995). For the CC, each species is given a rank between 0 and 10, based on its degree of fidelity to a range of synecological parameters (Oldham et al. 1995). Synecology is the study of the structure, development, and distribution of ecological communities. Species ranked between 0 and 3 are found in a variety of plant communities, including disturbed sites. Species ranked between 4 and 6 are those associated with a specific plant community, but which can tolerate moderate disturbance. Species ranked from 7 to 8 are found in plant communities in an advanced stage of succession with minor disturbance. Plants with a ranking of 9 or 10 have high degrees of fidelity to a narrow range of synecological factors.

The average CC per plot is shown on Figure 17. The highest CC value in 2015 was found in Plot 7 (4.93), which is located at the transition between Fresh-Moist Sugar Maple Deciduous Forest and White Cedar-Hardwood Mineral Mixed Swamp habitats. Plot 3, Plot 4 and Plot 7 all exhibited average CC values between 4 and 5 in 2015 and are consistently among the highest values from year to year. Plot 4 contains high CC value species including Rough-leaved Goldenrod (CC 8) and Black Ash (*Fraxinus nigra*), Cinnamon Fern (*Osmunda cinnamomea*), Crested Wood Fern (*Dryopteris cristata*) and Water Sedge (*Carex aquatilis*) (CC 7). Similarly, Plot 7 contains several of these species as well as Mountain Ash (*Sorbus americana*) (CC 8) and Bluebead Lily (*Clintonia borealis*), Dwarf Scouring-rush (*Equisetum scipoides*), Eastern Hemlock (*Tsuga canadensis*) and Oak Fern (*Gymnocarpium dryopteris*) (CC 7). The lowest average CC values have been found within Plot 6 between 2010 and 2015. The average CC value for the Reed Canary Grass meadow marsh (MAMM1-3) in 2015 was 2.54 followed by Plot 9 (2.73), a Cattail shallow marsh (MASM2-1) which is also dominated by low CC plant species. Neither of these plots contain trees and are likely to have been cleared and farmed historically given the abundance of early successional and non-native species as well as their proximity to existing (or previously existing) farm fields. These plots are dominated by species which have a low CC value or no CC value for those species considered non-native to Ontario.

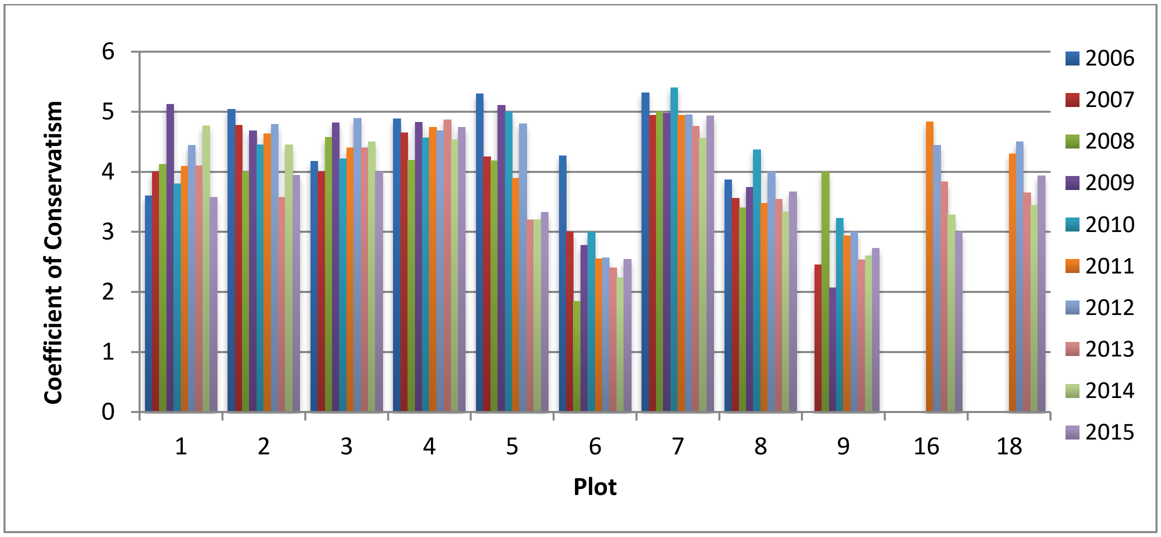


Figure 17. Coefficient of Conservatism by Plot 2006- 2015

In most plots, the average CC value fluctuates from one year to the next but the overall trend between 2006 and 2015 is that values have remained steady. As applicable to other parameters such as average CW, the low species diversity in Plot 5 is prone to producing fluctuations in average CC as some species are noted within the plot some monitoring years but not others. Plot 16 has demonstrated a trend of decreasing average CC and this is largely attributed to the seasonal standing water levels within the swamp feature and the influence this has on vegetation diversity.

The decrease in average CC value within Plot 16 is attributed to the disappearance of species observed in 2011 which have high CC values including Common Skullcap (*Scutellaria galericulata*), Tufted Loosestrife (*Lysimachia thyrsiflora*) and Meadow Horsetail (CC values of 6, 7 and 8 respectively). A decrease in soil moisture within the plot has likely altered the site suitability for these species which have not been observed since 2011. The very low amount of springtime precipitation in 2012 may be partially responsible for the disappearance of species with high site fidelity. There is potential that species which have disappeared from a plot may re-appear in later years through the germination of the seedbank or recolonization from areas adjacent to the plot where the plants may persist.

<u>Natural Area Index</u>

The NAI, or floristic quality index, allows the objective comparison of two or more natural areas or vegetation types (Oldham et al. 1995). The NAI is calculated by multiplying the average CC value by the square root of the total number of native species. Whereas the abundance and frequency of species can fluctuate greatly by season and year, the NAI is more stable and offers a more accurate picture. The NAI for each plot is shown on Figure 18.

The Ministry of Natural Resources and Forestry (MNRF) reports that natural areas with NAI values of over 35 are considered significant at the provincial level (Wilhelm and Ladd 1988 in MNR 1994). For comparison, an old successional field may score as low as <5 (Andreas et al. 2002). None of the plots within the HCBP score a value of 35 or higher. In 2015, 5 of the 11 vegetation monitoring plots were equal to or showed slight increases in NAI over 2013 values; however overall values are still generally lower than in previous years at most stations. Figure 18 shows that NAI values peaked in the during construction monitoring years 2010 and 2011.

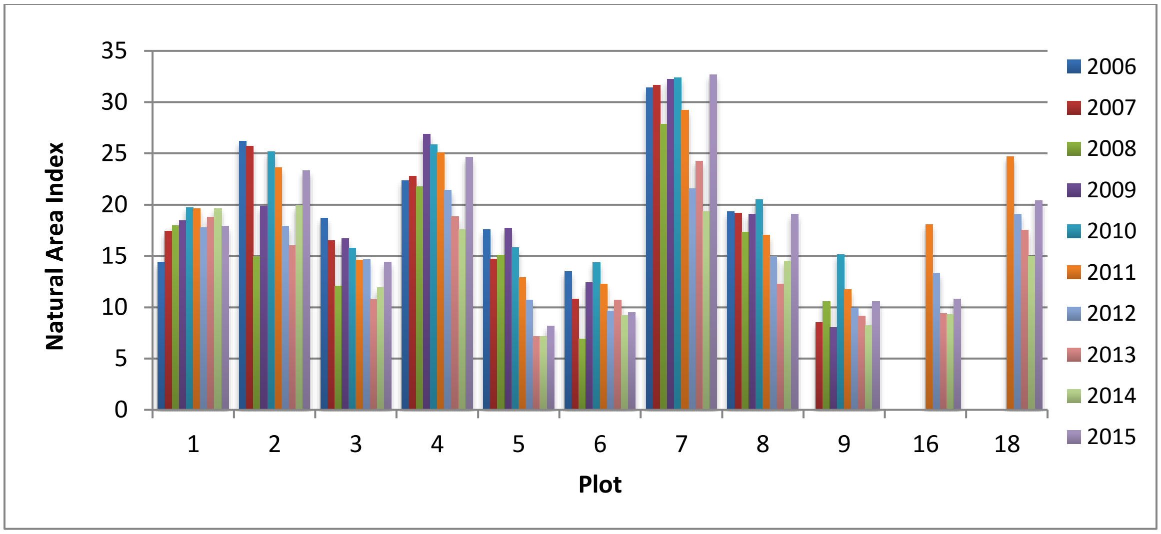


Figure 18. Natural Area Index by Plot 2006 – 2015

None of the plots within the HCBP score a value of 35 or higher. In 2015, none of the vegetation monitoring plots showed a notable decrease in NAI values between 2014 and 2015 with Plot 1 being the only plot to decrease in values. Plots 2, 3, 4, 7 and 8 have all shown a notable increase in NAI values over the past several years, with Plot 7 at an all-time high of 32.70 (up from 19.36 in 2014) which nears the value of 35 which would be considered significant by the MNRF. The complex micro-topography within Plot 7 which includes wetland, upland hummocks and a watercourse provides a diversity of habitat within the 10x10m plot and in turn a high number of plant species, many with higher CC values.

The lowest NAI values in 2015 were observed in Plot 5 (8.16), Plot 6 (9.50), Plot 9 (10.57) and Plot 16 (10.82). Each of these values can be attributed to different factors. The very low species diversity in Plot 5 had produced higher NAI values between 2006 and 2009 before a drop to present values. Within a low diversity plot such as this, the influence of a single species has a notable bearing on NAI values.

Plot 6 exists within an old field meadow which contains a number of non-native species and early successional species. The absence of high CC species in the plot maintains a low NAI value. This plot is unlikely to undergo notable changes in NAI for a number of years until woody species cover establishes which will subsequently lead to significant changes in the composition of the community and the herbaceous species present.

Plot 9 is dominated by Reed Canary Grass (CC 0), with abundant Broad-leaved Cattail (*Typha latifolia*) (CC3). Both species are highly aggressive and limit the ability of other herbaceous species to establish thus a consistently low NAI value is documented in this plot. Similar to Plot 6, until woody species establish canopy and change the structure of the vegetation community within the plot (to a swamp thicket or treed swamp), the plot will continue to show low species diversity and a low NAI value.

As noted in previous reports, the effects of the extremely dry spring in 2012 are likely to have lingering effects on the diversity of plants throughout the site. Further monitoring will determine to what degree the plot vegetation rebounds.

2.7.1.2 Non-Native Species

A total of 17 non-native species were recorded within the vegetation plots in 2015. The number of non-native species found in each plot is compared on Figure 19. In general, non-native species have been present in all plots over the course of monitoring with the exception of Plot 5, a low diversity plot within which Helleborine (*Epipactis helleborine*) is present in very low numbers in some years but not others. The greatest number of non-native species was recorded in Plot 8, with 9 species documented. In 2010, 15 non-native species were documented within this plot, a number which has declined every year since. In general, the same aggressive non-native species have been observed between 2006 and 2015. Situated within a successional reed canary grass meadow marsh, Plot 6 has consistently contained a high number of non-native species due to historic disturbance (human disturbance from ATV's/machinery during pre-construction monitoring year) and close proximity to the previous agricultural land use. Non-native species such as Quack Grass (*Elymus repens*), Coltsfoot (*Tussilago farafara*) and Bird's-foot Trefoil (*Lotus corniculatus*) are clonal, somewhat aggressive and will likely continue to exclude higher quality plant species from establishing until tree canopy develops and the area is in an advanced state of succession.

The non-native species observed in 2015 do not represent any significant introductions or reductions of aggressive non-native species. Plot 2 has shown an increase in non-native species while Plot 9 has shown a decrease. In general, those species with weediness values of 2 or 3 tend to be present year after year, while less invasive species with a value of 1 are present intermittently and often in low numbers.

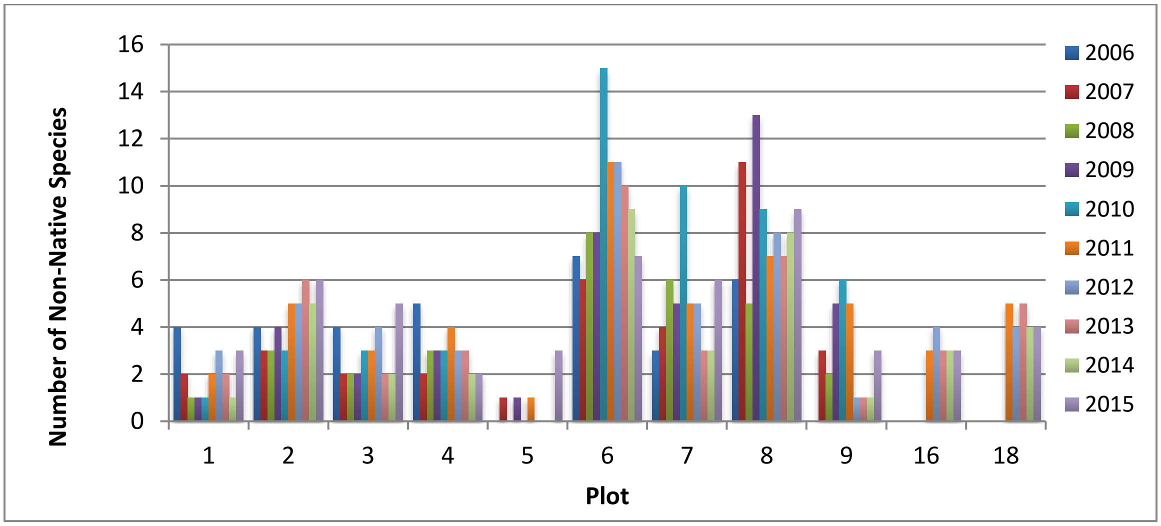


Figure 19. Non-Native Species by Plot 2006 - 2015

Between 2006 and 2014, 28 other non-native species were recorded that were not observed during the 2015 surveys. This fluctuation suggests that some non-native species may only establish for a single season before ecosystem resilience, site conditions (including drought or flooding), or a combination of both suppress the species from establishing within the plots permanently.

Certain non-native species are considered particularly invasive, and are given a score of '-3' on a weediness scale ranging from '-1' to '-3'. The invasive species found within the HCBP vegetation monitoring plots include 4 shrub species (3 species with a weediness value of -3) and 12 herbaceous species (all species with a weediness value of -2 or -1).

Garlic Mustard (*Alliaria petiolata*) was only recorded in Plot 18 during the 2011 monitoring year. This species is very common and invasive and it is rare to find areas that do not contain this plant. Most of the non-native species present within the monitoring plots are common agricultural weeds or shrub species which produce prolific amounts of berries that are distributed by deer, birds and other wildlife.

Common Buckthorn is the most widely dispersed non-native plant within the monitoring plots, with Glossy Buckthorn (*Rhamnus frangula*) also found in a number of plots with mesic to wet soils. Both species are tolerant of shading and fruiting specimens tend to be most common at the edge of wooded features where they receive ample sunlight. Due to the ability of these species to grow beneath a dense canopy, a groundcover of herbaceous vegetation is often interspersed with many young seedlings which germinate from the seedbank. Common Buckthorn is widespread throughout southern Ontario; it is often found on calcium-rich soils and occurs in a range of soil moisture and sunlight conditions (Anderson 2012).

During vegetation surveys some species were only identified to genus as the identifying traits of the plant may not have been apparent at the time of the survey. These include Avens Species (*Geum sp.*), Sedge Species (*Carex sp.*), Willow Herb Species (*Epilobium sp.*) and unidentifiable grass species. These species were included in the overall species count for the plot but were not included in the non-native species totals as a positive identification of the species was not possible.

2.7.1.3 Herbaceous Inventory

A total of 103 species of herbaceous plants were observed during the plot-based vegetation monitoring that was conducted in 2015. All herbaceous species documented within vegetation monitoring plots had been noted in previous years with no new species additions in 2015.

2.7.1.4 Shrub Inventory

In 2015, 22 shrub species were recorded. This number has varied over the monitoring years with low values of 15 species recorded in 2007, 2008, and 2009. All shrub species documented within vegetation monitoring plots had been noted in previous years with no new species additions in 2015.

2.7.1.5 Tree Inventory

Following monitoring in 2014 the scope of tree inventory work was reduced to collect only canopy closure data. Data pertaining to tree health is not conducive to quantitative analysis and DBH measurements were determined to be of little value for comparison from one year to the next and was thus discontinued.

Measures of canopy closure continue to provide insight into regeneration and the establishment of naturalization plantings at Plot 8. Comparison of these values from one year to the next provide insight into the resilience of the ecosystem as naturalization plantings have yet to reach heights which would influence canopy cover readings. The filling in of canopy provides benefits to the site, including the maintenance of microhabitat conditions for riparian vegetation and helping to regulate water temperatures within Hanlon Creek. No tree species are present within Plots 1, 6 and 9.

Signs of Emerald Ash Borer (*Agrilus planipennis*) (EAB) were observed among Ash (*Fraxinus* spp.) trees within the larger natural feature, including those within monitoring Plot 1. A loss of canopy cover due to Ash decline is likely to make for a temporary increase in herbaceous species both in numbers and in vigour. In time the canopies of existing trees including White Cedar, Red Maple (*Acer rubrum*) and Yellow Birch (*Betula alleghaniensis*) will fill in those areas where Ash was once present. Canopy openings will also spur the growth of shrub and tree saplings.

2.7.2 Breeding Birds

2.7.2.1 Breeding Bird Species Diversity

During 2015 monitoring, a total of 49 species of birds were observed during the point counts at the monitoring plots. Including those species which were noted outside of point counts or incidentally during other surveys, a total of 58 bird species were documented within the study area in 2015. Of the 49 species observed during the formal point counts, 19 exhibited possible breeding evidence, 25 exhibited probable, three were confirmed, and three did not show breeding evidence.

The most abundant species observed during 2015 surveys were Red-Winged Blackbird (*Agelaius phoeniceus*), and Song Sparrow (*Melospiza melodia*), comprising 14% and 10% of the observations during breeding bird point counts, respectively These were followed by American Robin (*Turdus migratorius*) and American Goldfinch (*Spinus tristis*) at 7% each. These species are consistently the most abundant within the point counts largely due to the presence of suitable habitat and the large populations of these species within Southern Ontario. Figure 20 represents the 10 most abundant species observed in 2015, with all other birds observed less frequently compiled as ‘other’.

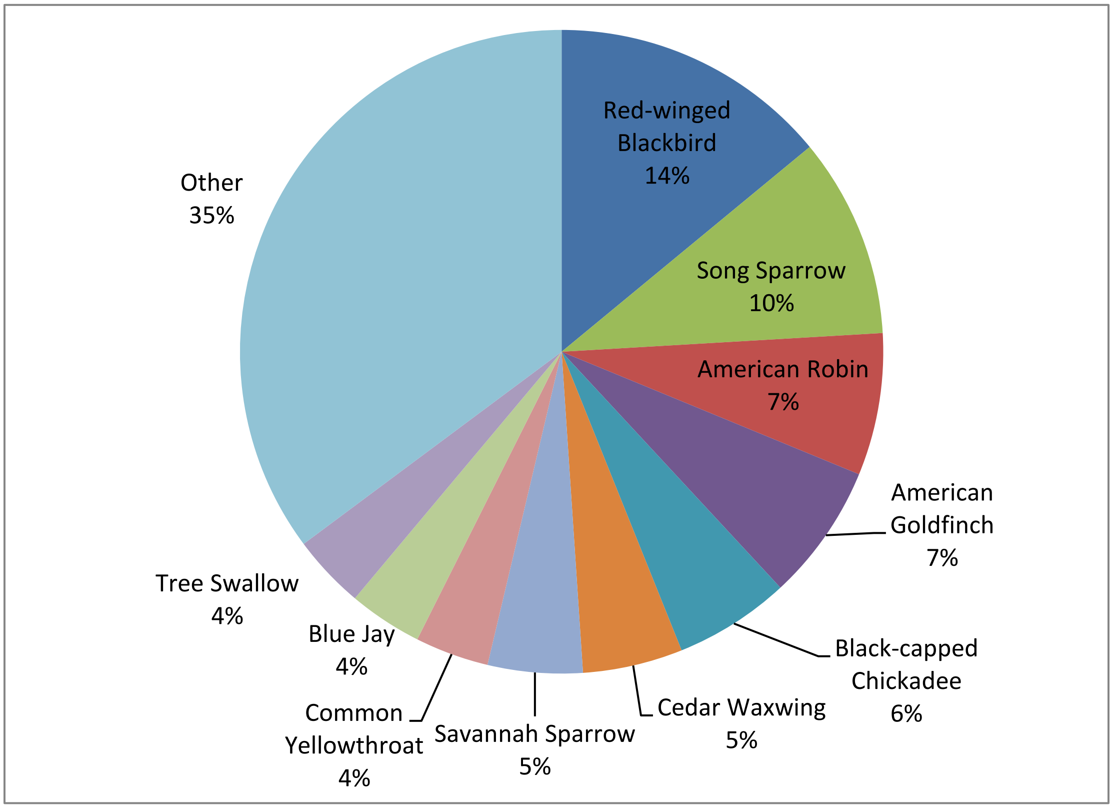


Figure 20. Most Abundant Bird Species Observed in 2015

In general, the diversity of bird species at each plot in 2015 was similar to those numbers documented between 2006 and 2011, with 2012 and 2013 appearing as exceptional years of high diversity across the study area (Figure 21). In 2015, no bird species new to the site were recorded either during breeding bird surveys or as an incidental observation.

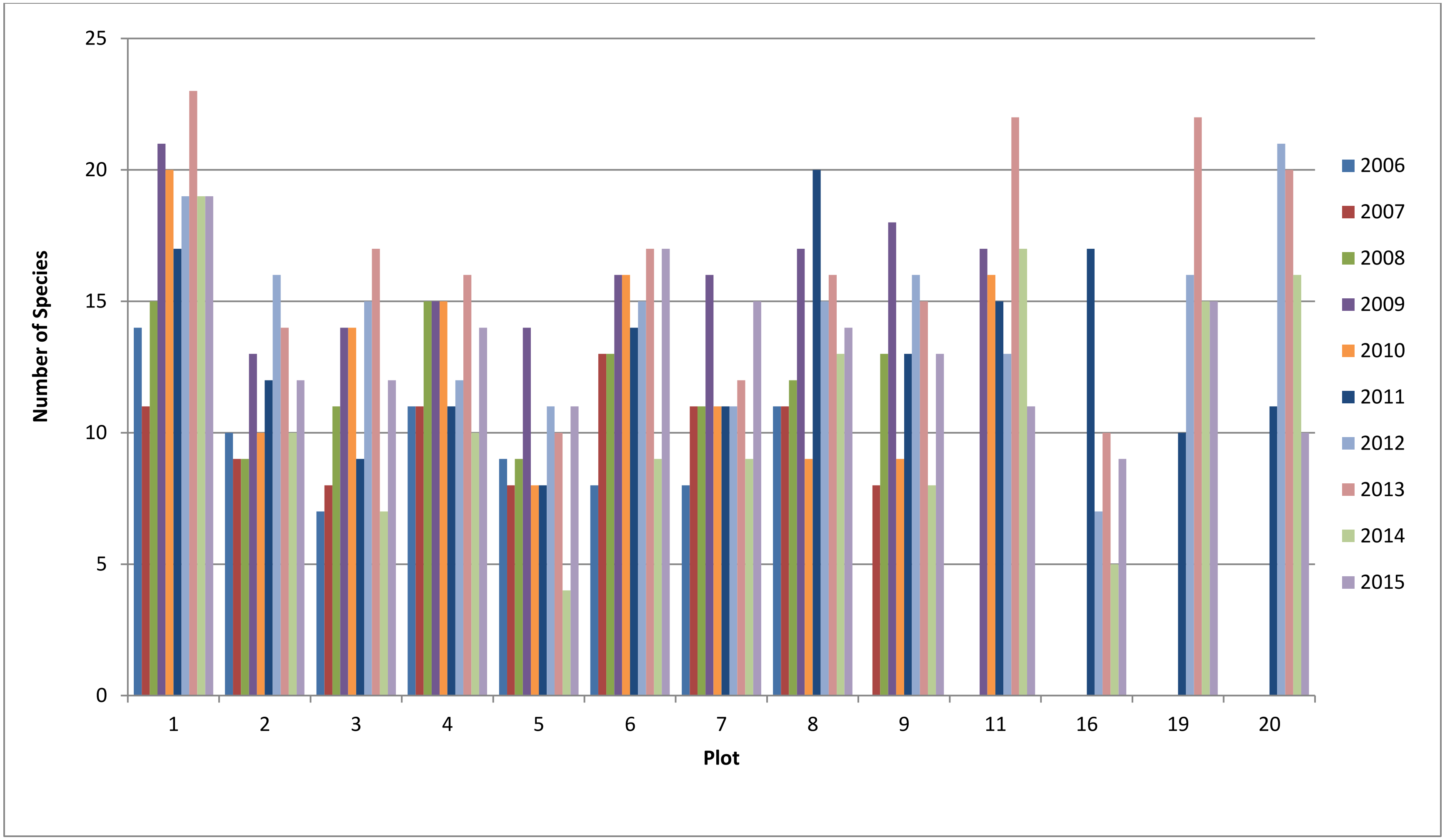


Figure 21. Breeding Bird Species Diversity 2006 – 2015

In 2015, notable increases in bird diversity (over 2014 values) were observed at Plots 3-7, 9 and 16. Plot 11 and Plot 20 have both shown steady decreases in diversity since 2013.

At Plot 11, only 4 species were documented on the first breeding bird survey, with 11 recorded on the second visit. The 22 species documented in 2013 appears to have been well above the 7-year average of 15.86. In 2015 there was no construction activity in the vicinity of Plot 11. Although the previously existing hedgerows have been removed, the lands surrounding the plot (including the Forestell Road berm) have developed into early successional meadow habitat which has value for bird species. The understorey of the Heritage Maple Grove within which Plot 11 is situated is dominated by European Buckthorn which has been present since monitoring began here in 2009.

Bird species diversity in Plot 20 had decreased to 10 species in 2015, down from 21 in 2012, 20 in 2013 and 16 in 2014. A cause for this trend is not clear given that the plot is situated among agricultural fields which have gone fallow and support a variety of grassland bird species. As in years prior to 2015, species including Eastern Meadowlark (Sturnella magna), Bobolink (*Dolichonyx oryzivorus*) and Savannah Sparrow (*Passerculus sandwichensis*) all utilize the fallow field habitat for foraging and nesting. No construction has occurred in this area to date. The decrease in diversity may simply be a result of point-in-time observations of species during the breeding bird surveys. Previous years had recorded species including Black-capped Chickadee, American Crow, Blue Jay, Ring-billed Gull and Downy Woodpecker, none of which would explicitly utilize the open country habitat. Despite the reduction in diversity recorded within the plot, the maintained presence of grassland birds from one year to the next supports that the plot continues to provide functional habitat for those species which would require grassland for foraging and breeding.

2.7.2.2 Breeding Bird Abundance

The breeding bird abundance (the number of individual birds) since 2006 is shown on Figure 22. In general, the 2015 abundance reflects the overall average since monitoring began in 2006. Similar to species diversity, breeding bird abundance showed a notable spike during the 2012 and 2013 monitoring years and 2015 data generally reflects abundance data observed between 2006 and 2011. Those species which have tended to comprise much of the abundance value for each plot including Red-winged Blackbird, American Goldfinch, Song Sparrow, Black-capped Chickadee and American Robin continue to comprise the bulk of individuals observed. Spikes in bird abundance have been observed in past monitoring years due to large flocks of a single species which have included Red-winged Blackbirds in Plot 6 in 2006 and Canada Goose (*Branta canadensis*) in Plot 9 in 2007.

Plot 1 showed a decrease in bird abundance in 2015 with 31 individuals recorded. The 2013 and 2014 monitoring years had recorded 70 and 51 species respectively. Situated at the transition between a Slender Willow Mineral Deciduous Thicket Swamp and Mixed Meadow, this plot documents a range of bird species as a result of varied habitats. While bird abundance was lower in 2015 than the previous 7 years, bird species diversity remained generally consistent with previous year at 19 species.

Plots 4, 5, 6 and 16 all exhibited notable increases in bird abundance over 2014 values. The 2015 values generally reflect the overall average for each plot over the course of monitoring.

Plot 6 continues to have the highest bird abundance with 50 individuals recorded during 2015 surveys. This plot is likely to yield higher bird abundance due to a combination of treed and open upland and wetland habitats present within the immediate survey area. Additionally, the marsh vegetation within this plot provides good sight lines to forest and swamp edges, the skyline and distant features which allow biologists to observe species well beyond the formal 100m breeding bird plot. Those plots which consistently show the lowest bird abundance, particularly Plot 5 are situated well within wooded features and are thus less likely to have species that prefer edge or open country habitat.

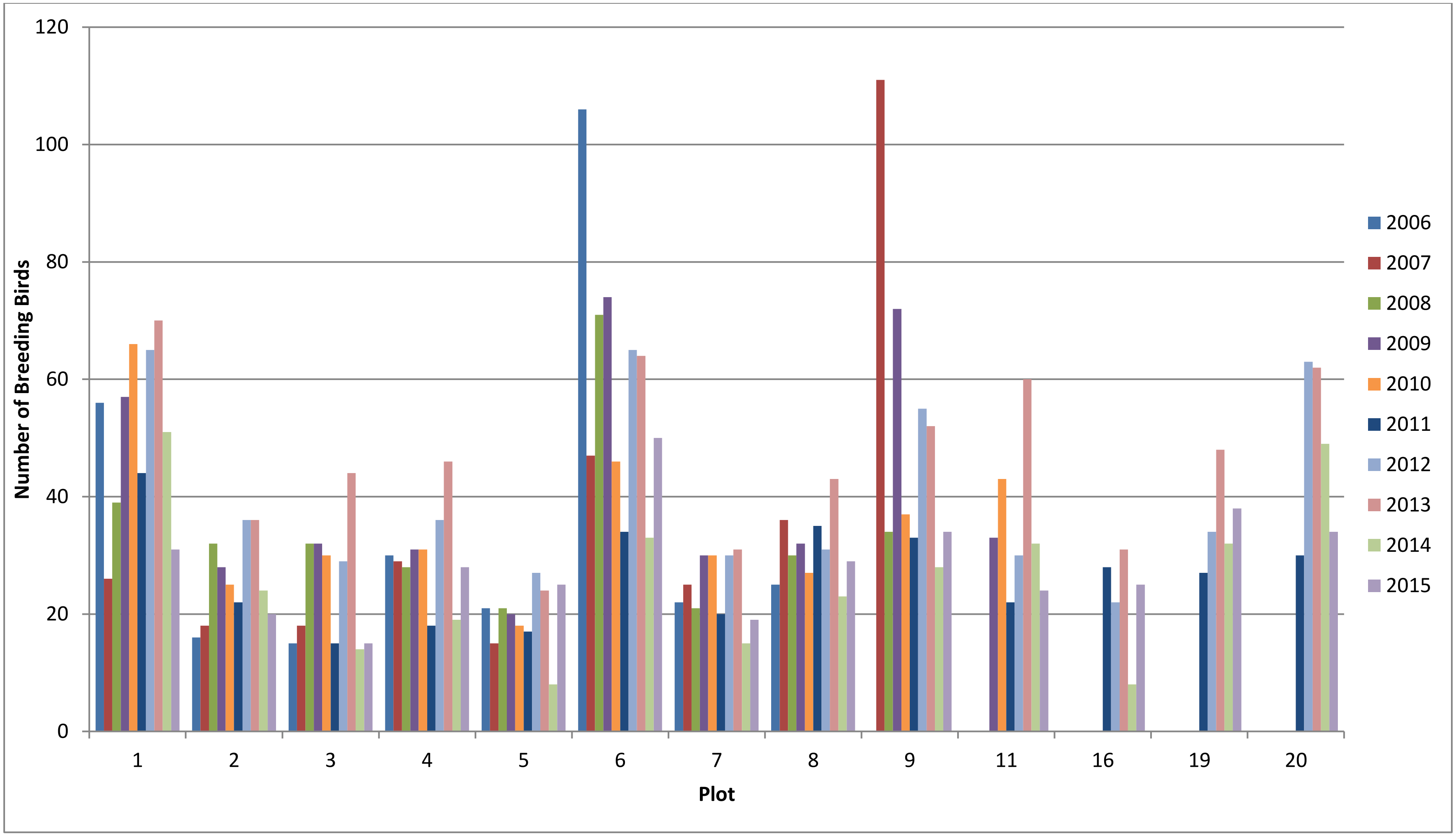


Figure 22. Breeding Bird Abundance 2006 - 2015

2.7.2.3 Significant Species

NRSI observed five species that are considered Threatened federally and provincially (COSEWIC 2016, MNRF 2015): Bobolink, Eastern Meadowlark, Barn Swallow (*Hirundo rustica*), Bank Swallow (*Riparia riparia*), and Chimney Swift (*Chaetura pelagica*). Additionally, Eastern Wood-pewee (*Contopus virens*), a species listed as Special Concern federally and provincially (COSEWIC 2016, MNRF 2015) was documented during 2015 breeding bird surveys.

In Plot 20, Bobolink and Eastern Meadowlark were noted showing probable breeding evidence with as many as 3 individuals of each species present. Incidental observations of Bobolink were also made from the vicinity of Plot 1 and 9 with Eastern Meadowlark documented in the vicinity of Plot 1. Bobolink requires large, open expansive grasslands (>50ha) with dense ground cover; hayfields, meadows or fallow fields; marshes (OMNR 2000). This species has been observed each monitoring year with probable breeding evidence documented in 2010 and 2012 through 2015. Eastern Meadowlark requires grassy meadows, farmland, pastures or hayfields at least 10ha in size (OMNR 2000). Suitable habitat is found within the southwest portion of the subject property (Phase 3) as well as within the retained open meadow habitat associated with Plot 19.

Barn Swallows were observed at four breeding bird plots within the Phase 3 lands (Plots 1, 9, 19 and 20). Based on breeding bird surveys, the species was documented showing confirmed breeding evidence with as many as four individuals present at Plot 19 on the June 29th survey. Barn Swallows are found in farmlands and rural areas, and generally use buildings (such as barns) or other man-made structures for nesting. They are often found foraging in open country near water (Brown and Bomberger-Brown 1999, OMNR 2000). Suitable nesting habitat for this species is present at the Crawley farmhouse within Phase 3. Barn Swallow may also be nesting outside of the subject property in barns along Forestell Road or Downey Road and utilizing the subject property for foraging habitat.

A single Bank Swallow was observed in suitable habitat at Plot 6 during the June 17th survey. This species nests within eroding banks of streams and rivers and forages within open and water-associated habitats (Garrison 1999). Suitable nesting habitat for this species may be provided by a large topsoil pile in the block adjacent to Plot 16. The SWM ponds present may provide suitable foraging habitat.

A pair of Chimney Swifts were documented foraging above Plot 2 during the June 17 survey. This species is known to roost and nest in chimneys, predominantly within urban landscapes and feed above forests and open country (Steeves et al. 2014). While suitable nesting and roosting habitat is not present within the study area, the fields and treed habitats provide foraging habitat.

A single singing male Eastern Wood-Pewee was documented at Plot 3 and was also noted as an incidental at Plot 19. Eastern Wood-Pewee prefers open forest (deciduous, coniferous or mixed) often predominated by oak with little understorey or forest clearings, edges, farm woodlots or parks (OMNR 2000). The open understorey habitat present at Plot 3 provides ideal habitat for this species which may also utilize other treed and edge habitats throughout the study area.

A total of 17 bird species were observed which are considered significant within the City of Guelph (Dougan & Associates 2009). Of these 15 species, 1 showed confirmed breeding evidence; Baltimore Oriole (*Icterus galbula*) at Plot 19. A total of 6 species showed probable breeding evidence, including American Redstart (*Setophaga ruticilla*) Bobolink, Chimney Swift, Eastern Meadowlark, Savannah Sparrow, and Willow Flycatcher (*Empidonax traillii*). Additionally, 10 species showed possible breeding evidence and 1 did not show any breeding evidence (i.e. flying over habitat). Chimney Swift was the only species considered significant in Wellington County which had not been recorded within the subject property previously.

2.7.3 Amphibians

Calling anuran species were recorded at 11 of the 16 plots in 2015. Plots 6, 9 and 16 recorded 3 species of anuran. No calling anurans were recorded in 2015 at Plots 4, 8, 13, 17 and 18. These plots often lack standing water and do not always provide ideal anuran breeding habitat.

Five amphibian species were recorded during evening call count surveys in 2015; Spring Peeper (*Pseudacris crucifer crucifer*), Wood Frog (*Lithobates sylvatica*), American Toad

(*Anaxyrus americanus*), Green Frog (*Rana clamitans melanota*) and Gray Treefrog (*Hyla versicolor*). Since 2006, the number of species recorded during the calling anuran surveys has fluctuated. The five amphibian species recorded calling in 2015 is above the annual average of 3.8 species recorded in previous years. Species recorded during surveys have fluctuated over the nine-year monitoring period, with as many as six species recorded during 2009 surveys and none recorded during the first preconstruction monitoring year (2006).

Spring Peeper has consistently been one of the most abundant calling anurans with the species widely distributed and somewhat abundant in 2015. A full chorus of many individuals was recorded at Plot 9. No individuals were recorded at Plot 16, which has had Spring Peeper documented each year between 2009 and 2014.

Green Frog was documented sporadically and in low numbers in 2015, similar to previous years. An estimated two individuals were noted calling at Plot 14 in 2015, which is the first time this species has been recorded at this plot.

Gray Treefrog was the most widely distributed species in 2015. It was recorded at nine of the 16 anuran monitoring stations with an estimated 56 individuals recorded. This species has been recorded in high numbers at Plot 1, which is within a willow thicket swamp that is subject to seasonal flooding. Other plots with high numbers in 2015 included Plot 10, Plot 12 and Plot 16.

Wood Frog has shown a pattern of higher numbers in one season followed by lower numbers (or none calling) in the next. The data from 2015 reflects a year of higher Wood frog abundance with an estimated 14 individuals calling between 4 plots.

American Toad has been limited in numbers and distribution throughout the study area between 2006 and 2014. This continued in 2015 with a single toad documented during calling anuran surveys at Plot 4.

No Leopard Frog (*Lithobates pipiens*), Pickerel Frog (Lithobates *palustris*) or Western Chorus Frog (*Pseudacris triseriata*) were observed in 2015, either during call counts or incidentally. All of these species have been recorded intermittently within the subject property in previous years, with a call code of 1 or 2 and in low numbers. Pickerel Frog and Western Chorus Frog have not been documented since 2012.

The 2015 terrestrial and wetland monitoring report (Appendix IV) provides detailed information on the ambient air temperature, water temperature, and pH ranges for each of the field visits in 2015.

3.0 Summary of Thresholds

Thresholds have been developed for each component of the HCBP Monitoring Program. Each threshold is described within the *HCBP Consolidated Monitoring Program* (NRSI 2010) and is listed in Table 10.

Table 10. Summary of Thresholds by Monitoring Component

Component	Threshold	Exceedance in 2015 (Yes/No, stations)	Exceedances from 2009 to 2014
Groundwater	A specific quantitative threshold is not used. However, groundwater elevations that increase above previously observed seasonal high levels or decline below previously observed seasonal low levels, without an obvious relationship to precipitation, will be identified as observations of concern. Similarly, groundwater quality that differs from previous ranges in parameters, and/or indicates an upward trend, will be identified as observations of concern.	No	Yes, in 2010, 2011 and 2012
Surface Water	1. Any single temperature exceedance of 22°C requires analysis in the annual consolidated monitoring report.	Yes, at HC-A(03), HC-A(04), HC-A(06), HC-A(09), HC-A(10), HC-A(11), HC-A(12), HC-A(13), HC-A(14), SR-1(01)	Yes, in 2009, 2010, 2011, 2012, 2013 and 2014
	2. Any single temperature exceedance of 24°C triggers the Rapid Assessment and Action Protocol.	Yes, at HC-A(06), HC-A(09), HC-A(14), SR-1(01)	Yes, in 2010, 2011, 2012, 2013 and 2014
Fish	1. A 50% change in the number of taxa represents a potential decline in the suitability of the habitat for Brook Trout. Because coldwater fish communities typically have a lower species diversity, an increase in species diversity may represent a negative change in relation to the Brook Trout management objective. Specifically, the warm-water fish community may increase in species richness as a result of warmer water temperatures, which indicates that	Yes, at EMS-001	Yes, 2011

Component	Threshold	Exceedance in 2015 (Yes/No, stations)	Exceedances from 2009 to 2014
	the habitat is becoming less suitable for Brook Trout. A decrease in species diversity may also represent a negative change in the suitability of the habitat for Brook Trout, likely attributable to some cause other than water temperature.		
	2. A 50% reduction in the number of fish captured represents a potential decline in the fish community resulting from habitat impacts. However, it may also represent an improvement in habitat suitability for Brook Trout based on temperature changes.	Yes, at EMS-003	Yes, in 2010, 2012 and 2014
Benthic Invertebrates	1. For the Percent Model Affinity (PMA) analysis, the threshold is an "Impact" determination at a station for 2 consecutive years following 2 consecutive years where the determination was "No Impact" at that station.	Yes, at BTH-002, BTH-005	Yes, in 2013 and 2014
	2. For Total Taxonomic Richness, the threshold is a 50% decline in the total number of taxa at a station, as compared to the results from the previous year.	No	Yes, in 2011 and 2013
	3. For EPT Taxonomic Richness, the threshold is a 50% decline in the number of EPT taxa at a station, as compared to the average results from the previous 2 years.	No	Yes, in 2011, 2012, 2013 and 2014
Vegetation and Soils	1. A change in herbaceous cover by more than 25%.	Yes, at Plot 2, Plot 3	Yes, in 2011, 2012, 2013 and 2014
	2. A change in species diversity by more than 25%.	Yes, at Plot 1, Plot 2, Plot 5	Yes, in 2010, 2011, 2013 and 2014
	3. A change in canopy cover by more than 25%.	Yes, at Plot 8	Yes, in 2010, 2011 and 2014
Breeding Birds	1. A negative change in species diversity (number of species) by more than 25%.	Yes, at Plot 11	Yes, in 2010 and 2014
	2. A negative change in the breeding bird abundance (number of individuals birds) by more than 25%.	Yes, at Plot 1, Plot 3, Plot 6, Plot 9,	Yes, in 2010, 2011 and 2014

Component	Threshold	Exceedance in 2015 (Yes/No, stations)	Exceedances from 2009 to 2014
		Plot 11	
Amphibians	1. A decrease in species diversity (number of species) by more than 2 species.	No	Yes, in 2010 and 2012
	2. A change in species abundance measured by a decrease in two call codes.	Yes, at Plot 12, Plot 14	Yes, in 2010, 2011, 2012, 2013 and 2014

4.0 Rapid Assessment and Action Protocol

In 2011 a Rapid Assessment and Action Protocol (RAAP) was implemented as a response protocol for when thresholds are exceeded or when other unexpected environmental issues arise. A six-person committee was set which included a primary and an alternate designated for each represented group (City of Guelph, GRCA, and Monitoring Team). Whenever there was a RAAP event, all six people were contacted via email, and a meeting was scheduled. The list of designated persons for 2015 is shown in Table 11.

Table 11. List of RAPP Designated Persons (2015)

Affiliation	Name
Monitoring Team (AECOM)	Adrienne Sones
Monitoring Team (NRSI)	Andrew Schiedel
City of Guelph	Prasoon Adhikari
City of Guelph	Prachi Patel
GRCA	John Palmer
GRCA	Tony Zammit

The specific thresholds that require rapid response are the 22.0°C and 24.0°C stream temperature thresholds, and the turbidity threshold which was initially set at 10 NTU in the HCBP Consolidated Monitoring Program guidance document (NRSI 2010). These targets were set with the primary goal of maintaining Brook Trout habitat within the Hanlon Creek tributaries. To determine when temperatures or turbidity exceed these thresholds, a telemetry system was implemented at four stations within the site to monitor temperature, turbidity and depth. This system notified the monitoring staff when there was an exceedance, triggering the RAAP. In addition, any on-site observations of immediate problems, such as sediment observed entering a wetland or watercourse during a rainfall event, one or more of the designated persons should be contacted. If a RAAP is triggered, the basic steps are:

1. After the exceedance/event occurs the monitoring staff member, inspector or notified person will contact the designated persons immediately.
2. The designated persons must meet/conference call within 48 hrs.
3. Notification and corrective actions must be proposed within three business days.
4. Report should be produced.
5. This report should be included in the consolidated monitoring report.

Section 4.1 provides an account of the meetings that occurred as a result of threshold exceedances in 2015.

4.1 Chronology of Events

The following summary is based on the correspondence and meeting minutes of the RAAP committee found in Appendix V.

The first exceedance of 2015 was observed by AECOM on July 26, 2015. This exceedance was observed daily between July 26 and July 29 at HC-A(06) and on July 28 and 29 at HC-A(14). In response to these exceedances an email was circulated by AECOM to NRSI and GRCA on July 30 noting the exceedance and initiating a RAAP call. AECOM indicated that they would have staff on site to download the temperature and flow data from SWM Pond 4 and HC-A(06) in order to look at potential influencing factors. The email was sent along to the City of Guelph to notify of the exceedance and the call and, following this, a conference call was held to discuss the exceedance. Representatives from AECOM, NRSI, GRCA, and the City of Guelph were on the call, which included a new City of Guelph representative for 2015. During the call AECOM provided a brief history of the RAAP team and their role for addressing temperature and turbidity exceedances in addition to a brief history of the issues observed at SWM Pond 4. The exceedance at HC-A(14) was also discussed. Discussion of the exceedance at HC-A(14) indicated that Tributary A at this monitoring station is a losing reach and has historically exhibited warmer water temperatures due to exposure to solar inputs and groundwater infiltration condition (as opposed to the discharge that occurs further upstream on site). As such, no follow-up was required regarding this exceedance. For the exceedance at HC-A(06) it was determined that a follow-up discussion would need to occur once the Pond 4 and stream temperature downloads had been completed for the site. Towards the end of the call NRSI was tasked with providing an update on the status of the plantings in 2015. City of Guelph requested that a site visit be set up to help familiarize new staff with the project. NRSI was tasked with taking photographs of the vegetation within SWM Pond 4 and the cooling trench and AECOM was tasked with reviewing SWM Pond 4 data and providing plotted data for the July exceedances.

Photographs of the pond and cooling trench were taken during the site visit on August 13, 2015.

On August 12, 2015 an email was circulated to the RAAP team that included a set of three figures for review showing; the flows for SWM Pond 4 and Tributary A at HC-A(03) and HC-A(06) between July 20 and July 30, the water temperatures for SWM Pond 4 between July 20 and July 30, and the overall water temperatures between July 20 and July 30. An additional email and attached Memo was circulated on August 27 that outlined in detail the exceedances of 24°C at HC-A(06) and HC-A(14). The Memo considered a variety of influencing factors including ambient air temperature, monthly precipitation, and groundwater flow and temperatures between July 20 and July 30. The main factor influencing the threshold exceedance at HC-A(06) continued to be the continuous discharge from Pond 4 and the warming of the adjacent groundwater as it flows through Pond 4. Due to the temperature exceedances experienced in the headwaters of the creek and the constant discharge from Pond 4 the RAAP team decided that it was necessary to implement mitigation measures to reduce the temperature impacts of Pond 4 between rain events. Four mitigation measures were recommended to be investigated and implemented if found appropriate.

1. Installation of a drainage tile along the south side of the Pond 4 trail from the pond's inlet to the pond's outlet. The drainage tile is to be installed at the pond's permanent pool elevation in order to intercept some of the incoming groundwater before it reaches the pond. The intercepted ground water will be directed towards the cooling trench to help enhance the trenches' cooling properties. The tile drain would run approximately 360m in length.
2. Installation of floating islands in the pond to provide further shading and reduce heat gain. However, discussion on site identified that although monitoring has shown that these islands have a positive impact on water quality, little to no temperature reductions have been realized.
3. Increase the vegetative cover at the cooling trench outlet to provide additional shading and review the possibility of moving rock to install live stakes in the 'bank' areas of the cooling trench.
4. Redirect the cooling trench outlet to the Hanlon Creek tributary in order to reduce the undercutting that is occurring on the west bank and/or use

bioengineering at the cooling trench outlet to protect the banks and provide additional shading.

On September 7, 2015 an exceedance was identified by AECOM at HC-A(03) between 12:45 and 17:15, and at HC-A(06) at 14:15. A conference call was held on September 8 to discuss these exceedances. It was noted that no previous exceedances have been observed at HC-A(03) and it was unlikely that the exceedance was a result of development upstream of the station. AECOM indicated that a visit to the site the week before identified generally low water levels in the creek and the exceedance may have been a result of this. A follow-up visit to the site following the call would take place to confirm. A follow-up investigation by AECOM following the conference call confirmed that the data logger was out of the water and the logger was repositioned on September 8 in an attempt to prevent a future false exceedance. It was also noted on the call that the City of Guelph was considering alternatives to mitigate impacts of SWM Pond 4 to the Hanlon Creek system as was summarized in the August 28, 2015 Memo prepared by AECOM. The City was also considering implementation of Low Impact Development (LID) practices in the catchment in their review of alternatives.

A RAAP meeting was also held on December 14, 2015 to further discuss solutions for SWM Pond 4. It was decided that a memo should be prepared outlining some of the details and data requirements to properly implement any of the mitigation measures being considered. Further discussion on the mitigation measures and actions taken for SWM Pond 4 mitigation will be provided in the 2016 HCBP Consolidated Monitoring Report.

5.0 Discussion of Thresholds and Issues

Several issues were identified during the 2015 monitoring season. These were identified based on the exceedances of the various monitoring component thresholds that have been described within the *Hanlon Creek Business Park Consolidated Monitoring Program* (NRSI 2010). Threshold exceedances are identified in Section 3.0. The following is a discussion of the issues that were identified or ongoing in 2015.

5.1 Water Temperature Impacts from Stormwater Management Pond 4

As discussed in Section 2.4.2, water temperatures during summer months of 2015 continued to be elevated as a result of the effects of SWM Pond 4. While higher than average air temperatures and lower precipitation levels were noted in 2015 compared to 2014, which contributed to these elevated water temperatures, the influence of SWM Pond 4 continued to be evident in 2015. The evidence is focused on the stations on Tributary A that are the nearest to the SWM Pond 4 outlet. Water temperatures exceeded both 22°C and 24°C at the stations downstream of the SWM Pond 4 outlet while the station upstream of the outlet exhibited only a brief exceedance of 22°C and did not exceed 24°C in 2015. Thermal effects are evident in the proportion of the summer that the temperature was above 19°C, and by the thermal regime classifications in 2015 compared to pre-construction data.

Looking at the temporal evidence, the 2015 thermal regime classifications continued to be warmer than pre-construction years (2009/2010 and earlier) at stations HC-A(04), HC-A(06), HC-A(09) and HC-A(10). In addition, the proportion of time that the temperature was above 19°C at stations HC-A(04) and HC-A(06) was greater in 2015 compared to pre-construction conditions, being 62% and 51% in 2015 versus 9% and 18% in 2010, respectively. In 2009, the summer temperature data demonstrated no time (0%) above 19°C at stations HC-A(04) and HC-A(06). It is clear that SWM Pond 4 has changed the conditions at these stations.

Looking at the spatial evidence, stations HC-A(04) and HC-A(06), located in Tributary A downstream of the SWM Pond 4 outlet, recorded higher average temperatures and little daily fluctuation compared to station HC-A(03) located upstream of the SWM Pond 4 outlet. The subdued daily fluctuation resulted from the very constant temperature of water that continuously discharges from the SWM Pond 4 outlet. Furthermore, the temperatures at the two of these stations that are downstream in Tributary A were consistently in between the upstream temperatures and the SWM Pond 4 outlet temperatures, providing evidence of the mixing of the two sources of flow.

Further downstream at station HC-A(09), it is difficult to discern how much SWM Pond 4 is affecting the temperatures. In 2009, the temperature at this station was at times above 19°C, with a proportion of 2.1% of the 21 days of data that was available that summer. In 2010, station HC-A(09) exceeded 19°C for 34% of the time. This indicates that there has been a history of higher water temperatures at station HC-A(09). The data for 2015 shows that the temperature was above 19°C 50% of the time. This could be a result of the influence of SWM Pond 4, although the greater distance from the pond and the lesser temporal difference in this statistic makes the relationship less certain.

Downstream from station HC(A)-09 it is unlikely that SWM Pond 4 is affecting the temperatures, as evidenced by the thermal regime classification at station HC-A(11) which was cooler in 2015 compared to pre-construction condition. This cooler thermal regime at station HC-A(11) may reflect the cooling effect of the removal of the online pond in conjunction with building the Hanlon Creek Blvd crossing of Tributary A in 2009. In spite of the cooling in that location, station HC-A(14), which is farthest downstream on the site, was one category warmer in 2015 compared to pre-construction conditions. Therefore, the warmer classification at station HC-A(14) was largely due to factors beyond the potential influence by SWM Pond 4.

As another effect to consider for the stations further downstream of the two stations nearest to SWM Pond 4, stations HC-A(09) and HC-A(14) experienced exceedances of the 24°C threshold. Station HC-A(09) may have been influenced by SWM Pond 4 and, based on review of the groundwater and surface water information, it is unlikely that the warm temperatures at that station were caused by other development-related effects. The exceedances at station HC-A(14) are not unusual, so are less likely to be related to warming from SWM Pond 4. All stations had some time with temperatures over 22°C, but they were nominal amounts of time often rounding down to 0%. It appears that the main issue with stream temperatures in 2014 was the effects of SWM Pond 4, and there is no clear evidence that other aspects of the development are contributing to the exceedances of 22°C and 24°C. Thus, it is appropriate to focus on the stream temperature impacts of SWM Pond 4, and consider whether there are possible restoration activities for station HC-A(09), in order to reduce the potential for exceedances of 22°C and 24°C.

Further analysis of the spatial and temporal characteristics of the stream temperatures in Tributary A and Tributary A1 is provided in Section 2.4.2, and a focus on the suitability of the temperatures for Brook Trout is provided in Section 2.4.2.1. Analysis of stormwater management pond temperatures is provided in Section 2.4.2.2, and analysis of the modes of impact of SWM Pond 4 is provided as follows.

Two potential modes of impact by SWM Pond 4 were previously discussed in the 2012, 2013 and 2014 consolidated monitoring reports. The first mode is the water that is discharging to Tributary A through the SWM Pond 4 outlet; the second is the pond's effects on adjacent groundwater that eventually discharges to Tributary A as groundwater. They are outlined again as follows.

5.1.1 Warm Water Discharging Through SWM Pond 4 Outlet

In 2015, the continuous outflows from the SWM Pond 4 cooling trench continued to be approximately 3 to 6°C warmer than the upstream water temperatures at station HC-A(03) in Tributary A. The resulting temperature in Tributary A immediately downstream at station HC-A(04) is closer to the SWM Pond 4 outflow temperatures. However, in general, outflow temperatures were still up to 8 degrees cooler than pond temperatures, indicating that the cooling trench is functioning to mitigate and cool water from SWM Pond 4 to some degree.

As discussed in Section 2.4.2.2, the cooling trench at SWM Pond 4 has limited performance during storm events. The HCPB Stream Temperature Impact (AECOM 2009) indicated that there was little information on performance of the outlet trenches in terms of reducing temperature; however it refers to the Max Becker Subdivision Pond, at which the outlet temperature exceeded 22 C only once during a storm event. At SWM Pond 4 the cooling trench is noted to lower the pond outflow temperatures in between storm events, but only mitigates temperatures for a few hours after a storm event begins.

Thereafter, the temperature is largely driven by the pond outflow temperature during a storm. This is understood to be a potential limitation of cooling trenches, with the understanding that the first flush of water has the greatest potential for thermal impact. Nevertheless, it is important to understand that the cooling trench is most likely functioning to mix groundwater with the outflow from SWM Pond 4, and its perceived performance under current conditions may not reflect extensive absorption of heat by the rock in the cooling trench. If the continuous discharge from the SWM Pond 4 outlet were not occurring, there may be additional heat capacity in the rock and surrounding groundwater to facilitate additional cooling of the first flush of a storm event. Refer to Section 2.4.2.2 for further explanation of the current function of the cooling trench at SWM Pond 4.

In order to improve the performance of the cooling trench and mitigate the effects of the continuous discharge from the pond, herbaceous species and vines were planted along the cooling trench in the fall of 2012. These were installed as an additional mitigation feature with the hope that they would grow over the rock lined cooling trench and reduce the impacts from solar radiation. It was determined that they provided little benefit during their first year as they covered only a small area of the trench, and this continued to be the case in 2015. It may be necessary to augment these plantings, or to pursue additional measures. A variety of mitigation measures were discussed by the RAAP team in 2015, and these are listed in Section 4.1. However, no additional mitigation measures were implemented in 2015.

5.1.2 Warming of Groundwater Adjacent to SWM Pond 4

The warming of the groundwater adjacent to and down-gradient from SWM Pond 4 continued in 2015. In 2012 it was determined that surface water from SWM Pond 4 could be migrating toward Tributary A through the ground as another pathway from SWM Pond 4 to Tributary A. This was evidenced by elevated groundwater temperatures compared to pre-2012 monitoring and compared to groundwater temperatures up-gradient from SWM Pond 4 in the same year. This effect continued through 2013 and 2014, and is again evident in 2015.

In July and August, 2015, the water temperatures at monitoring well MW119A, located down-gradient from SWM Pond 4, were again approximately 4 to 5°C higher than those at monitoring well MW 131, located up-gradient of SWM Pond 4. This is a clear indication that an effect is occurring, and it is clearly illustrated on Graph G24a in Appendix G of the groundwater monitoring report (see Appendix I of this report). In addition, groundwater temperatures at monitoring well MW119A and piezometers PZ-13D and PZ-14D demonstrated potentially-elevated temperatures (Section 2.4.1).

Mitigation of this mode of effect would need to either lower the temperature of the water in SWM Pond 4, or curtail the flow of groundwater out of this part of the pond. Such measures have been discussed in 2015, however none were implemented.

5.2 Change in Benthic Invertebrate Community at Two Stations

5.2.1 Sequential PMA-Analysis 'Impact' Determinations at Two Stations

Two stations, BTH-002 and BTH-005, produced an exceedance of the first benthic invertebrate threshold in 2015.

Station BTH-002 had an 'impact' determination for the fifth consecutive year, which resulted in another exceedance of the first threshold in 2015. The threshold exceedances observed at this station over the previous years would suggest an overall change in the quality of the benthic community and habitat. However, in 2015 there was an increase in EPT taxa, and the dominant and subdominant families from the sample were both species indicative of good water quality, including a species of caddisfly, which was the subdominant family. The community used is for streams with rock/cobble substrate, and it sets a higher standard for BTH-002. This threshold is therefore of little concern in 2015.

Station BTH-005 experienced an 'impact' determination for the second year since monitoring began at this station in 2009. The 'impact' determination was previously observed in 2014, and the two consecutive years results in the first exceedance of threshold number one at this station in 2015. Station BTH-005 is the uppermost station along Tributary A and exists just downstream of the outlet of SWM Pond 4. The 'impact' determination in 2015 is somewhat surprising, as the EPT richness index showed a substantial increase from 2014, which suggests an improvement. Monitoring using the PMA analysis should continue with the intention of determining whether or not a ‘no impact’ determination is observed again at Station BTH-005.

The occurrence of ‘impact’ determinations at BTH-002 and BTH-005 of these stations suggests a change in the quality of the benthic community at both of these stations. The cause of these determinations is not clear at this point in time, although it is understood that BTH-002 is analyzed using a different model community. Monitoring using the PMA analysis should continue with the intention of determining whether or not a ‘no impact’ determination is observed again at these stations.

5.3 Change in the Fish Community at Two Stations

5.3.1 Reduction in the Number of Taxa by 50% at One Station

For the first fish threshold, one station, EMS-001, exhibited a 50% reduction in the number of taxa. This occurred due to a decrease from four taxa to two, which included Blacknose Dace and Creek Chub. The total number of taxa at EMS-001 have been variable over the years ranging from a previous low of three to a high of five, which occurred for three consecutive years between 2011 and 2013. The previous low of three taxa has occurred four times in 2006, 2007, 2009, and 2010. These years all fall during pre-construction monitoring, and are assumed to have occurred under natural conditions. As such, this appears to be a return to a more ‘typical’ number of taxa under natural conditions.

The highest numbers of taxa have been captured during construction-phase monitoring between 2011 and 2014. The higher numbers during these years were partially attributed to augmented flows in Tributary A resulting from the continuous discharge of SWM Pond 4. In 2015 the continuous discharge continued from Pond 4 and only two taxa were captured. Blacknose Dace and Creek Chub have been captured at EMS-001 regularly since 2006. Brook Stickleback and Central Mudminnow have also been caught frequently at this station, in particular between 2011 and 2014, however their numbers relative to the other two species are generally low. The years where five taxa were captured, the fifth taxa, which has included White Sucker and Northern Redbelly Dace have only included between one and three individuals. Further, the population estimate for EMS-001 shows a population that is similar to or higher than the majority of previous years. As such, there is no cause for concern at this time regarding this exceedance.

5.3.2 Reduction in the Number of Fish Captured by 50% at One Station

For the second fish threshold, one station, EMS-003, exhibited a 50% reduction in the number of fish captured. At EMS-003 this occurred due to the decrease in total catch from 10 fish in 2014 to 5 fish in 2015, a 50% decline in fish capture.

The catch totals at EMS-003 have been consistently low since monitoring began in 2006. As a result it has a greater likelihood of exhibiting threshold exceedances than the other four monitoring stations since a small fluctuation in fish presence within the delineated site could result in a 50% decline. This monitoring station is located on a small groundwater-fed tributary (Tributary A1) to Hanlon Creek Tributary A, which typically provides less habitat than Tributary A. Numbers of fish have been low in the past, being similar in 2010 and 2011, and lower in 2012. Those years registered as threshold exceedances as well, but as noted the low numbers of fish predispose this site to an exceedance. Therefore, the results are considered typical for station EMS-003.

5.4 Changes in Vegetation

5.4.1 Change in Herbaceous Cover by 25% at Two Stations

Herbaceous cover exceeded the threshold positively in Plot 2 which is seen as a positive trend. Plot 3 exceeded the lower reach of the threshold in 2015.

While increases in herbaceous species in Plot 3 (7.2% between 2013 and 2014 and 19.1% between 2014 and 2015) reflect a positive change in recent years, the 28.2% cover in 2015 is still well below the pre-construction average of 57.83%. Herbaceous cover in this plot is primarily influenced by the presence of Ostrich Fern (*Matteuccia struthiopteris*) which, prior to 2011 had comprised a significant portion of herbaceous cover within the plot before values dropped significantly. It should be considered that the mortality of Ostrich Fern during the driest monitoring years would require time for the population to rebound (assuming conditions are suitable for the species) to pre-construction numbers. Should the site receive abundant precipitation during the spring of 2016, vegetation monitoring may find that herbaceous cover continues to build on the 2015 figures.

5.4.2 Change in Herbaceous Species Diversity by 25% at Three Stations

Species diversity positively exceeded the pre-construction threshold in both Plots 1 and 2. Given that these increases were not based on the addition of aggressive non-native species to the plots, these changes are considered positive. Plot 5 fell below the threshold in 2015.

With consistently low species diversity, the threshold for Plot 5 is based on a small number of species and is thus easily exceeded. Had the 9 species observed in 2015 monitoring been raised to 10, the plot would have been within the lower reach of the threshold. It is not anticipated that species diversity will change drastically within this plot in the near future as the White Cedar canopy that exists in Plot 5 limits the groundcover and species diversity.

5.4.3 Change in Canopy Cover by 25% at One Station

Plot 8 remains the only plot which exceeded the canopy cover threshold. As reported in the 2011 HCBP Consolidated Monitoring Report (NRSI 2012a), canopy cover has been reduced in Plot 8, but the area of impact, adjacent to the plot has been restored through native plantings according to the HCBP EIR Restoration Plans. These plantings are being monitored for success and will increase shading to Tributary A that bisects Plot 8 as they mature.

5.4.4 Decreasing Coefficient of Wetness at Two Stations

Although Coefficient of Wetness (CW) is not used as a specific threshold for the vegetation monitoring, it is noteworthy that the CW values have shown a drying trend between 2011 and 2015 at Plots 16 and 18. These plots are located in close proximity to recent development (Block 9 and Block 10) and Hanlon Creek Boulevard. Groundwater levels at adjacent monitoring wells have been analyzed for temporal patterns and compared to the ground elevations (Section 2.7.1.1). However, the drought year in 2012 is the only obvious groundwater effect. Furthermore, it appears that fluctuations in groundwater levels would have little to no effect on the soil wetness in the wetlands because their elevations have never been above the ground surface of the wetlands. Groundwater levels in the vicinity of Plots 16 and 18 do not show a trend that matches the declining trend in CW values. Monitoring of vegetation and groundwater should continue at these plots in order to better understand the impacts which may be occurring within these features. It is also recommended that the presence and depth of surface water be monitored within these two stations in an agreed-upon manner each spring.

5.5 Change in Breeding Bird Species Diversity by 25% at Three Stations

Breeding bird species diversity was below the 25% threshold at Plot 11 in 2015 and was above the threshold at two stations including Plot 6 and Plot 7. Data indicates that species diversity in 2013, and 2012, to some extent, were exceptionally high in comparison to previous years which raised the 25% threshold notably.

At Plot 11 species diversity has fluctuated, reaching a high of 22 species in 2013 and with an average of 16 species between 2009 and 2015. In 2015 a total of 11 bird species were identified, which resulted in the exceedance and was the lowest diversity that has been seen at Plot 11 since sampling began in 2009. No construction work occurred in the vicinity of Plot 11 in 2015; however recent years have seen the installation of roads and servicing around the site, replacing a series of hedgerows that were originally present to the north. The lands surrounding Plot 11 now include a naturalized berm and graded lands which have recolonized with a variety of small herbaceous species. Given that Plot 11 does not provide core forest habitat, species which require larger tracts of forest would not be expected at this location and this area is not likely to support a high diversity of bird species. The exceedance at Plot 11 has been attributed to a natural fluctuation in bird species diversity in 2015.

Overall, the 2015 data strongly reflects a year of average to above average bird diversity. Temporary impacts relating to nearby development, as well as annual fluctuations in bird presence at each plot are to be expected. Continued monitoring will help to inform long-term trends.

5.6 Change in Breeding Bird Abundance by 25% at Six Stations

Plots 1, 3, 6, 9 and 11 were all below the 25% threshold in 2015 while Plot 5 was above the threshold. Breeding bird abundance was generally average to below average for the majority of plots in 2015, although bird numbers experienced an increase at the majority of plots between 2014 and 2015. As mentioned in previous monitoring reports, observations of flocks can have a notable impact on bird abundance figures. The threshold set within Plots 6 and 9 for pre-construction (2006-2009) both include very large numbers of Red-winged Blackbird or Canada Geese which inflated the threshold substantially. As both 2012 and 2013 constitute years of high bird abundance, and the presence of flocks within pre-construction threshold calculations, 2015 data is generally on average with the during-construction data set despite the threshold exceedances which were documented.

Monitoring should continue to assess breeding bird abundance to determine if bird abundance is being maintained across the site and within the different vegetation communities.

5.7 Decline in Amphibian Species Abundance at Three Stations

A decrease in two calling codes was established as the threshold in the HCBP Consolidated Monitoring Program (NRSI 2010). Two of these decreases were observed in 2015 including:

- Spring Peeper in Plots 12 and 14 – no individuals recorded in 2015, down from a call code 2 recorded at each of these plots in 2014.

It should be noted that Spring Peeper remains widespread and abundant within the study area. Additionally, Spring Peeper was only documented for the first time in Plot 14 in 2014. Plot 12 is now separated from the larger natural area by the Laird Road overpass and associated curbs. As an isolated feature Spring Peepers may have relocated to larger and more suitable habitats in the vicinity or the localized population may have disappeared following several years of drier conditions which may have limited successful reproduction. It should be noted that this species was only recorded within Plot 14 for the first time in 2014.

As noted in previous monitoring reports, the use of SWM ponds by Spring Peepers, as well as American Toads, has increased notably since their creation. The continued establishment of riparian and aquatic vegetation within SWM ponds will likely continue to provide suitable foraging and breeding habitat for some anuran species.

The remaining identified species, Green Frog, Northern Leopard Frog, Pickerel Frog and Western Chorus Frog have all been observed intermittently within the subject property dating back to the 2007 monitoring year. Generally, these species have been observed in low numbers at a call code of 1 or 2. It is likely that these species have always existed in low numbers within the property and are subject to natural population fluctuations.

6.0 Summary of Corrective Measures Undertaken

No corrective measures were undertaken in 2015. The RAAP group met on several occasions regarding temperature exceedances, including one site visit by the RAAP team in August following an exceedance at HC-A(06), and an additional visit by AECOM to confirm site conditions following an exceedance at Station HC-A(03).

The temperature effects continued at SWM Pond 4, and the corrective measures undertaken in 2012 were again monitored for effectiveness in 2015. The corrective measures undertaken in 2012 included:

1) raising the outlet of the cooling trench at Pond 4 (this was removed in early 2013),
2) raising the weir level at the pond outlet at Pond 4, and
3) planting of aquatic vegetation throughout the shallow areas of the pond as well as planting vines and herbaceous species in and around the cooling trench at Pond 4.

The decision to wait on implementing additional corrective measures was based on the fact that the vegetation planted in 2012 can take several years (5+) to become well established and mature in order to function as intended. The 2015 monitoring year was the 4th year that the plantings have had to establish and a review of the plantings near the end of the growing season has indicated that they still haven't established enough to have a positive effect on the Pond 4 temperatures. Looking ahead, it will be necessary to undertake additional corrective measures to address the thermal impacts from SWM Pond 4. The RAAP team identified four mitigation measures to be considered for implementation, including: the installation of a drainage tile along the east side of Pond 4, installation of a floating island, planting of live stakes along the edges of the cooling trench, and redirecting or bioengineering the cooling trench outlet. By the end of 2015 these mitigation measures were still under consideration and review and it is expected that decisions regarding this will be made in 2016.

While other issues have been identified through review of the monitoring results, there were no other clear cause-and-effect relationships that constituted problems to be rectified through corrective measures.

7.0 Recommendations

7.1 Actions for 2015

Based on the 2015 monitoring results, it is recommended that additional corrective measures be developed to address the effects of SWM Pond 4 on water temperatures in Tributary A. A variety of corrective measures were identified and have been included in Section 6.0. The need for additional monitoring requirements should be considered in conjunction with the development and implementation of the corrective measures.

While other issues were identified as a result of threshold exceedances or other occurrences, none of the issues were clearly linked to impacts from development. Therefore, no further actions are recommended at this time based on the available monitoring information.

7.2 Future Monitoring

2015 marked the sixth year of construction-phase monitoring at the HCBP. The following recommendations for monitoring are made with this in mind.

It is recommended that monitoring continue with diligent attention given to stream temperatures and the SWM Pond 4 mitigation measures put in place to date, using the RAAP as prompted by any stream temperature or turbidity exceedances. This will ensure that attention is given to any ongoing patterns in stream temperature, and actions can be taken if deemed necessary. Additional monitoring may also be required to inform the development and implementation of measures to mitigate the effects on stream temperatures.

The long-term groundwater monitoring program at the HCBP site should continue in 2015 on a quarterly basis as previously recommended. Particular attention should be given to monitoring wells MW119A, PZ-13D and PZ-14D regarding the temperature effects of SWM Pond 4, and to monitoring wells MW103 and MW118A regarding the declining CW values at vegetation Plots 16 and 18. As a new monitoring item, surface water should be monitored at Plots 16 and 18 and adjacent roads, swales and development blocks in order to determine whether surface hydrology has been altered in a manner that is affecting Plots 16 and 18. Groundwater samples should continue to be collected from selected monitoring wells and analyzed for the established water quality parameters. The improved filtering of water samples should be continued as standard practise.

The surface water monitoring program during and post construction should continue in 2016 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010) to ensure temperature targets are met and water temperatures are suitable for Brook Trout. Monitoring of stormwater management ponds should also continue in 2016 to monitor their effectiveness, including the bottom draw outlet and cooling trench performance. Flow monitoring should be resumed at stations HC-A(08) and HC-A(09) in order to improve analysis of the fish and benthic invertebrate monitoring results. Also, it may be suitable for the surface water monitoring technicians to monitor for surface flow/ponding in the area within and around Vegetation Plots 16 and 18 using an agreed-upon method.

Fish and benthic invertebrate monitoring should continue to occur in 2016 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

Vegetation monitoring should continue as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010), with the following notes for 2016. Special attention should be given to Plots 16 and 18 to determine if there is a continued decline in CW values. The frequency of terrestrial monitoring should be reviewed to determine if some or all of the plots should be monitored at a reduced frequency.

Monitoring of the aquatic and riparian vegetation within the SWM Pond 4 and herbaceous plants along the cooling trench should also continue in order to monitor the survival and establishment of the vegetation planted in the fall of 2012.

Breeding bird and amphibian monitoring should continue in 2016 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

Monitoring of all anuran plots should continue with a particular focus on changes observed within Plot 16. In the case that anuran diversity and abundance is found to be impacted by development activities, management recommendations may be made in order to mitigate or reverse negative trends.

8.0 Conclusions

Monitoring at the Hanlon Creek Business Park in 2015 was successful in providing useful information to describe environmental conditions on site, detect issues and develop solutions. Elevated stream temperatures and the contributing temperature impacts from SWM Pond 4 continued to be the most prominent issue in 2015. As such, monitoring in 2016 should give particular attention to this issue through the continued monitoring of nearby wells and the effectiveness of the planted vines and aquatic vegetation. The RAAP group should carefully review any stream temperature threshold exceedances. Additional corrective measures should also be developed to mitigate the effects on stream temperatures, including additional monitoring as required to inform such measures.

The decline in CW at vegetation Plots 16 and 18 represents another issue to be investigated further, and surface water and groundwater monitoring should continue to be investigated in the nearby monitoring wells.

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MAPS

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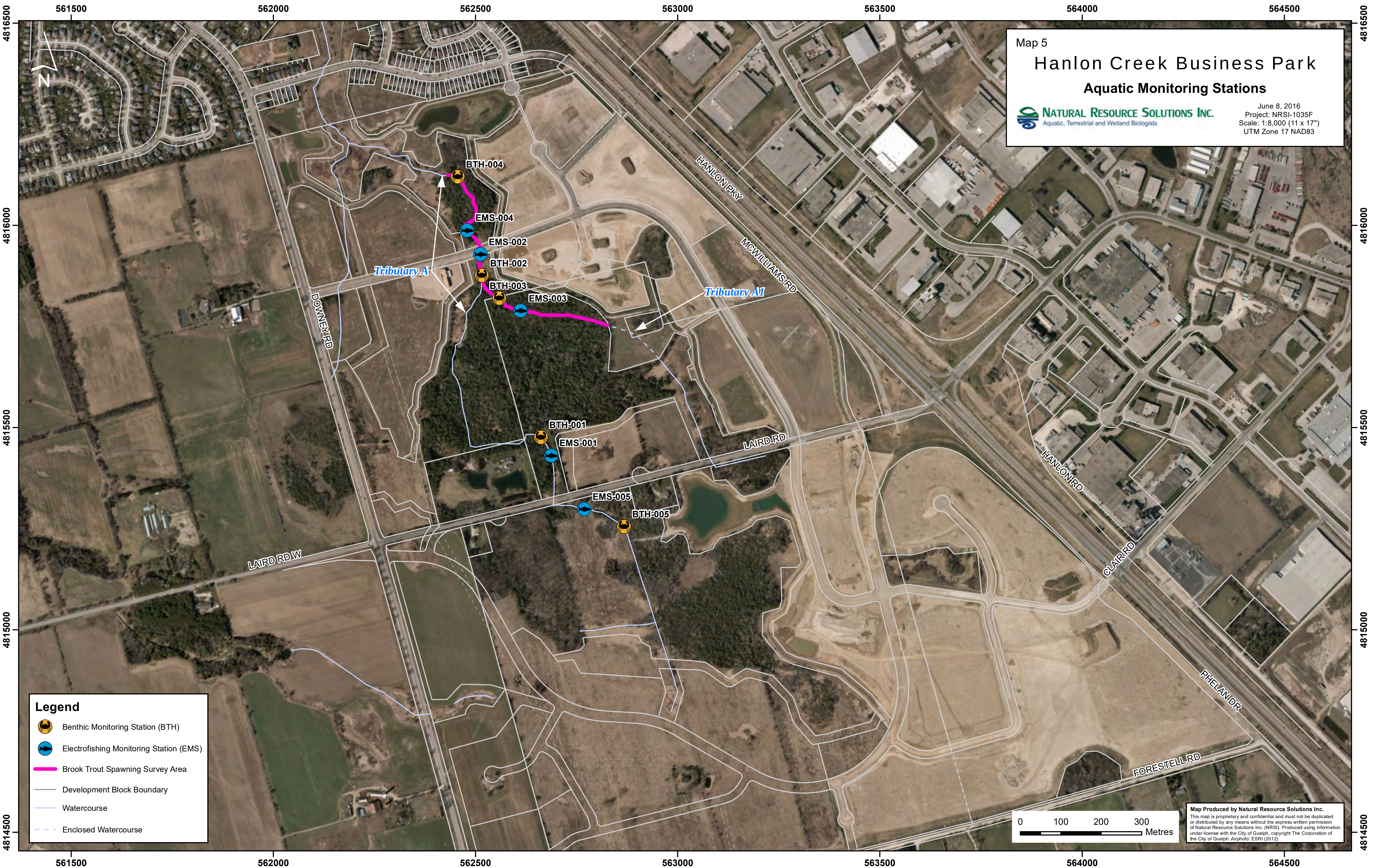

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APPENDIX I

GROUNDWATER MONITORING REPORT

APPENDIX II

SURFACE WATER MONITORING REPORT

APPENDIX III

AQUATIC MONITORING REPORT

APPENDIX IV

TERRESTRIAL AND WETLAND MONITORING REPORT

APPENDIX V

RAPID ASSESSMENT AND ACTION PROTOCOL DOCUMENTATION

Annual Technical Memorandum
Groundwater Monitoring Program for 2015
Hanlon Creek Business Park
City of Guelph

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Technical Memorandum

21 April 2016

Hanlon Creek Business Park
2015 Groundwater Monitoring Program

1 Introduction

This Technical Memorandum presents the results of the eighth year of a long-term groundwater monitoring program for the Hanlon Creek Business Park (HCBP). The results of the first seven years were presented in Technical Memoranda completed in 2009 through 2015 respectively. A Hydrogeology Report was completed by Banks Groundwater Engineering Limited in May 2008, as part of the Environmental Implementation Report (EIR), in support of the proposed HCBP. The Hydrogeology Report presented a recommended long-term groundwater monitoring program. This program was developed in recognition of the importance of establishing baseline groundwater conditions and to assess any changes in groundwater elevations and groundwater quality during and following development of the site. The monitoring program is also required to assess the performance of the stormwater management facilities as they are constructed and to observe seasonal trends in water levels in the core wetland. This monitoring program is consistent with the recommendations of the Hanlon Creek State-of-the-Watershed Study Report (2003).

Baseline groundwater conditions were established during five years of on-site monitoring. The detailed results for the period spring 2003 to spring 2008 were presented in the Hydrogeology Report. Banks Groundwater Engineering is continuing to monitor groundwater in on-site monitoring wells and in wetland and streambed mini-piezometers on a quarterly basis. To correspond to previous monitoring, the preferred monitoring periods are January, April, July and October. Data loggers have been installed to measure and record groundwater levels and temperatures on a more frequent basis in selected monitoring wells and mini-piezometers. Groundwater samples are being collected from selected monitoring wells on an annual basis and analyzed for a representative list of groundwater quality parameters to augment the existing background water quality data.

It is not expected that development of this site will have any effect on local private water wells. It is expected that if any changes in groundwater elevations and groundwater quality occur during and following development of the site, as a result of construction and post-construction activities, they will become apparent first in the on-site monitoring wells. Therefore, it was concluded that monitoring of local private wells was not required.

It is also noted that selected monitoring wells and mini-piezometers are currently being monitored for the purpose of establishing baseline data in advance of proposed adjacent land use activities (e.g. Mast-Snyder Gravel Pit). Changes related to climatic conditions are being observed in the on-site monitoring wells and mini-piezometers.

Site grading began in 2010 in Phases 1 and 2. This necessitated decommissioning of selected monitoring stations located within the grading areas, in accordance with Ontario Regulation 903 (as recently amended) of the Ontario Water Resources Act by a licensed Water Well Technician. Records of well decommissioning are required by this Regulation to be completed and submitted to the Owner and the Ministry of the Environment and Climate Change (MOECC).

A total of 12 monitoring wells had been decommissioned by the end of 2011, three monitors were located in Phase 1 and the remaining nine monitors were located in Phase 2.

Many existing monitoring wells have been maintained, with minor modifications or improvements, for continued monitoring. Six additional monitors were installed within Phase 1 in October 2011, and five additional monitors were installed within Phase 2 in January 2012. Monitoring of the eleven additional wells began in January 2012.

The monitoring data has been compiled, plotted, and analyzed and the results are presented in this Technical Memorandum. Conclusions and recommendations related to the monitoring program are summarized.

2 Groundwater Monitoring

2.1 Groundwater Monitoring Background

Groundwater level monitoring was conducted at this site for more than five years in support of the evaluation of local hydrogeological conditions. The various stages of monitoring that have been completed are summarized in the EIR Hydrogeology Report. Since January 2007, groundwater levels have been monitored at the HCBP site on a quarterly basis.

The locations of the current groundwater monitoring stations are shown in Figure 1. As noted above, some stations have been decommissioned and new stations were installed as of January 2012.

2.2 Groundwater Monitoring Stations Status

The status of each groundwater monitoring station is determined during each monitoring round. This includes all monitoring wells and mini-piezometers. The current condition of each station and other relevant attributes are described in Appendix A. Monitoring wells decommissioned during 2010 and 2011 are identified. Additional monitoring wells and mini-piezometers in Phases 1 and 2 are also included.

2.3 Groundwater Monitoring Data Collection and Compilation

The establishment of baseline groundwater conditions continued until grading of the site was initiated. This included monitoring of groundwater levels in selected monitoring wells and mini-piezometers (listed in Appendix A). In most cases this monitoring will continue to occur on a seasonal basis to establish variations in groundwater levels for each season at each station. In a selected number of monitors, groundwater levels and temperatures will also continue to be recorded on a frequent basis using data loggers. This will assist in determining the relationships of groundwater levels, wetland levels, surface water flow, and precipitation. Groundwater samples were collected from selected monitoring wells and analyzed for general chemical parameters in 2015. Sampling and analysis is to continue on an annual basis.

During the 2015 monitoring period, there were 37 functioning monitoring wells and 19 mini-piezometers located across the HCBP site. Two of the mini-piezometers were installed in June 2013 on a temporary basis, and remained in-place at the end of 2015 (details below). The data obtained from all groundwater monitoring locations during 2015 were compiled for the purpose of the analyses presented below.

Following each seasonal monitoring period, the data was recorded and entered into the groundwater level and temperature monitoring dataset. Data downloaded from each data logger was corrected for barometric pressure and then incorporated into the respective records within the groundwater level monitoring dataset. As the dataset is updated, tables and graphs are also updated to support on-going analysis of the groundwater monitoring results.

2.4 Groundwater Monitoring Results

The results of manual groundwater level measurements at the HCBP site up to October 2015 are summarized in tabular format in Appendix B. Selected monitoring station details are included with the monitoring data, which is presented as depth (in metres) to groundwater below current ground level and groundwater elevation (metres above mean sea level).

The groundwater elevation data for each monitoring station, based on the manual measurements, are presented in graphical format in Appendix C. The groundwater elevations from April 2003 to October 2015 presented in these graphs illustrate seasonal levels for most locations. The range of groundwater elevations varies with each monitoring location, ranging from as little as 0.45 m, to as much as 2.53 m over this 12.5-year monitoring period. Monitoring well MW123 is excluded from this comparison as it is completed in the deep bedrock aquifer and the groundwater levels are influenced by municipal well production.

Presented in Appendix D is a summary of vertical hydraulic gradient calculations, based on comparisons of shallow, intermediate and deep monitoring intervals, on selected dates. Graphs illustrating groundwater elevations and hydraulic gradients are included, with monitoring stations grouped in seven west-to-east profiles. These data and graphs confirm the downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Groundwater discharge conditions have also been confirmed at the wetland adjacent to Downey Road, situated between Laird and Forestell Roads.

Given that climate is one of the most significant factors influencing groundwater elevations, available local climate data was compiled and is presented in graphical format in Appendix E. During 2015, groundwater elevations and temperatures were recorded using data loggers in 38 groundwater monitoring stations. These data are presented with the climate data in Appendixes F, G, and H.

The hourly groundwater elevation data presented in Appendixes F, G, and H has been further assessed by reducing the data into graphs of the quarterly (i.e. seasonal) range in hourly groundwater elevations for each of the currently-existing monitors that are equipped with data loggers for part or all of the period from 2007 to 2015. This format is intended to assist in illustrating any significant changes and/or trends in the data when compared year-over-year for each quarter. This is the second annual report to include such graphs, which are presented in Appendix I.

Groundwater samples have been collected from selected monitoring wells in July 2003 and each April from 2008 to 2015. The samples were submitted to an accredited laboratory for analysis of selected chemical parameters. As indicated previously, this will provide a baseline of groundwater quality data prior to and during development of the site. The water quality data are presented in Appendix J.

3 Groundwater Characterization Update

3.1 Factors Influencing Fluctuations in Groundwater Elevations

There are a number of factors that influence groundwater levels at any given time and location, including:

- Precipitation
- Ambient air temperature and solar radiation (influencing snowmelt, evaporation and evapotranspiration)
- Vegetation
- Soils
- Geology
- Topography and associated drainage characteristics

- Land cover
- Local groundwater withdrawals and uses (e.g. construction dewatering).

Each of these factors can influence the rate and spatial distribution of groundwater recharge. As such, it was important to account for these factors under the pre-development conditions in order to appreciate the causes of observed groundwater elevation changes. These changes also need to be evaluated relative to long-, medium-, and short-term influences. For the purposes of this evaluation, a long-term influence is considered for example to be lower-than-normal precipitation over several years, which have caused drought conditions in this area of Ontario historically and recently. For the purposes of this evaluation, medium-term influences are considered seasonal. Short-term influences are considered event-related, such as spring thaw and periods of above-normal or sustained rainfall.

Given that climate is one of the most significant factors influencing groundwater elevations, available local climate data was compiled and plotted to evaluate short-, medium-, and long-term variations and trends in precipitation and air temperature. A detailed evaluation of climate and fluctuations in groundwater elevations was presented in the EIR Hydrogeology Report.

Updated climate data is presented in graphical format in Appendix E. Graph E1 presents the total annual precipitation recorded at the Region of Waterloo International Airport Station (WMO ID 71368), for the period 1971 to 2015 inclusive. This station was selected due to its' proximity to the HCBP site and availability of total daily precipitation and maximum daily air temperature data. Also illustrated in Graph E1 is a trend line depicting the annual cumulative departure from the average annual precipitation for this 45-year period, which is estimated to be 879 mm/year. This technique is helpful in illustrating periods of above- and below-average annual precipitation. An upward trend indicates sequential years of above-average precipitation (e.g. 1982 to 1988). A downward trend indicates a period of below-average precipitation (e.g. 1997 to 2007), possibly resulting in drought conditions. These longer-term trends can have a notable influence on groundwater levels. They need to be considered in the context of past, present, and future groundwater levels on-site due to the relatively shorter period (i.e. less than 13 years) of groundwater monitoring that has been conducted at the HCBP site.

The data presented in Graph E1 indicates that during the period 1997 to 2015 inclusive, the total annual precipitation for 13 out of 19 years was below the 45-year average of 879 mm/year. It is therefore interpreted that groundwater levels would have been elevated during the early to mid-1990's and likely declined from 1997 to 2007. Since groundwater monitoring began on-site in 2003, the total annual precipitation has been above the longer-term annual average in the years 2003, 2006, 2008, 2011, and 2013. The varying annual precipitation during this period has caused groundwater levels to continue to fluctuate.

As indicated above, the groundwater monitoring program on-site began in April 2003. It is therefore useful to consider total monthly precipitation during this period (and shortly before) to evaluate medium-term influences on groundwater levels. Graph E2 presents the total monthly precipitation recorded at the Region of Waterloo International Airport Station, for the period January 2003 to December 2015 inclusive. Also illustrated in Graph E2 is a trend line depicting the monthly cumulative departure from the average monthly precipitation for this period. The average monthly precipitation for the period 2003 to 2015 has been calculated to be about 68 mm/month. Similar to the annual data, an upward trend indicates sequential months of above-average precipitation, which may cause increases in groundwater levels. A downward trend indicates a period of below-average precipitation, possibly resulting in a reduction in groundwater levels. On the basis of Graph E2, it would be expected that groundwater levels would be higher following months of above average precipitation (e.g. October through December 2007, June through December 2008, April through August 2009, August through December 2011, September through October 2012, April through July 2013, April, July and September 2014, and April, June, August, and October 2015).

The monthly observed precipitation from January 2003 to December 2015, the monthly normals, and the cumulative departure from the normal monthly precipitation are presented in Graph E3. This plot suggests that, due to a declining trend in precipitation from the spring of 2004 to the spring of 2008, groundwater levels would have declined during the same period, followed by an increase from the summer of 2008 to the summer of 2009, when monthly precipitation was greater. Increases in groundwater levels would also be expected in the spring of 2010, the fall of 2011, the fall of 2012, the spring and fall of 2013, and in the summer and fall of 2014 and 2015.

An alternative method to evaluate fluctuations in groundwater levels relative to monthly precipitation trends is to consider the monthly cumulative departure from normal monthly amounts. The normal amounts are based on the updated 30-year record (i.e. from 1981 to 2010), which was published in 2013 by Environment Canada. The updated record was applied in preparation of Graph E3.

These observations are further illustrated in Graph E4, which presents the preceding 18-month average monthly precipitation for the period from January 2003 to December 2015. This graph was developed with the understanding that the preceding 18 months of precipitation are likely the most influential on observed groundwater elevation trends. The cumulative departure from the 18-month average precipitation over this period also emphasizes the trends observed in Graph E2. One of the most notable recent trends is the increase in average precipitation beginning late-2008 and continuing to January 2010. This was followed by fluctuations up to about October 2014, including a declining trend from January to August 2011, and then somewhat of a rebound from September 2011 to April 2012. A significant rise is observed from July 2013 to January 2015, and this 18-month increase represents the second highest level since monitoring began in 2003.

Short-term influences related to events are depicted by daily precipitation totals and ambient air temperature (i.e. maximum daily temperature). These data are presented in Graph E5, for the March 2007 to December 2015 monitoring period, and in Graph E6 for the January to December 2015 period. To determine which events have an immediate influence on groundwater levels, total daily precipitation and air temperature are plotted together and compared with groundwater levels. Based on available data, the relationship of the above factors to observed fluctuations in groundwater elevations within the HCBP site was evaluated with direct reference to Graphs E1 to E6 and graphs of groundwater elevations observed at each monitoring station. This analysis is presented in the following sub-sections.

3.2 Observed Groundwater Elevations and Depths to Groundwater

The manually-recorded groundwater elevations for each monitoring station are summarized in tabular form in Appendix B, and presented as graphs in Appendix C. Groundwater elevations recorded by data loggers installed in 38 of the active monitoring locations are presented as graphs in Appendixes F, G, and H. Graphs for monitoring stations that have been decommissioned are also included for reference in Appendixes C, G and H. The observed groundwater elevations can be associated with the long-, medium-, and short-term factors discussed previously. To assist with the direct comparison of groundwater elevations and precipitation, the total monthly precipitation has been included in each of the graphs in Appendixes F, G, and H. The interpreted relationships are discussed below.

3.2.1 Long-Term

Analyses presented in the seven previous Technical Memoranda and the EIR Hydrogeology Report showed that it is likely groundwater levels declined from the spring of 1997 to the fall of 2007, based on the recorded precipitation for this period. Evidence of the effects of the longer trend of below-average precipitation is shown by the groundwater levels in July and November 2007, which prior to 2012 were the lowest observed groundwater elevations on-site. Precipitation in 2007 was well below average and was the lowest observed from 1971 to 2015 (refer to Graph E1). Below-average annual precipitation in 2009 and 2010 also influenced groundwater elevations through the summer and fall of 2010.

The total precipitation in 2012 was 684 mm, which was the fourth lowest recorded amount from 1971 to 2015. This was attributed to below-average precipitation in nine of twelve months in 2012.

Groundwater levels at many monitored locations on-site during the summer and fall of 2012 were the lowest recorded since monitoring began in 2003.

In contrast, annual precipitation in 2003, 2006, 2008, 2011, and 2013 was above average. This appears to have influenced groundwater levels in the spring of 2004 and 2007, the spring and fall of 2008, in the last five months of 2011, and from spring to fall in 2013.

3.2.2 Medium-Term

Analyses presented in the seven previous Technical Memoranda and the EIR Hydrogeology Report showed that monthly total precipitation and trends (depicted in Graphs E2 and E3) provide additional insight related to the observed seasonal fluctuations in groundwater elevations. Following below-average precipitation in late 2009, through most of 2010, and into February 2011, groundwater elevations declined and approached the low levels observed in 2007. Above-average precipitation from March to December 2011 (with the exception of July), reversed the declining groundwater levels at many locations. But then the below-average precipitation through seven of the first eight months of 2012 caused groundwater levels to decline, and at many locations to the lowest recorded since monitoring began in 2003. These effects were reversed following above-average monthly precipitation in September and October 2012, and the following spring and fall of 2013.

Throughout 2015, maximum daily temperatures fluctuated within the typical seasonal ranges, although the winter of 2014-2015 was considered one of the coldest in recent years. With the exception of only four days in January, maximum daily temperatures remained below freezing until the second week of March. There were only four days in March when the maximum daily temperature was below freezing, otherwise temperatures remained above freezing from March almost through to the end of December 2015. There were only three days in December that were just below freezing.

Combined snow and rainfall through January, February and March was only about 38 mm, which is about 139 mm below the normal amount of precipitation for this period. Further comparisons of 2015 monthly precipitation amounts versus normal monthly amounts are presented in Table 1.

Table 1: 2015 Monthly Precipitation versus Monthly Normals

Month	2015 Total Monthly Precipitation (mm)	Normal Monthly Precipitation (mm)	Difference (mm)
January	21.5	65.2	- 43.7
February	7.5	54.9	- 47.4
March	8.8	61.0	- 52.2
April	73.7	74.5	- 0.8
May	66.1	82.3	- 16.2
June	124.3	82.4	41.9
July	26.6	98.6	- 72.0
August	83.9	83.9	0.0
September	55.9	87.8	- 31.9
October	92.0	67.4	24.6
November	49.5	87.1	- 37.6
December	57.0	71.2	- 14.2
Total	666.8	916.5	- 249.7

The data presented above in Table 1 illustrates there were only three months in 2015 where precipitation was at or above normal monthly amounts (i.e. June, August and October). During June there were five days with precipitation totals of more than 10 mm, totalling almost 90 mm. During August precipitation events of more than 10 mm occurred on three separate days, for a total of 68 mm. In October there were four days where precipitation events of more than 10 mm occurred, with a total of 73 mm.

The slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at most locations during the second half of March and early-April. Groundwater levels began the typical decline in May. Precipitation events in June resulted in short-term groundwater level increases, but levels continued to decline until events in October caused groundwater levels to rise and fluctuate through November and December.

3.2.3 Short-Term

The manual measuring and recording of groundwater levels across the HCBP site has been conducted on 45 occasions, during various months and seasons, from April 2003 to October 2015. As a result, monitoring of groundwater levels may not have occurred at precisely the best time to observe the highest and lowest annual elevations. Fortunately however, groundwater levels were observed in selected monitors in the spring of 2003, in most monitors in the springs of 2004 and 2006, and in all available monitors during the spring from 2007 to 2015 inclusive. Therefore, it is expected that these observations represent the influence of spring thaw and precipitation events, and as such are reasonably close to the highest annual levels for this monitoring period.

To evaluate the response to spring thaw and precipitation at selected groundwater monitors, data loggers were installed to record groundwater levels on a more frequent basis. Table 2 below lists the monitoring wells and mini-piezometers where 38 data loggers were in operation for all of 2015 (refer to Figure 1 for locations). A number of locations were selected to evaluate groundwater levels and to establish baseline conditions relative to various climate effects prior to development of the HCBP.

The EIR Hydrogeology Report presented a detailed evaluation of daily influences from March 2007 to April 2008. The previous seven Technical Memoranda presented a detailed evaluation of climate influences on groundwater levels for January through December for each year from 2008 to 2014 respectively. For reference, the total daily precipitation and maximum daily air temperature recorded at the Region of Waterloo International Airport Station are presented in Graph E5, for the period March 2007 to December 2015.

The following is noted for January through December 2015 in Graphs E2 to E6:

- As noted above, with the exception of only four days in January, maximum daily temperatures remained below freezing until the second week of March. There were only four days in March when the maximum daily temperature was below freezing, otherwise temperatures remained above freezing from March almost through to the end of December 2015. There were only three days in December that were just below freezing.
- Combined snow and rainfall through January, February and March was only about 38 mm, which is about 139 mm below the normal amount of precipitation for this period. However, despite the limited amount of precipitation during this period, the slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at most locations during the second half of March and early-April.
- Rainfall continued to be below normal for the months of April and May (refer to Table 1), resulting in a decline in groundwater levels at many monitoring locations from mid-April through May.
- June rainfall was almost 42 mm above normal, causing groundwater levels to rise temporarily. Groundwater levels then tended downwards to a low in early October.
- October received about 25 mm above the normal amount of rain, causing groundwater levels to rise through the month. This was followed by a combined lower-than-normal amount in

November and December. A precipitation total of about 106.5 mm was less than the normal combined amount of 158.3 mm for these two months.

- Total precipitation was above-normal for the months of June and October only. August rainfall was equal to the monthly normal. Total monthly precipitation was below normal amounts for the other nine months.
- The total precipitation through 2015 was about 667 mm, as compared to a 45-year average of about 879 mm and a normal of 916.5 mm.

These are considered to be the main climatic factors influencing groundwater levels on-site during the 2015 interval. The highest groundwater levels observed in monitors equipped with data loggers occurred during the months of January, April, June, and December. The lowest groundwater levels occurred in early-March and September.

Table 2: Monitoring Stations Equipped With Data Loggers as of December 2015

Monitoring Well	Data Logger Installed	Monitoring Well	Data Logger Installed
003	March 2007	122A	July 2008
004	August 2009	124	January 2012
103	June 2010	125	January 2012
104	January 2008	126	January 2012
105	January 2008	127	January 2012
107	July 2008	128	January 2012
109	April 2009	129	January 2012
111	October 2010	130A	January 2012
112	October 2010	131	January 2012
116A	January 2008	132	January 2012
117A	January 2008	133	January 2012
118A	July 2008	134	January 2012
119A	July 2008	135	January 2012
121A	July 2008		

Mini-Piezometer	Data Logger Installed	Mini-Piezometer	Data Logger Installed
1D	April 2009	9D	March 2007
2D	January 2007	10D	April 2012
4D	April 2009	11D	June 2010
7D	November 2007	12D	January 2012
8D	June 2010	14D	June 2013

2015 Groundwater Level Monitoring at Downey Road PSW

Groundwater levels and temperatures are monitored at two stations at the Downey Road PSW. These include monitoring well MW003, which is located on the north edge of the PSW, and mini-piezometer nest PZ-9, which is located in the centre of the PSW. The groundwater level and temperature observations for MW003 and PZ-9D are presented in graphical format in Appendix F.

Graph F1 presents the daily groundwater elevations (with occasional manual readings) recorded in monitor MW003, from March 2007 to January 2008. In late January 2008, the data logger was re-set to record groundwater levels and temperatures on an hourly basis. The EIR Hydrogeology Report presented a detailed evaluation of groundwater levels from March 2007 to April 2008, and the seven previous Technical Memoranda presented a detailed evaluation for each respective year from 2008 through 2014. The following is a summary of 2015 observations at this location.

During the months of January, February and March 2015, groundwater levels declined and were somewhat lower than the typical range for this time of year for this location. As noted previously, combined snow and rainfall through January, February and March was only about 38 mm, which is about 139 mm below the normal amount of precipitation for this period. However, despite the limited amount of precipitation during this period, the slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at this location during the second half of March and early-April.

Groundwater levels began a gradual decline in mid-April, which is earlier than most years, and continued to decline through May. June rainfall caused levels to rise again, before declining through July to early October. Groundwater levels rose in response to precipitation events in October and December.

The responses to precipitation events and spring thaw, or lack thereof, observed in this monitor during the period 2007 to 2015, have demonstrated the local sensitivity of the shallow groundwater system, which is associated with the coarse-grained nature of the overburden deposits within and above the uppermost aquifer. The below-normal precipitation during 2015 caused groundwater levels to decline to the third-lowest late-summer/early-fall levels at this location since data logger monitoring began in 2007.

As noted above, two mini-piezometers were installed in the Downey Road PSW. PZ-9S was installed to a depth of about 0.5 m and PZ-9D to a depth of about 1.0 m below ground level. Graph F2 presents the groundwater elevations recorded in mini-piezometer PZ-9D, for the period March 2007 to December 2015. Groundwater levels for this pair of shallow and deeper mini-piezometers have illustrated the upward hydraulic gradient that exists in this PSW.

It is noted that responses to precipitation and temperature are apparent in PZ-9D in Graph F2, similar to MW003, confirming the infiltrative capacity of the medium- to coarse-grained deposits on this site and the inherent relationship of the wetlands to the shallow groundwater system. Each year, groundwater levels decline to an elevation that is below ground level in the wetland, typically during June or July.

The groundwater elevations for MW003 and PZ-9D are combined in Graph F3, indicating similar trends in each monitor. A small upward hydraulic gradient is also evident at various times when groundwater levels in MW003 are higher when compared with levels in the adjacent PZ-9D.

2015 Groundwater Level Monitoring in the Core PSW

Groundwater level and temperature observations, for monitoring wells and mini-piezometers that are located in and adjacent to the Core PSW of the HCBP, are presented in graphical format in Appendix G. The total monthly precipitation has been included for comparison in the groundwater elevation graphs. The maximum daily air temperature trend has been included for comparison in the groundwater temperature graphs. The graphs in Appendix G are presented in an order that corresponds to the north-to-south locations of the monitoring stations (refer to Figure 1).

The responses to maximum daily air temperatures and precipitation are apparent in these plots. This confirms the infiltrative capacity of the medium- to coarse-grained deposits adjacent to the Core PSW and the inherent relationship of the wetlands to the shallow groundwater system. The hourly recording of groundwater levels at mini-piezometer locations also indicates subtle fluctuations during each 24-hour period, likely associated with diurnal cycles of evapotranspiration in the wetland. The range of groundwater levels in mini-piezometers is more subdued than other plots, which reflects the relatively constant groundwater elevations in the wetland area, usually with only minor perturbations observed relative to precipitation and/or temperature changes.

The observed relationship of total daily rainfall and maximum daily temperature, recorded at the Region of Waterloo International Airport Station, to the groundwater levels and temperatures recorded on-site continues to validate the use of this station’s data for these analyses.

Groundwater levels at Core PSW monitoring stations during 2015 responded to climatic factors similar to the Downey Road PSW monitors described in the previous section. During the months of January, February and March 2015, groundwater levels declined and were somewhat lower than the typical range for this time of year for these locations. As noted previously, combined snow and rainfall through January, February and March was only about 38 mm, which is about 139 mm below the normal amount of precipitation for this period. However, despite the limited amount of precipitation during this period, the slow melt of the retained snow-pack and ground frost caused groundwater levels to rise at this location during the second half of March and early-April.

Groundwater levels began a gradual decline in mid-April, which is earlier than most years, and continued to decline through May. June rainfall caused levels to rise again, before declining through July to early October. Groundwater levels rose in response to precipitation events in October and December.

The below-normal precipitation during 2015 caused groundwater levels to decline to the third-lowest late-summer/early-fall levels at some locations. The lowest levels observed in 2015 varied from location to location, but most occurred during late-September or early-October. At almost all locations where data loggers had been in place for more than three years, the 2015 summer levels were comparable to 2013 and 2014 summer levels, which were above the low levels observed during the drought in the summer of 2012. At many Core PSW monitoring stations, groundwater levels rose in response to precipitation in early-October and December.

Groundwater levels in the three mini-piezometer monitoring locations (i.e. from north to south PZ-4D, PZ-2D, and PZ-1D) that are located in the Core PSW, were below the normal range for most of 2012. During 2013 through 2015, groundwater levels were within the range of previous years. The recorded groundwater elevations for PZ-4D, PZ-2D, and PZ-1D are presented in Graphs G13, G20, and G22 respectively. These graphs show groundwater levels that are typically at, or above, ground level during spring months and reduced levels during late-summer months.

Similarly, groundwater levels recorded in streambed mini-piezometers (i.e. from north to south PZ-10D, PZ-8D, PZ-11D, PZ-7D) were below the level of the creek and the streambed for part, if not most, of 2012. Groundwater levels during 2013 through 2015 were within the range observed in previous years, where data is available. The recorded groundwater elevations for PZ-10D, PZ-8D, PZ-11D, and PZ-7D are presented in Graphs G2, G4, G6, and G8 respectively. These graphs show groundwater levels at, or above, the streambed during spring months and reduced levels during late-summer months.

Climate had the greatest, if not only, influence on groundwater levels within the Core PSW in 2015. There were no apparent short-term and/or longer-term changes in groundwater levels that could be attributed to construction activities during 2015 within the HCBP (i.e. there were no abnormal changes in groundwater elevations that would have suggested otherwise). As of the end of 2015, six lots in Phase 1 had been developed and another five were at various stages of development. The first lot in Phase 2 was also being developed. The remainder of the graded portion of the site consisted of paved roadways, vegetated stormwater management swales and ponds, gravel-surfaced trails, and barren soils across most vacant lots. Based on the observed responses of groundwater levels to rainfall events and above-normal total monthly precipitation during June and October, it is evident that infiltration was occurring across the site.

2015 Groundwater Level Monitoring at Perimeter Locations

Groundwater level and temperature observations, for monitoring wells that are located at perimeter locations around the HCBP site, are presented in graphical format in Appendix H. The total monthly precipitation has been included for comparison in the groundwater elevation graphs. The maximum daily air temperature trend has been included for comparison in the groundwater temperature graphs. The graphs in Appendix H are presented in an order that corresponds to the north-to-south locations of the monitoring stations (refer to Figure 1).

The responses to precipitation and maximum daily air temperatures are also apparent in these plots. Groundwater elevations vary more widely over the year at perimeter locations in comparison to the Core

PSW locations. The perimeter groundwater monitoring stations responded to spring thaw and the above-normal precipitation during June and October 2015, similar to the monitoring stations described in the previous two sections. There were no apparent short-term and/or longer-term changes in groundwater levels at perimeter monitoring stations that could be attributed to construction activities during 2015 within the HCBP.

3.2.4 Site-Wide Observations

Groundwater Elevations

It is noted that, as expected, the greatest range in groundwater elevations occurs around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant. The smallest fluctuations occur in and adjacent to the core wetland and Hanlon Creek Tributary 'A'. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range of groundwater elevations in these areas.

The hourly groundwater elevation data presented in Appendixes F, G, and H has been further assessed by reducing the data into graphs of the quarterly (i.e. seasonal) range in hourly groundwater elevations for each of the currently-existing monitors that are equipped with data loggers for part or all of the period from 2007 to 2015. This format is intended to assist in illustrating any significant changes and/or trends in the data when compared year-over-year for each quarter/season. This is the second annual report to include such graphs, which are presented in Appendix I.

The graphs in Appendix I are presented in numerical order, with monitoring wells presented first and then followed by piezometers (refer to Figure 1). The responses to short-, medium- and longer-term precipitation amounts are apparent in these plots. There are no apparent changes in groundwater levels at these monitoring stations that could be attributed to construction activities within the HCBP, with the exception of those monitors affected by short-term construction dewatering events in 2010, 2011, and 2012. Therefore, it is recommended that this format continue to be utilized to track fluctuations in groundwater elevation trends as part of the long-term monitoring program.

Depth to Groundwater

The smallest fluctuations in depth to groundwater occur in and adjacent to the core wetland and Hanlon Creek Tributary 'A'. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range in depths to groundwater in these areas. The greatest range in depths to groundwater occurs around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant.

Groundwater Flow

The EIR Hydrogeology Report illustrated the horizontal direction of shallow groundwater flow is from southeast of the site, arcing towards the northern boundary of the site. The horizontal direction of groundwater flow coincides with the wetlands and creek, indicating that a portion of groundwater is discharging to this surface water system.

Also of interest is the vertical direction of groundwater flow. Presented in Appendix D is a summary of vertical hydraulic gradient calculations, based on comparisons of shallow, intermediate and deep monitoring intervals, on selected dates. Graphs illustrating groundwater elevations and hydraulic gradients are included, with monitoring stations grouped in seven west-to-east profiles. These data and graphs confirm the downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Seasonal variations in vertical directions of groundwater flow are also observed in some monitoring well pairs. Groundwater discharge conditions have also been confirmed at the Downey Road PSW.

3.2.5 Groundwater Temperatures

Data loggers installed in either a monitoring well or mini-piezometer also record groundwater temperature. These data are illustrated in graphical format in Appendixes F, G, and H, following the groundwater elevation graphs. The maximum daily air temperature trend has been included for comparison in these groundwater temperature graphs. Seasonal variations and associated time lags in groundwater temperatures are illustrated by these graphs.

PSW Groundwater Temperature Monitoring

As noted previously, groundwater level and temperature monitoring has been conducted using data loggers since 2007 at four PSW monitoring locations (i.e. MW003, PZ-9D, PZ-2D, and PZ-7D). These locations are representative of shallow groundwater conditions, although each location has somewhat different characteristics. The characteristics and factors that may influence groundwater temperatures are described as follows:

- MW003 – completed in the shallow water table aquifer; groundwater levels have ranged from 0.3 m above grade to 1.3 m below grade; located at the edge of an open agricultural field, adjacent to a provincially significant wetland (PSW); shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and by sunlight and standing water in the wetland during summer months (Graphs F 1 and F 1a, Appendix F)
- PZ-9D – relatively shallow (i.e. 1.0 m deep) mini-piezometer; groundwater levels have ranged from 0.62 m above grade to 0.88 m below grade; located in the PSW close to MW003; shallow groundwater temperature recorded is potentially influenced by cold air temperatures and frozen wetland during winter months and by sunlight and standing water in the wetland during summer months (Graphs F 2 and F 2a, Appendix F)
- PZ-2D – relatively shallow (i.e. 1.0 m deep) mini-piezometer; groundwater levels have ranged from 0.04 m above grade to 0.80 m below grade; located in a core wetland complex about 50 m east of Hanlon Creek Tributary 'A'; shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and moderated by trees providing shade during summer months (Graphs G 20 and G 20a, Appendix G)
- PZ-7D – relatively shallow (i.e. 1.0 m deep) mini-piezometer; groundwater levels have ranged from 0.25 m above grade to 0.05 m below grade; located in a core wetland complex in the eastern tributary of Hanlon Creek Tributary 'A'; shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and moderated by trees providing shade during summer months (Graphs G 8 and G 8a, Appendix G)

Temperatures recorded from March 2007 to December 2015 at these locations range from a low of just below 3^0C to a high of almost 16^0C. The 2015 temperature ranges for each location were as follows:

- MW003 – similar to previous years ranging from a low of 4.9^0C in the second week of April to a high of 11.6^0C in late-October
- PZ-9D – ranged from a low of 2.1^0C in the second week of April to a high of 14.6^0C in mid-September
- PZ-2D – ranged from a low of 4.0^0C in mid-April to a high in mid-September of 12.6^0C
- PZ-7D – ranged from a low of 4.2^0C in early-March to a high of 11.5^0C in early- to mid-September.

The temperature range of groundwater at greater depths in this general area tends to fluctuate in a narrower range, typically between 5 and 10^0C. It is therefore apparent that the temperatures in the shallower groundwater regime in the vicinity of these four monitors are influenced by seasonal variations in air temperature and solar radiation. These data are interpreted to be representative of the temperature of groundwater discharging to the wetlands and creeks in these locations.

Monitoring Well MW119A

This monitor is located adjacent to the northwest edge of stormwater management pond 4. The principal groundwater flow direction in this part of the HCBP site is north-westerly towards Tributary 'A' of Hanlon Creek. This monitor location is therefore down-gradient of pond 4. Groundwater temperatures recorded in monitoring well MW119A during 2015 ranged from a low of 5.2^{0}C at the start of April, to a high of 14.9^{0}C in mid/late-September (Graph G 18a, Appendix G). This is comparable to the ranges observed from 2008 to 2010. The highest temperature recorded to-date at this location was 17.5^{0}C on 5 September 2012. Prior to construction of pond 4 in late 2010, the highest groundwater temperature at this monitor was 15^{0}C in early-September 2010. The previous two years had reached a maximum of about 13^{0}C in September.

The pond bottom is below the shallow groundwater surface and as a result the un-lined pond is in direct contact with the local groundwater system. A portion of the water in the pond is interpreted to discharge from the pond as groundwater and flow in a north-westerly direction. Therefore, water in the pond warmed by solar radiation during summer months appears to have increased the groundwater temperature marginally in the area down-gradient of the pond. It was noted previously that the groundwater temperature at monitoring well MW119A at the end of December 2012 was 10^{0}C, compared to about 7 to 8^{0}C on the same date the preceding four years.

Additional monitoring of groundwater temperatures down-gradient of pond 4 was initiated in June 2013. A pair of shallow mini-piezometers (PZ-13D and PZ-14D) were installed on the east and west bank of Tributary 'A', and equipped with data loggers (refer to Figure 1). The piezometers were located a short distance down-stream from surface water monitoring station HC-A(04). The groundwater temperatures recorded in PZ-13D up to 27 September 2015 when the data logger failed and in PZ-14D up to the end of October 2015 are presented in Graph G24a. Also included in this graph are the groundwater temperatures recorded in MW119A and MW131. MW131 is located about 130 m up-gradient of pond 4. It is apparent from comparison with the MW131 graph that the groundwater temperatures at PZ-13D and possibly PZ-14D, which reached a maximum of just less than 14^{0}C in mid-September, was likely influenced by the warmer shallow groundwater flow affected by pond 4. The groundwater temperature at PZ-14D may have been influenced by solar radiation during summer months on the adjacent, up-gradient field. Graph 24a also shows that temperatures in PZ-13D and PZ-14D returned to below those recorded in MW131 by late-October each year.

The temperatures recorded in the remaining monitoring stations also reflect shallow groundwater temperatures near the central wetland complex and around the perimeter of the site. Temperature ranges and the timing of higher and lower temperatures are similar in most monitors. The highest observed groundwater temperatures are evident in monitors where the groundwater elevation is close to surface during summer months, particularly the monitors located in open fields. These monitors also exhibit the lowest groundwater temperatures during the late winter and early spring, when melting snow and frost infiltrate to the shallow groundwater system.

3.3 Relevance to Site Development and Stormwater Management

The observed minimum and maximum depths to shallow groundwater (i.e. water table) are presented in Appendix B for the 2003 to 2015 monitoring period. These observations indicate specific locations where there may be limitations to lot-level stormwater infiltration facilities. As noted previously, the greatest range in depths to groundwater occurs around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant. It is interpreted that it is in these areas where the groundwater elevations in the spring of 1997 would have been up to 0.5 m above those observed in April 2004, April 2007, and April 2008. Therefore, allowance should be made for this potential high groundwater elevation during the design of stormwater infiltration facilities, at the Site Plan Approval stage. The design should be in accordance with the Ministry of the Environment Stormwater Management Planning and Design Manual 2003, thus allowing adequate separation between the bottom of the infiltration system and the high water table elevation.

The business park has been partially-graded for development purposes. It will be necessary to consider the estimated depth to groundwater based on proposed site grading to further evaluate potential locations for lot-level stormwater infiltration facilities. Continued monitoring of groundwater levels at all functioning monitoring well locations is required to support these evaluations, which will be required as part of the Site Plan Approval process.

3.4 Groundwater Quality

Groundwater samples were first collected in 2003 from 23 selected monitoring wells, and then from 33 selected monitoring wells in 2008, 2009, and 2010, and 25 available monitoring wells in 2011. A total of 36 monitoring wells were available for sampling in 2012, 2013 and 2014, including the 11 additional monitoring wells. These wells were sampled again in 2015. The groundwater quality data are summarized in Appendix J. The data were compared to the Ontario Drinking Water Quality Standards (ODWQS), Ontario Regulation 169/03. Concentrations that exceeded the ODWQS are indicated on the tables. The groundwater can be characterized as basic (i.e. pH>7) and, based on the reported calcium and magnesium concentrations, as hard.

In general, the concentrations of the parameters analyzed were below the applicable ODWQS criteria, with the following exceptions (refer to Appendix J for specific exceedances and Figure 1 for well locations):

- Nitrate (as N) concentrations exceeded the ODWQS of 10.0 mg/L on at least one occasion in six monitoring wells
- Aluminum concentrations exceeded the ODWQS of 0.1 mg/L on at least one occasion in 24 monitoring wells
- Cadmium concentrations exceeded the ODWQS of 0.005 mg/L on at least one occasion in 11 monitoring wells
- Iron concentrations exceeded the ODWQS of 0.3 mg/L on at least one occasion in 32 monitoring wells
- Lead concentrations exceeded the ODWQS of 0.010 mg/L on at least one occasion in 22 monitoring wells
- Manganese concentrations exceeded the ODWQS of 0.05 mg/L on at least one occasion in 37 monitoring wells
- Sodium concentrations exceeded the ODWQS of 20 mg/L on at least one occasion in 37 monitoring wells
- Hardness concentrations exceeded the ODWQS of 100 mg/L in all monitoring wells.

The ODWQS for nitrate is health-related and the concentrations above this level in five monitoring wells can be attributed to the agricultural use of this site and the application of nutrients. Nitrate was also elevated above normal levels in five other monitoring wells. The elimination of nutrients applied to crops would be expected to reduce levels of nitrate. Such changes have been observed in other areas of Guelph.

The ODWQS for aluminum is an operational guideline for drinking water supplies and the elevated levels detected may be attributed to monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection since 2009 has resulted in reduced levels in all monitors.

The ODWQS for lead is a standard for drinking water supplies and the elevated levels detected may be attributed to monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection since 2009 has resulted in reduced levels in all monitors.

The ODWQS for iron and manganese is an aesthetic objective and the elevated levels are typical of groundwater in this area of Ontario. Improved filtering of samples at the time of collection since 2009 has resulted in reduced levels in all monitors.

The ODWQS for sodium is a health-related parameter for people on sodium-restricted diets. Elevated levels of sodium and chloride are often associated with the application of road salt for de-icing purposes. The levels of chloride do not exceed the ODWQS of 250 mg/L in any of the monitors; however, the level of chloride was elevated above normal levels in many of the monitors where sodium was elevated. The source of the elevated sodium and chloride occurring in some of the monitoring wells, including one of the bedrock wells, can likely be attributed to road salting along the Hanlon Expressway, Downey Road, and possibly Forestell Road.

The ODWQS for hardness is an aesthetic objective and the elevated levels observed in all monitoring wells are typical of groundwater in this area of Ontario.

Colour, turbidity, total dissolved solids, and DOC exceeded the respective ODWQS concentrations in most of the monitoring wells. This observation is typical for monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection since 2009 has resulted in reduced levels of some parameters.

3.5 Thresholds 2015

3.5.1 Groundwater Elevations

The manually-recorded groundwater elevations for each existing and decommissioned monitoring station are summarized in tabular form in Appendix B, and presented as graphs in Appendix C. Groundwater elevations recorded by data loggers currently installed in 38 of the monitoring locations are presented as graphs in Appendixes F, G, and H. Decommissioned monitoring stations that had been equipped with data loggers are also included in Appendixes G and H for reference. These graphs also include the total monthly precipitation to assist with the direct comparison of groundwater elevations and precipitation.

As described previously, groundwater elevations across the HCBP were affected by the lack of precipitation in 2012. However, precipitation, combined with the spring melt in 2013, 2014 and 2015, have caused groundwater levels to rise across the HCBP. Throughout 2015, groundwater elevations at almost all monitoring stations remained within the respective ranges observed in previous years, and as a result, there were no thresholds observed during this monitoring period. This is further illustrated by the quarterly/seasonal range in hourly groundwater elevation graphs presented in Appendix I.

In summary, climate had the greatest, if not only, influence on groundwater elevations across the HCBP in 2015. There were no apparent short-term and/or longer-term changes in groundwater levels that could be attributed to construction activities during 2015 within the HCBP. Construction dewatering occurred on two lots in Phase 1 during 2014, and there was no effect on groundwater levels in any of the nearby HCBP monitoring wells and piezometers. As of the end of 2015, six lots in Phase 1 had been developed and another five were at various stages of development. The first lot in Phase 2 was also being developed. The remainder of the graded portion of the site consisted of paved roadways, vegetated stormwater management swales and ponds, gravel-surfaced trails, and barren soils across most vacant lots. Based on the observed responses of groundwater levels to rainfall events and above-normal total monthly precipitation during June and October, it is evident that infiltration was occurring across the site.

3.5.2 Groundwater Temperatures

As described in sub-section 3.2.5, data loggers installed in either a monitoring well or mini-piezometer also record groundwater temperature. These data for 38 monitoring locations are illustrated in graphical format in Appendixes F, G, and H, following the groundwater elevation graphs. The maximum daily air temperature trend has been included for comparison in these groundwater temperature graphs.

Seasonal variations and associated time lags in groundwater temperatures are illustrated by these graphs.

Despite the influence of climate on groundwater elevations during 2015, groundwater temperatures fluctuated within the typical ranges at most of the 38 monitoring stations where data loggers are installed. Groundwater temperatures at monitoring stations MW119A, PZ13-D and PZ-14D, which are located down-gradient of pond 4, were likely influenced by the warmer water in this stormwater management pond in late summer. High temperatures in mid-September were 14.9^{0}C in MW119A, and at PZ-13D and PZ-14D were just less than 14^{0}C. Further comparison also shows that groundwater temperatures at PZ-13D and PZ-14D returned to below those recorded in up-gradient monitor MW131 by late-October each year, whereas MW119A was similar to MW131 beginning in December both years.

3.6 Long-Term Groundwater Monitoring Program

The long-term groundwater monitoring program at the HCBP site should continue as previously recommended on a quarterly basis. As the site is graded and blocks prepared for development, new monitoring wells are installed to replace decommissioned wells. This has been completed as soon as practically possible, such that the effects of development on groundwater levels, if any, can be identified without delay. If required, mitigative measures can then be developed and implemented. A map illustrating these locations is presented on Figure 1, in the Hanlon Creek Business Park 2015 Consolidated Monitoring Report, prepared by Natural Resource Solutions Inc., AECOM, and Banks Groundwater Engineering Limited.

Data loggers have been installed in monitoring wells and mini-piezometers that are expected to remain during and following site grading. Additional data loggers are being installed in new monitoring wells as they are installed. This will improve the groundwater monitoring dataset and the establishment of the influences of climate on groundwater elevations over the short-, medium-, and long-term. Groundwater samples should continue to be collected on an annual basis from selected monitoring wells. Improvements to filtering of water samples have been successful in reducing the amount of sediment and should be continued as a standard practise.

4 Summary

The on-going monitoring of groundwater levels has provided an updated characterization of the hydrogeological conditions across the HCBP site and surrounding area, including the local occurrence and movement of groundwater in relation to the on-site wetlands and Hanlon Creek Tributary 'A'. The following is a summary of conclusions and recommendations related to the groundwater monitoring program.

- A long-term groundwater monitoring program is required to assess any changes in groundwater elevations and groundwater quality during and following development of the site. The monitoring program is also required to assess the performance of the stormwater management facilities once they are constructed and to observe seasonal trends in water levels in the core wetland. It is therefore recommended that groundwater levels continue to be monitored on a quarterly basis at a minimum in all available monitoring wells and mini-piezometers, before and where possible during grading of the site. To correspond to previous monitoring, the preferred monitoring periods would continue to be January, April, July and October. Groundwater samples should continue to be collected from all available monitoring wells to augment the existing background water quality data.
- Any monitoring stations located within grading areas must be properly decommissioned, in advance of grading, in accordance with Ontario Regulation 903, as recently amended, of the Ontario Water Resources Act, by a licensed Water Well Technician.
- In some cases, existing monitoring wells can be maintained, with minor modifications or improvements, for continued monitoring. Several monitors have been replaced following grading and development of selected blocks. The locations for long-term monitoring of groundwater levels and quality are identified, including existing and new monitors that are expected to be maintained and proposed future monitoring locations (refer to Figure 1, Hanlon Creek Business Park 2015 Consolidated Monitoring Report, prepared by Natural Resource Solutions Inc., AECOM, and Banks Groundwater Engineering Limited).
- Groundwater level and temperature monitoring using data loggers should continue for many, if not all, of the groundwater monitoring stations over the long-term. By utilizing this technology, the frequency of monitoring can be increased significantly and trends in groundwater level changes (e.g. related to construction) can be detected sooner and with improved accuracy.
- It is recommended that the monitoring data continue to be compiled, plotted, and analyzed on an annual basis by a qualified professional engineer or geoscientist. The results should be presented in a Technical Memorandum that is submitted as an Appendix to the Consolidated Monitoring Report to the City of Guelph, for the purpose of review, acceptance, and response to recommendations. Recommendations related to the monitoring program, including any proposed modifications, would be included. The GRCA should also receive a copy for review and comment in relation to maintenance of groundwater levels across the site, but with particular emphasis on the Provincially Significant Wetlands and Hanlon Creek Tributary 'A'. In the event of unexpected changes in groundwater elevations or quality, the frequency of monitoring, sampling, and reporting would be evaluated and revised as required.

Respectfully submitted,
Banks Groundwater Engineering Limited

Original signed by:

William D. Banks, P.Eng.
Principal Hydrogeologist

The Figure, Tables and Graphs referenced in this Technical Memorandum are appended under the following headings:

Figure 1: Groundwater Monitoring Stations December 2015

Appendix A: Current Groundwater Monitoring Network December 2015

Appendix B: Groundwater Level Monitoring Data 2003 – 2015

Appendix C: Groundwater Monitoring Graphs 2003 – 2015

Appendix D: Vertical Hydraulic Gradient Data and Graphs 2003 – 2015

Appendix E: Climate Monitoring Graphs 1971 – 2015

Appendix F: Downey Road PSW Groundwater Monitoring Graphs 2007 – 2015

Appendix G: HCBP Core PSW Groundwater Monitoring Graphs 2007 – 2015

Appendix H: HCBP Perimeter Groundwater Monitoring Graphs 2007 – 2015

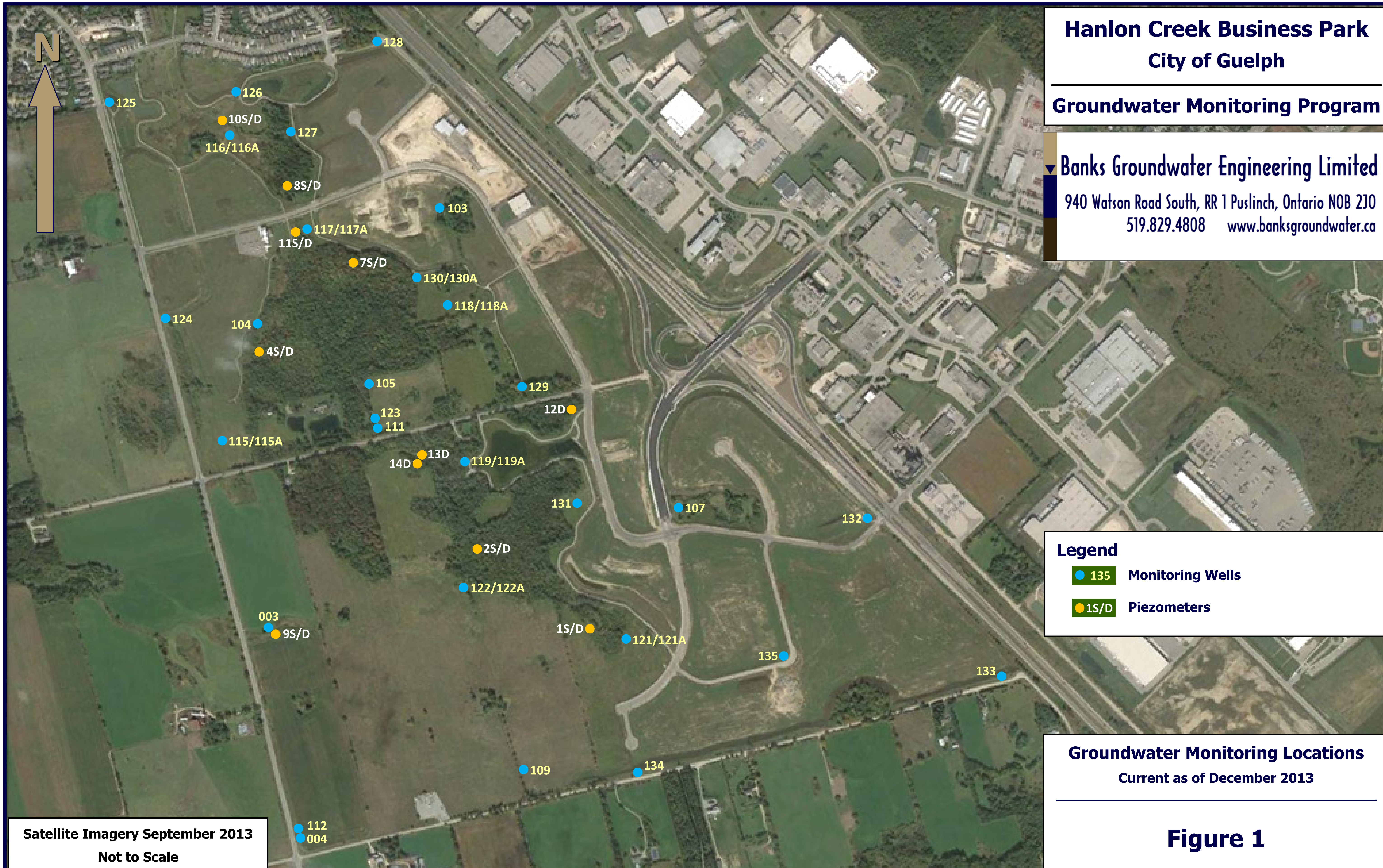
Appendix I: HCBP Quarterly Groundwater Elevation Range Graphs 2007 – 2015

Appendix J: Groundwater Quality Monitoring Data 2003 – 2015

Figure 1

Groundwater Monitoring Stations
December 2015

Banks Groundwater Engineering Limited


Hanlon Creek Business Park
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13D
14D
119/119A
131
107
132
2S/D
122/122A
003
9S/D
1S/D
121/121A
135
133
109
134
112
004
Legend
135 Monitoring Wells
1S/D Piezometers
Groundwater Monitoring Locations
Current as of December 2013
Figure 1
Satellite Imagery September 2013
Not to Scale

Appendix A

Current Groundwater Monitoring Network
December 2015

Hanlon Creek Business Park - Groundwater Monitoring Program

Monitoring Well and Mini-Piezometer Condition Summary - as of December 2015

Monitoring Well Number	Type *	Nominal Well Diameter (mm)	Protective Casing Size/Diameter (mm)	Condition of Monitor & Protective Casing	Waterra Tubing In Place	Monitoring Started	Most Recent Monitoring	Data Logger Installed	Data Logger Removed
001	S	50	100	Abandoned in 2011	No	Apr-03	May-11	Jan-08	May-11
002	S	50	100	Abandoned in 2010	No	Apr-03	Oct-08	--	
003	S	50	100	Functioning; square protective casing in good condition	Yes	Apr-03	Oct-14	Mar-07	
004	S	50	100	Functioning; square protective casing in satisfactory condition	Yes	Apr-03	Oct-14	Aug-09	
005 (S)	S	13	100	Abandoned in 2010	No	Apr-03	Sep-10	--	
005 (I)	I	50	100	Abandoned in 2010	No	Apr-03	Sep-10	Aug-09	Sep-10
006	S	50	100	Abandoned in 2010	No	Apr-03	Sep-10	Aug-09	Sep-10
101	S	50	100	Abandoned in 2011	No	Jun-03	Jan-11	Jun-10	Oct-10
102	S	50	100	Abandoned in 2010	No	Jun-03	Apr-10	--	
103	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jun-10	
104	S	50	100	Functioning; square protective casing in satisfactory condition	Yes	Jun-03	Oct-14	Jan-08	
105	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jan-08	
106	S	50	100	Abandoned in 2012	No	Jun-03	Jul-10	Aug-09	Aug-10
107	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jul-08	
108	S	50	100	Inaccessible	Yes	Jun-03	Apr-04	--	
109	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Apr-09	
110	I	50	100	Abandoned in 2010	No	Jun-03	Sep-10	Aug-09	Sep-10
111	D	50	150	Functioning; 150mm dia. cap, well casing in good condition	Yes	Sep-03	Oct-14	Oct-10	
112	D	50	150	Functioning; 150mm dia. cap, well casing in good condition	Yes	Sep-03	Oct-14	Oct-10	
113	D	50	150	Abandoned in 2010	No	Sep-03	Sep-10	--	
114	D	50	150	Abandoned in 2010	No	Sep-03	Sep-10	--	
115	I	50	100	Functioning; square protective casing in satisfactory condition	Yes	Jun-03	Oct-14	--	
115A	S	50	100	Functioning; square protective casing in satisfactory condition	Yes	Jun-03	Oct-14	--	
116	I	50	150	Functioning; square protective casing in satisfactory condition	Yes	Jun-03	Oct-14	--	
116A	S	50	150	Functioning; square protective casing in satisfactory condition	Yes	Jun-03	Oct-14	Jan-08	
117	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	--	
117A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jan-08	
118	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	--	
118A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jul-08	
119	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	--	
119A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jul-08	
120	I	50	100	Abandoned in 2010	No	Jun-03	Apr-04	--	
120A	S	50	100	Abandoned in 2010	No	Jun-03	Apr-04	--	
121	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	--	
121A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-14	Jul-08	
122	I	50	100	Functioning; square protective casing in good condition	Yes	Sep-03	Oct-14	--	
122A	S	50	100	Functioning; square protective casing in good condition	Yes	Sep-03	Oct-14	Jul-08	
123	D	50	100	Functioning; round protective casing in good condition	Yes	Oct-05	Oct-14	--	
124	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
125	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
126	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
127	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
128	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
129	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
130	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	--	
130A	S	50	100	Functioning; square protective casing in good condition	No	Jan-12	Oct-14	Jan-12	
131	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
132	S	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
133	I	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
134	I	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	
135	I	50	100	Functioning; square protective casing in good condition	Yes	Jan-12	Oct-14	Jan-12	

Hanlon Creek Business Park - Groundwater Monitoring Program

Monitoring Well and Mini-Piezometer Condition Summary - as of December 2015

Mini-Piezometer Number	Type **	Nominal Piezometer Diameter (mm)	Protective Casing Size/Diameter (mm)	Condition of Mini-Piezometer	Waterra Tubing In Place	Monitoring Started	Most Recent Monitoring	Data Logger Installed	Data Logger Removed
1S	SP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	--	
1D	DP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	Apr-09	
2S	SP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	--	
2D	DP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	Jan-07	
4S	SP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	--	
4D	DP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	Apr-09	
7S	SP	20	n/a	Functioning - PVC pipe	No	Dec-06	Oct-14	--	
7D	DP	20	n/a	Functioning - PVC pipe	No	Dec-06	Oct-14	Nov-07	
8S	SP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	--	
8D	DP	20	n/a	Functioning - Steel pipe	No	Dec-06	Oct-14	Jun-10	
9S	SP	20	n/a	Functioning - Steel pipe	No	Mar-07	Oct-14	--	
9D	DP	20	n/a	Functioning - Steel pipe	No	Mar-07	Oct-14	Mar-07	
10S	SP	20	n/a	Functioning - Steel pipe	No	Jun-10	Oct-14	--	
10D	DP	20	n/a	Functioning - Steel pipe	No	Jun-10	Oct-14	Apr-12	
11S	SP	20	n/a	Functioning - Steel pipe	No	Jun-10	Oct-14	--	
11D	DP	20	n/a	Functioning - Steel pipe	No	Jun-10	Oct-14	Jun-10	
12D	DP	20	n/a	Functioning - Steel pipe	No	Jul-11	Oct-14	Jan-12	
13D	DP	20	n/a	Functioning - Steel pipe	No	Jun-13	Oct-14	Jun-13	Oct-15
14D	DP	20	n/a	Functioning - Steel pipe	No	Jun-13	Oct-14	Jun-13	

* S=shallow (overburden); I=intermediate (overburden); D=deep (bedrock)
** SP=shallow piezometer (1.0m); DP=deeper piezometer (1.5m)

Appendix B

Groundwater Level Monitoring Data 2003 – 2015

Hanlon Creek Business Park - Groundwater Monitoring Program 2003 - 2015

Monitoring Well Elevation Data

Monitoring Well Number	Northing	Easting	Ground Elevation (m)	Original Top of Protective Casing Elevation (m)	Current Top of Well Elevation (m)	Depth to Top of Screen (m)	Depth to Groundwater (m) Apr 23-25/03	Groundwater Elevation (m) Apr 23-25/03	Depth to Groundwater (m) Jul 7/03	Groundwater Elevation (m) Jul 7/03	Depth to Groundwater (m) Sep 3-9/03	Groundwater Elevation (m) Sep 3-9/03	Depth to Groundwater (m) Oct 8/03	Groundwater Elevation (m) Oct 8/03	Depth to Groundwater (m) Nov 6/03	Groundwater Elevation (m) Nov 6/03	Depth to Groundwater (m) Apr 13/04	Groundwater Elevation (m) Apr 13/04	Depth to Groundwater (m) Nov 8, 11/05	Groundwater Elevation (m) Nov 8, 11/05
001	4815738	563019	324.80	325.81		4.00	0.67	324.13			0.84	323.96	0.89	323.91	0.76	324.04	0.43	324.37	0.98	323.82
002	4815264	563116	327.26	328.21		2.20	1.38	325.88			1.87	325.39	damaged	damaged	n/a	n/a	n/a	n/a	n/a	n/a
003	4814814	562436	326.61	327.91	327.784	2.10	0.79	325.82			1.00	325.61	0.96	325.65	0.62	325.99	0.05	326.56	1.01	325.60
004	4814286	562532	330.43	331.33	331.220	5.10	4.44	325.99			4.71	325.72	4.82	325.61	4.75	325.68	3.18	327.25	4.86	325.57
005 (S)	4814708	564015	336.53	337.22		3.00	6.17	330.36			6.74	329.78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
005 (I)	4814708	564015	336.53	337.22		10.80	9.58	326.95			9.60	326.92	9.66	326.86	9.67	326.86	8.33	328.19	n/a	n/a
006	4815051	563955	334.70	335.70		7.50	7.58	327.12			7.73	326.97	7.74	326.96	7.70	327.00	6.54	328.16	7.61	327.09
101	4816126	562590	321.70	322.55		4.00			4.05	317.65	4.12	317.58	3.96	317.74	3.52	318.18	3.46	318.24	4.26	317.44
102	4815860	562163	320.66	321.56		3.00			1.57	319.10	1.75	318.91	1.41	319.26	0.84	319.83	0.92	319.75	2.26	318.40
103	4815933	562895	323.85	324.86	324.762	2.20			1.14	322.71	1.22	322.63	1.05	322.81	0.65	323.21	0.40	323.45	1.29	322.56
104	4815648	562401	322.04	322.72	322.609	2.30			1.24	320.80	1.21	320.83	0.86	321.18	0.53	321.51	0.63	321.41	1.07	320.97
105	4815489	562700	323.87	324.75	324.610	2.70			1.25	322.62	1.27	322.60	1.12	322.75	1.03	322.84	1.03	322.84	1.12	322.75
106	4815478	563458	328.65	329.53		4.00			2.73	325.92	2.86	325.78	2.77	325.88	2.42	326.23	2.00	326.64	2.75	325.90
107	4815143	563540	327.44	328.15	327.971	1.90			0.98	326.46	1.13	326.31	1.07	326.37	0.80	326.63	0.07	327.37	1.07	326.37
108	4814607	562867	330.33	331.02		5.00			4.11	326.22	4.27	326.06	4.30	326.03	4.12	326.21	3.06	327.27	damaged	damaged
109	4814444	563116	331.70	332.52	332.391	7.20			5.23	326.46	5.41	326.29	5.48	326.22	5.39	326.31	4.09	327.61	5.41	326.29
110	4814502	563532	339.59	340.49		14.80			12.89	326.70	13.06	326.53	13.14	326.44	13.12	326.47	11.74	327.85	12.99	326.60
111	4815365	562710	324.20	324.95	324.900	18.90			n/a	n/a	-0.40	324.60	-0.41	324.61	-0.54	324.74	n/a	n/a	-0.36	324.56
112	4814288	562531	330.44	331.25	331.180	28.00			n/a	n/a	4.97	325.47	5.11	325.33	4.95	325.49	3.64	326.79	5.15	325.29
113	4814478	563532	339.85	340.71		40.80			n/a	n/a	14.43	325.42	14.48	325.37	14.40	325.45	13.33	326.51	14.38	325.47
114	4814640	564115	338.68	339.62		34.10			n/a	n/a	12.86	325.82	12.94	325.74	12.90	325.79	11.72	326.96	12.85	325.83
115	4815311	562313	323.12	323.89	323.760	7.10			n/a	n/a	0.11	323.02	0.03	323.10	-0.02	323.14	0.19	322.93	0.46	322.66
115A	4815309	562312	323.10	323.91	323.770	1.60			0.64	322.45	0.66	322.44	0.29	322.81	0.16	322.93	0.16	322.93	0.26	322.84
116	4816139	562305	318.75	319.68	319.598	9.80			3.83	314.91	3.89	314.86	3.69	315.06	3.21	315.54	2.97	315.78	4.03	314.71
116A	4816139	562311	318.67	319.56	319.478	1.50			0.51	318.16	0.74	317.92	n/a	n/a	0.15	318.52	0.15	318.52	0.63	318.04
117	4815889	562525	321.21	321.94	321.826	7.10			3.07	318.14	3.11	318.09	2.96	318.24	2.63	318.58	2.70	318.51	3.34	317.87
117A	4815885	562527	321.25	322.18	322.076	2.00			1.30	319.95	1.28	319.97	1.21	320.04	0.98	320.26	1.05	320.20	1.25	320.00
118	4815685	562921	324.02	324.91	324.766	7.30			0.59	323.43	0.84	323.18	0.73	323.30	0.45	323.58	0.57	323.45	0.88	323.14
118A	4815689	562926	323.97	324.89	324.611	2.10			0.72	323.25	0.81	323.16	0.69	323.28	0.55	323.41	0.47	323.50	0.77	323.20
119	4815279	562960	325.88	326.93	326.863	6.00			1.16	324.72	1.12	324.76	0.86	325.02	0.62	325.26	0.65	325.24	0.92	324.96
119A	4815280	562965	325.88	326.99	326.918	2.80			1.11	324.77	1.11	324.77	0.85	325.03	0.61	325.27	0.64	325.25	0.92	324.96
120	4814948	563249	327.38	328.89		7.20			0.35	327.04	0.47	326.91	0.36	327.02	0.09	327.29	-0.19	327.57	destroyed	destroyed
120A	4814941	563244	327.38	328.23		2.50			1.06	326.33	1.19	326.19	1.08	326.30	0.80	326.59	0.52	326.87	destroyed	destroyed
121	4814817	563395	327.44	328.15	328.022	8.80			1.55	325.89	1.72	325.72	1.74	325.71	1.58	325.86	0.83	326.61	1.61	325.83
121A	4814817	563396	328.09	328.93	328.885	2.70			1.47	326.61	1.64	326.44	1.67	326.42	1.52	326.57	0.78	327.30	damaged	damaged
122	4814929	562960	326.79	327.64	327.504	5.80			n/a	n/a	0.87	325.93	0.81	325.98	0.69	326.11	0.48	326.31	0.90	325.89
122A	4814931	562959	326.81	327.58	327.514	2.80			n/a	n/a	1.01	325.81	0.96	325.86	0.85	325.97	0.68	326.13	0.78	326.03
123	4815368	562710	324.20	325.06	324.827	49.00			n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	14.21	309.99
124	4815650	562155	321.59	322.57	322.410	4.62														
125	4816227	561991	319.23	320.29	320.190	4.16														
126	4816259	562328	320.63	321.49	321.390	4.62														
127	4816149	562485	320.06	321.03	320.930	2.49														
128	4816388	562714	322.22	322.97	323.050	4.62														
129	4815475	563115	326.16	327.12	327.060	4.62														
130	4815757	562823	323.55	324.54	324.500	1.99														
130A	4815764	562819	323.58	323.52	324.530	0.89														
131	4815181	563267	326.72	327.65	327.540	3.07														
132	4815128	564031	334.98	335.90	335.780	7.36														
133	4814714	564395	340.08	341.09	340.940	12.54														
134	4814454	563436	341.46	342.11	341.960	14.83														
135	4814765	563819	333.54	334.66	334.360	9.19														

Hanlon Creek Business Park - Groundwater Monitoring Program 2003 - 2015

Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Apr 26/06	Groundwater Elevation (m) Apr 26/06	Depth to Groundwater (m) Dec 20/06	Groundwater Elevation (m) Dec 20/06	Depth to Groundwater (m) Feb 1/07	Groundwater Elevation (m) Feb 1/07	Depth to Groundwater (m) Apr 27/07	Groundwater Elevation (m) Apr 27/07	Depth to Groundwater (m) Jul 25/07	Groundwater Elevation (m) Jul 25/07	Depth to Groundwater (m) Nov 2/07	Groundwater Elevation (m) Nov 2/07	Depth to Groundwater (m) Jan 25,29/08	Groundwater Elevation (m) Jan 25,29/08	Depth to Groundwater (m) Apr 22-25/08	Groundwater Elevation (m) Apr 22-25/08	Depth to Groundwater (m) Jul 23-28/08	Groundwater Elevation (m) Jul 23-28/08	Depth to Groundwater (m) Oct 24-28/08	Groundwater Elevation (m) Oct 24-28/08
001	0.54	324.27	0.47	324.33	0.56	324.24	0.47	324.33	0.93	323.87	1.13	323.67	0.51	324.29	0.38	324.42	0.59	324.22	0.77	324.03
002	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.93	325.33	1.99	325.27	1.31	325.95	1.25	326.01	1.35	325.91	1.43	325.83
003	0.13	326.48	0.24	326.37	0.28	326.33	0.04	326.57	0.72	325.89	1.13	325.48	0.44	326.17	0.03	326.58	0.39	326.22	0.69	325.92
004	3.68	326.75	3.87	326.56	3.78	326.65	3.40	327.03	4.24	326.19	4.91	325.52	4.21	326.22	2.90	327.53	3.94	326.49	4.40	326.03
005 (S)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	moist/dry	moist/dry	dry	dry	6.43	330.10	6.33	330.20	6.20	330.33	6.47	330.05
005 (I)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8.65	327.88	9.37	327.16	9.24	327.29	7.91	328.62	8.40	328.13	8.83	327.70
006	6.83	327.88	6.94	327.77	6.85	327.85	6.43	328.27	6.96	327.74	7.59	327.11	7.24	327.46	6.16	328.54	6.65	328.05	7.08	327.62
101	3.70	318.00	3.61	318.09	3.86	317.84	3.69	318.01	4.16	317.54	4.35	317.35	3.61	318.09	3.21	318.49	3.91	317.79	3.93	317.77
102	0.95	319.71	0.98	319.68	1.08	319.58	0.92	319.74	1.94	318.72	2.36	318.30	0.92	319.74	0.77	319.89	0.48	320.18	1.51	319.15
103	0.56	323.29	0.53	323.32	0.76	323.09	0.52	323.33	1.41	322.44	1.45	322.40	0.52	323.33	0.41	323.44	0.80	323.05	1.06	322.79
104	0.53	321.51	0.68	321.36	0.79	321.25	0.55	321.49	1.45	320.59	1.34	320.70	0.58	321.46	0.61	321.43	0.74	321.30	0.90	321.14
105	1.02	322.85	1.07	322.80	1.11	322.76	0.94	322.93	1.39	322.48	1.25	322.62	1.10	322.77	1.05	322.82	1.10	322.77	1.15	322.72
106	2.17	326.47	2.16	326.48	2.23	326.42	1.99	326.66	2.58	326.07	2.89	325.76	2.26	326.39	1.82	326.83	2.15	326.50	2.46	326.19
107	0.39	327.05	0.45	326.99	0.48	326.96	n/a	n/a	0.73	326.71	1.15	326.29	0.66	326.78	-0.08	327.52	0.29	327.15	0.69	326.75
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
109	4.46	327.24	4.67	327.03	4.52	327.18	4.14	327.56	4.82	326.88	5.41	326.29	4.99	326.71	3.79	327.91	4.60	327.10	4.96	326.74
110	12.07	327.52	12.31	327.28	12.11	327.48	11.69	327.90	12.29	327.30	12.96	326.63	12.70	326.89	11.39	328.20	12.06	327.53	12.45	327.14
111	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-0.83	325.03	-0.47	324.67	-0.98	325.18	-1.73	325.93	-0.85	325.05	-0.66	324.86
112	3.82	326.62	4.22	326.22	4.19	326.25	3.95	326.49	4.67	325.77	5.09	325.35	4.47	325.97	3.37	327.07	4.18	326.26	4.63	325.81
113	13.65	326.20	13.66	326.19	13.53	326.32	13.12	326.73	13.75	326.10	14.30	325.55	13.96	325.89	12.90	326.95	13.59	326.26	13.97	325.88
114	12.09	326.59	12.20	326.48	11.96	326.72	11.64	327.04	12.03	326.65	12.64	326.04	12.39	326.29	11.25	327.43	11.81	326.87	12.23	326.45
115	0.15	322.97	frozen	frozen	frozen	frozen	0.36	322.77	-0.02	323.14	-0.07	323.19	frozen	frozen	-0.64	323.76	-0.64	323.76	-0.32	323.45
115A	0.11	322.99	0.19	322.90	0.19	322.90	0.05	323.05	1.12	321.97	0.75	322.34	0.28	322.81	0.27	322.82	-0.01	323.10	0.35	322.74
116	3.02	315.73	3.07	315.68	3.35	315.39	3.03	315.71	4.12	314.63	4.34	314.41	3.40	315.35	2.75	316.00	4.12	314.63	3.91	314.84
116A	0.17	318.50	0.26	318.41	0.32	318.35	0.16	318.50	1.09	317.58	1.11	317.56	0.20	318.47	0.18	318.49	0.40	318.27	0.46	318.21
117	2.88	318.33	2.91	318.30	3.03	318.17	3.02	318.19	3.16	318.05	3.17	318.04	2.66	318.55	2.37	318.84	3.15	318.06	2.96	318.25
117A	1.01	320.24	1.06	320.19	1.17	320.08	0.79	320.45	1.42	319.83	1.32	319.93	1.12	320.13	1.00	320.25	1.21	320.04	1.15	320.10
118	0.67	323.35	0.60	323.42	0.73	323.29	0.59	323.43	0.69	323.33	0.68	323.34	0.36	323.66	0.27	323.75	0.53	323.49	0.59	323.43
118A	0.60	323.37	0.64	323.33	0.69	323.28	0.52	323.45	0.98	322.99	0.93	323.04	0.66	323.31	0.64	323.33	0.71	323.26	0.76	323.20
119	0.58	325.30	0.63	325.25	0.66	325.22	0.51	325.37	1.16	324.72	1.03	324.85	0.73	325.15	0.66	325.22	0.53	325.35	0.70	325.18
119A	0.58	325.30	0.62	325.26	0.65	325.23	0.70	325.19	1.15	324.73	1.01	324.87	0.71	325.17	0.64	325.24	0.53	325.35	0.69	325.20
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	0.95	326.49	1.06	326.38	0.94	326.51	1.06	326.38	1.09	326.35	1.63	325.81	1.29	326.15	0.73	326.71	0.94	326.50	1.15	326.29
121A	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.10	326.99	1.63	326.46	1.51	326.58	0.79	327.30	0.96	327.13	1.15	326.94
122	0.55	326.24	0.60	326.19	0.59	326.20	0.49	326.30	0.72	326.07	0.83	325.96	0.65	326.14	0.49	326.30	0.49	326.30	0.66	326.13
122A	0.75	326.06	0.71	326.10	0.79	326.03	0.72	326.10	0.88	325.93	0.97	325.84	0.83	325.98	0.69	326.12	0.69	326.12	0.82	325.99
123	17.53	306.67	n/a	n/a	n/a	n/a	18.26	305.94	18.95	305.25	19.54	304.66	13.56	310.64	12.45	311.75	15.98	308.22	17.12	307.08
124																				
125																				
126																				
127																				
128																				
129																				
130																				
130A																				
131																				
132																				
133																				
134																				
135																				

Hanlon Creek Business Park - Groundwater Monitoring Program 2003 - 2015

Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jan 2, 3/09	Groundwater Elevation (m) Jan 2, 3/09	Depth to Groundwater (m) Apr 27-29/09	Groundwater Elevation (m) Apr 27-29/09	Depth to Groundwater (m) May 20/09	Groundwater Elevation (m) May 20/09	Depth to Groundwater (m) Jul 29/09	Groundwater Elevation (m) Jul 29/09	Depth to Groundwater (m) Aug 27/09	Groundwater Elevation (m) Aug 27/09	Depth to Groundwater (m) Oct 26, 27/09	Groundwater Elevation (m) Oct 26, 27/09
001	0.40	324.40	0.37	324.43	0.46	324.34	0.60	324.20			0.70	324.10
002	n/a	n/a	n/a	n/a			n/a	n/a			n/a	n/a
003	0.05	326.56	-0.03	326.64			0.31	326.30			0.60	326.01
004	3.56	326.87	3.14	327.29			3.89	326.54	4.04	326.39	4.35	326.08
005 (S)	6.01	330.52	6.42	330.11			6.46	330.07	6.45	330.08	dry	dry
005 (I)	8.71	327.82	7.71	328.82			8.15	328.38	8.29	328.24	8.67	327.85
006	6.71	327.99	6.04	328.66			6.49	328.21	6.58	328.12	6.95	327.76
101	3.05	318.65	3.18	318.52					4.08	317.62	3.82	317.88
102	0.53	320.13	0.53	320.13					1.49	319.17	1.32	319.34
103	0.30	323.55	0.34	323.51					0.95	322.90	1.05	322.80
104	0.49	321.55	0.43	321.61	0.71	321.33			0.90	321.14	0.87	321.17
105	1.03	322.84	0.94	322.93	1.07	322.80	1.08	322.79			1.08	322.79
106	1.88	326.77	1.72	326.93			2.17	326.48	2.20	326.45	2.37	326.28
107	0.19	327.25	-0.32	327.76			0.30	327.14			0.59	326.85
108	-	-	-	-			-	-			-	-
109	4.39	327.31	3.83	327.87			4.49	327.21			4.87	326.83
110	12.16	327.43	11.36	328.23			11.89	327.70	12.04	327.55	12.34	327.25
111	-0.85	325.05	nm				-1.02	325.22			-0.53	324.73
112	3.90	326.54	3.65	326.79			4.20	326.24			4.89	325.55
113	13.68	326.17	12.98	326.87			13.43	326.42			14.01	325.84
114	12.00	326.68	11.25	327.43			11.61	327.07			12.19	326.49
115	frozen	frozen	-0.64	323.76					-0.43	323.55	-0.38	323.50
115A	0.17	322.92	0.00	323.09					0.36	322.73	0.18	322.91
116	not available	not available	2.80	315.95	3.17	315.58			4.49	314.26	3.70	315.05
116A	0.10	318.57	0.14	318.53	0.32	318.35			0.40	318.27	0.48	318.18
117	2.36	318.85	2.42	318.79	2.68	318.53			3.39	317.82	2.88	318.33
117A	0.88	320.37	0.89	320.36	1.09	320.16			1.25	320.00	1.16	320.09
118	0.33	323.69	0.28	323.74	0.43	323.59	0.48	323.54			0.54	323.48
118A	0.49	323.48	0.47	323.50	0.81	323.16	0.67	323.30			0.72	323.25
119	0.61	325.27	0.46	325.42	0.66	325.22	0.63	325.25			0.64	325.24
119A	0.60	325.29	0.46	325.42	0.64	325.24	0.61	325.27			0.62	325.26
120	-	-	-	-	-	-	-	-	-	-	-	-
120A	-	-	-	-	-	-	-	-	-	-	-	-
121	0.91	326.53	0.70	326.74			0.87	326.57			1.06	326.38
121A	0.94	327.15	0.75	327.34			0.90	327.19			1.08	327.01
122	0.51	326.28	0.41	326.38	0.49	326.30	0.53	326.26			0.60	326.19
122A	0.71	326.11	0.64	326.17	0.70	326.11	0.73	326.08			0.79	326.03
123	16.99	307.21	16.87	307.33							17.14	307.06
124												
125												
126												
127												
128												
129												
130												
130A												
131												
132												
133												
134												
135												

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Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jan 28, 29/10	Groundwater Elevation (m) Jan 28, 29/10	Depth to Groundwater (m) Apr 26-28/10	Groundwater Elevation (m) Apr 26-28/10	Depth to Groundwater (m) Jul 22, 23/10	Groundwater Elevation (m) Jul 22, 23/10	Depth to Groundwater (m) Sep 19/10	Groundwater Elevation (m) Sep 19/10	Depth to Groundwater (m) Oct 12-14/10	Groundwater Elevation (m) Oct 12-14/10
001	0.64	324.16	0.58	324.22	0.91	323.89			0.95	323.85
002	n/a	n/a	n/a	n/a	n/a	n/a			abandoned	abandoned
003	0.51	326.10	0.26	326.35	0.70	325.91			0.97	325.64
004	4.33	326.10	3.76	326.67	4.29	326.14			4.73	325.70
005 (S)	dry	dry	6.43	330.09	dry	dry	dry	dry	abandoned	abandoned
005 (I)	9.02	327.50	8.63	327.89	8.90	327.63	9.15	327.37	abandoned	abandoned
006	7.19	327.51	6.87	327.84	7.15	327.56	7.39	327.32	abandoned	abandoned
101	3.78	317.92	3.63	318.07	3.98	317.72			4.04	317.66
102	0.68	319.98	0.94	319.72	abandoned	abandoned			-	-
103	0.95	322.90	0.74	323.11	1.28	322.57			1.33	322.52
104	0.76	321.28	0.80	321.24	1.17	320.87			1.22	320.82
105	1.06	322.81	1.11	322.76	1.34	322.53			1.21	322.66
106	2.36	326.29	2.24	326.41	2.56	326.08			abandoned	abandoned
107	0.66	326.78	0.48	326.96	0.83	326.61			0.87	326.56
108	-	-	-	-	-	-			-	-
109	4.96	326.74	4.52	327.18	4.94	326.76			5.28	326.42
110	12.55	327.04	12.12	327.47	12.44	327.15	12.74	326.85	abandoned	abandoned
111	-0.58	324.78	-0.74	324.94	-0.46	324.66			-0.33	324.53
112	4.87	325.57	4.47	325.97	4.80	325.64			5.13	325.31
113	14.14	325.71	13.79	326.06	14.11	325.74	14.30	325.55	abandoned	abandoned
114	12.40	326.28	12.04	326.64	12.39	326.29	12.58	326.11	abandoned	abandoned
115	-0.49	323.61	-0.50	323.62	-0.06	323.19			-0.21	323.33
115A	0.14	322.95	0.15	322.94	0.69	322.40			0.37	322.72
116	3.58	315.17	3.43	315.32	3.95	314.80			4.02	314.73
116A	0.40	318.27	0.39	318.28	0.92	317.74			0.78	317.89
117	2.83	318.38	2.81	318.40	3.39	317.82			2.93	318.28
117A	1.12	320.13	1.15	320.10	1.93	319.32			0.99	320.26
118	0.50	323.52	0.52	323.50	0.58	323.44			0.56	323.46
118A	0.68	323.29	0.71	323.26	0.92	323.05			0.87	323.10
119	0.62	325.26	0.69	325.19	0.65	325.23			0.84	325.04
119A	0.61	325.27	0.68	325.20	0.62	325.26			0.82	325.06
120	-	-	-	-	-	-			abandoned	abandoned
120A	-	-	-	-	-	-			abandoned	abandoned
121	1.18	326.26	0.95	326.49	1.23	326.22			1.42	326.03
121A	1.19	326.90	0.98	327.11	1.23	326.86			1.43	326.66
122	0.65	326.14	0.59	326.20	0.50	326.29			0.76	326.03
122A	0.84	325.98	0.79	326.03	0.70	326.12			0.92	325.90
123	18.59	305.50	18.41	305.68	19.13	304.96			19.29	304.80
124										
125										
126										
127										
128										
129										
130										
130A										
131										
132										
133										
134										
135										

Hanlon Creek Business Park - Groundwater Monitoring Program 2003 - 2015

Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jan 18, 19/11	Groundwater Elevation (m) Jan 18, 19/11	Depth to Groundwater (m) Apr 27, 28/11	Groundwater Elevation (m) Apr 27, 28/11	Depth to Groundwater (m) Jul 18, 19/11	Groundwater Elevation (m) Jul 18, 19/11	Depth to Groundwater (m) Oct 20, 25/11	Groundwater Elevation (m) Oct 20, 25/11	Depth to Groundwater (m) Jan 10-18/12	Groundwater Elevation (m) Jan 10-18/12	Depth to Groundwater (m) Apr 13, 16/12	Groundwater Elevation (m) Apr 13, 16/12	Depth to Groundwater (m) Jul 16, 19/12	Groundwater Elevation (m) Jul 16, 19/12	Depth to Groundwater (m) Oct 16, 18/12	Groundwater Elevation (m) Oct 16, 18/12
001	1.07	323.73	0.57	324.24	abandoned	abandoned	-	-	-	-	-	-	-	-	-	-
002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
003	0.93	325.68	0.00	326.61	0.37	326.24	0.64	325.97	0.26	326.35	0.46	326.15	1.04	325.57	1.31	325.30
004	4.76	325.67	3.63	326.80	3.65	326.78	4.55	325.88	3.99	326.44	4.03	326.40	4.67	325.76	5.11	325.32
005 (S)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
005 (I)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101	4.06	317.64	abandoned	abandoned	-	-	-	-	-	-	-	-	-	-	-	-
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103	1.35	322.50	0.58	323.27	1.44	322.41	1.23	322.62	0.94	322.91	1.26	322.59	1.75	322.10	1.44	322.42
104	1.12	320.92	0.62	321.42	0.94	321.10	0.76	321.28	0.74	321.30	0.98	321.06	1.42	320.62	1.17	320.87
105	1.23	322.64	0.98	322.90	1.25	322.62	0.83	323.04	1.09	322.78	1.18	322.69	1.54	322.33	1.21	322.67
106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
107	1.30	326.14	0.44	327.00	0.77	326.67	1.22	326.22	1.02	326.42	1.11	326.32	1.37	326.06	1.46	325.98
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
109	5.36	326.34	4.45	327.25	4.35	327.35	5.05	326.65	4.77	326.93	4.76	326.94	5.29	326.41	5.64	326.06
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
111	-0.27	324.47	-0.95	325.15	-0.81	325.01	-0.50	324.70	-0.70	324.90	-0.70	324.90	-0.22	324.42	-0.20	324.40
112	5.15	325.29	4.09	326.35	4.26	326.18	4.88	325.56	4.33	326.11	4.48	325.96	5.21	325.23	5.32	325.12
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	-0.36	323.48	-0.63	323.75	-0.16	323.28	-0.45	323.57	-0.49	323.61	-0.46	323.58	0.29	322.83	-0.09	323.21
115A	0.29	322.80	0.02	323.07	0.82	322.28	0.00	323.10	0.15	322.95	0.18	322.92	1.16	321.94	0.45	322.65
116	3.98	314.77	2.96	315.79	3.51	315.24	3.52	315.23	3.19	315.56	3.65	315.10	4.20	314.55	3.98	314.77
116A	0.75	317.92	0.28	318.39	0.57	318.10	0.20	318.47	0.33	318.34	0.53	318.14	1.16	317.51	0.70	317.97
117	2.92	318.29	2.40	318.81	2.90	318.31	2.62	318.59	2.67	318.54	2.94	318.27	3.22	317.99	2.94	318.27
117A	0.96	320.29	0.67	320.58	1.17	320.08	0.55	320.70	1.02	320.23	1.14	320.11	1.28	319.97	1.07	320.18
118	0.61	323.41	0.30	323.73	0.82	323.21	0.56	323.47	0.46	323.56	0.59	323.43	1.00	323.02	0.63	323.40
118A	0.93	323.04	0.64	323.34	1.17	322.81	0.76	323.21	0.78	323.19	0.92	323.05	1.29	322.69	0.93	323.04
119	0.58	325.30	0.21	325.68	2.12	323.76	0.76	325.12	0.89	324.99	0.97	324.91	1.04	324.84	1.01	324.88
119A	0.58	325.30	0.20	325.68	2.12	323.77	0.73	325.15	0.87	325.02	0.95	324.94	1.03	324.86	0.98	324.90
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	1.64	325.81	0.95	326.49	0.84	326.61	1.21	326.24	1.22	326.22	1.21	326.24	1.62	325.82	1.87	325.57
121A	1.65	326.44	0.97	327.12	0.89	327.20	1.22	326.87	1.22	326.87	1.20	326.89	1.63	326.46	1.89	326.20
122	0.80	325.99	0.49	326.31	0.79	326.00	0.62	326.17	0.62	326.17	0.66	326.13	0.88	325.91	0.96	325.83
122A	0.95	325.86	0.70	326.11	0.78	326.04	0.80	326.02	0.81	326.01	0.84	325.97	1.03	325.79	1.09	325.72
123	19.33	304.76	17.55	306.54	17.28	306.81	15.80	308.29	15.77	308.32	11.18	312.91	18.48	305.61	16.73	307.36
124									1.30	320.29	1.76	319.83	2.39	319.20	2.31	319.28
125									4.40	314.83	4.83	314.40	5.20	314.03	5.01	314.22
126									3.28	317.35	3.81	316.82	5.01	315.62	4.61	316.02
127									1.51	318.55	1.67	318.39	1.87	318.20	1.66	318.40
128									1.93	320.29	2.03	320.20	2.28	319.94	2.12	320.10
129									1.10	325.07	1.29	324.87	1.54	324.62	1.25	324.91
130									1.03	322.52	n/a	n/a	1.56	321.99	1.08	322.47
130A									0.94	322.65	n/a	n/a	1.44	322.14	1.03	322.56
131									1.33	325.39	1.40	325.33	1.19	325.53	1.04	325.68
132									7.25	327.73	7.31	327.68	7.61	327.38	7.82	327.16
133									12.05	328.03	11.97	328.11	12.35	327.73	12.68	327.40
134									14.40	327.06	14.30	327.16	14.83	326.63	15.19	326.27
135									6.34	327.20	6.30	327.24	6.69	326.85	6.99	326.55

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Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jan 10, 11/13	Groundwater Elevation (m) Jan 10, 11/13	Depth to Groundwater (m) Apr 25, 26/13	Groundwater Elevation (m) Apr 25, 26/13	Depth to Groundwater (m) Jul 15, 16/13	Groundwater Elevation (m) Jul 15, 16/13	Depth to Groundwater (m) Oct 23, 24/13	Groundwater Elevation (m) Oct 23, 24/13	Depth to Groundwater (m) Jan 13, 14/14	Groundwater Elevation (m) Jan 13, 14/14	Depth to Groundwater (m) Apr 22, 23/14	Groundwater Elevation (m) Apr 22, 23/14	Depth to Groundwater (m) Jul 14, 15/14	Groundwater Elevation (m) Jul 14, 15/14	Depth to Groundwater (m) Oct 9, 10/14	Groundwater Elevation (m) Oct 9, 10/14
001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
003	0.88	325.73	0.05	326.56	0.46	326.15	0.59	326.02	0.21	326.40	0.05	326.56	0.47	326.14	0.58	326.03
004	4.74	325.69	3.27	327.16	3.93	326.50	4.47	325.96	4.17	326.26	3.30	327.13	3.94	326.49	4.32	326.11
005 (S)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
005 (I)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103	1.18	322.67	0.64	323.21	1.09	322.77	0.97	322.89	0.95	322.90	0.66	323.19	1.35	322.50	0.98	322.87
104	0.73	321.31	0.54	321.50	0.86	321.18	0.71	321.33	0.57	321.47	0.65	321.39	1.07	320.97	0.79	321.25
105	1.13	322.75	1.02	322.85	1.25	322.62	1.06	322.82	1.01	322.86	1.06	322.81	1.29	322.58	1.11	322.77
106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
107	1.37	326.07	0.77	326.66	0.84	326.59	0.99	326.45	1.00	326.43	0.75	326.68	0.89	326.54	0.94	326.49
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
109	5.40	326.30	4.20	327.50	4.63	327.07	5.01	326.69	4.88	326.82	4.19	327.51	4.62	327.08	4.92	326.78
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
111	-0.46	324.66	-1.19	325.39	-0.97	325.17	-0.82	325.02	frozen	frozen	-1.07	325.27	-0.83	325.03	-0.75	324.95
112	4.96	325.48	3.67	326.77	4.26	326.18	4.68	325.76	4.37	326.07	3.65	326.79	4.31	326.13	4.56	325.88
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	-0.34	323.46	-0.64	323.76	-0.39	323.51	-0.50	323.62	-0.59	323.71	-0.64	323.76	-0.35	323.47	-0.53	323.65
115A	0.15	322.95	0.11	322.99	0.48	322.62	0.13	322.97	0.06	323.03	0.10	323.00	0.55	322.55	0.17	322.93
116	3.61	315.14	2.88	315.87	3.27	315.48	2.80	315.95	3.22	315.53	2.79	315.96	3.52	315.23	3.18	315.57
116A	0.45	318.22	0.28	318.39	0.52	318.15	0.37	318.30	0.24	318.43	0.31	318.36	0.71	317.96	0.45	318.22
117	2.82	318.39	2.54	318.67	2.78	318.43	2.51	318.70	2.58	318.63	2.52	318.69	2.92	318.29	2.68	318.53
117A	1.07	320.18	1.00	320.25	1.17	320.08	1.03	320.22	0.96	320.29	1.03	320.22	1.19	320.06	1.11	320.14
118	0.57	323.46	0.36	323.67	0.51	323.52	0.43	323.60	0.39	323.64	0.39	323.64	0.75	323.28	0.59	323.44
118A	0.86	323.11	0.72	323.25	0.88	323.09	0.76	323.21	0.73	323.24	0.76	323.21	0.97	323.00	0.79	323.18
119	1.00	324.88	0.91	324.97	0.99	324.90	0.92	324.96	0.80	325.08	0.90	324.98	1.01	324.87	0.96	324.92
119A	0.98	324.91	0.89	324.99	0.97	324.92	0.90	324.99	0.79	325.10	0.88	325.01	1.00	324.89	0.95	324.94
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	1.72	325.72	0.95	326.49	1.03	326.41	1.24	326.20	1.18	326.26	0.93	326.52	1.03	326.41	1.18	326.26
121A	1.73	326.36	0.98	327.11	1.05	327.04	1.25	326.84	1.20	326.89	0.95	327.14	1.04	327.05	1.18	326.91
122	0.78	326.01	0.50	326.29	0.64	326.15	0.64	326.15	0.54	326.25	0.50	326.29	0.64	326.15	0.65	326.14
122A	0.93	325.88	0.71	326.10	0.83	325.98	0.82	325.99	0.75	326.06	0.73	326.08	0.83	325.98	0.83	325.98
123	16.25	307.84	15.46	308.63	17.41	306.68	17.27	306.82	17.11	306.98	16.27	307.82	17.06	307.03	17.09	307.00
124	1.40	320.20	1.17	320.42	1.64	319.96	1.25	320.34	1.16	320.43	1.20	320.39	2.03	319.56	1.36	320.23
125	4.79	314.44	4.06	315.18	4.54	314.69	4.16	315.08	4.47	314.76	3.96	315.28	4.70	314.53	4.51	314.72
126	3.79	316.85	2.99	317.64	2.74	317.89	2.54	318.10	2.66	317.98	2.48	318.16	3.13	317.51	2.59	318.04
127	1.57	318.49	1.41	318.66	1.56	318.50	1.46	318.61	1.42	318.64	1.39	318.68	1.61	318.46	1.48	318.58
128	2.01	320.21	1.80	320.43	1.90	320.32	1.87	320.36	1.82	320.40	1.83	320.40	1.99	320.23	1.87	320.35
129	1.19	324.97	0.92	325.24	1.12	325.04	1.00	325.16	0.93	325.23	0.91	325.25	1.20	324.96	1.05	325.11
130	1.11	322.44	1.05	322.50	1.18	322.37	1.06	322.50	1.01	322.54	1.05	322.51	1.25	322.30	1.07	322.48
130A	1.01	322.58	0.84	322.75	1.05	322.53	0.91	322.67	0.86	322.73	0.89	322.69	1.13	322.45	0.93	322.65
131	0.98	325.74	0.66	326.06	0.80	325.93	0.75	325.97	0.62	326.10	0.66	326.06	0.81	325.91	0.80	325.92
132	7.82	327.16	7.05	327.93	6.96	328.02	7.26	327.72	7.36	327.62	7.01	327.97	6.97	328.01	7.09	327.89
133	12.76	327.33	11.86	328.22	11.58	328.50	11.96	328.12	12.12	327.96	11.76	328.32	11.54	328.54	11.80	328.28
134	15.04	326.43	13.89	327.57	14.15	327.31	14.55	326.91	14.50	326.96	13.85	327.61	14.11	327.35	14.43	327.03
135	6.94	326.60	6.05	327.49	6.02	327.53	6.37	327.17	6.43	327.11	6.00	327.54	6.00	327.54	6.24	327.30

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Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jan 9, 14/15	Groundwater Elevation (m) Jan 9, 14/15	Depth to Groundwater (m) Apr 10, 13/15	Groundwater Elevation (m) Apr 10, 13/15	Depth to Groundwater (m) Jul 15, 16/15	Groundwater Elevation (m) Jul 15, 16/15	Depth to Groundwater (m) Oct 23, 24/15	Groundwater Elevation (m) Oct 23, 24/15
001	-	-	-	-	-	-	-	-
002	-	-	-	-	-	-	-	-
003	0.53	326.08	0.16	326.45	0.52	326.09	0.99	325.62
004	4.26	326.17	4.10	326.33	4.11	326.32	4.72	325.71
005 (S)	-	-	-	-	-	-	-	-
005 (I)	-	-	-	-	-	-	-	-
006	-	-	-	-	-	-	-	-
101	-	-	-	-	-	-	-	-
102	-	-	-	-	-	-	-	-
103	1.19	322.66	0.77	323.08	1.07	322.78	1.46	322.39
104	0.99	321.05	0.47	321.57	0.84	321.20	1.17	320.87
105	1.19	322.68	0.87	323.00	1.14	322.73	1.26	322.61
106	-	-	-	-	-	-	-	-
107	1.12	326.31	1.03	326.40	1.03	326.40	1.33	326.10
108	-	-	-	-	-	-	-	-
109	4.98	326.72	4.83	326.87	4.87	326.83	5.33	326.37
110	-	-	-	-	-	-	0.00	0.00
111	frozen	frozen	-0.69	324.89	-0.71	324.91	-0.30	324.50
112	4.48	325.96	4.25	326.19	4.38	326.06	4.94	325.50
113	-	-	-	-	-	-	-	-
114	-	-	-	-	-	-	-	-
115	-0.55	323.67	-0.58	323.70	-0.51	323.63	-0.16	323.28
115A	0.19	322.91	-0.02	323.11	0.19	322.91	0.44	322.66
116	3.53	315.22	3.26	315.49	3.11	315.64	3.86	314.89
116A	0.66	318.01	0.21	318.46	0.53	318.14	0.95	317.72
117	2.84	318.37	2.66	318.55	2.72	318.49	2.99	318.22
117A	1.16	320.09	0.85	320.40	1.12	320.13	1.16	320.09
118	0.69	323.34	0.38	323.65	0.62	323.41	0.79	323.24
118A	0.89	323.08	0.59	323.38	0.84	323.13	1.00	322.97
119	0.99	324.89	0.92	324.96	0.95	324.93	1.05	324.83
119A	0.97	324.92	0.90	324.99	0.93	324.96	1.03	324.86
120	-	-	-	-	-	-	-	-
120A	-	-	-	-	-	-	-	-
121	1.32	326.12	1.20	326.24	1.20	326.24	1.61	325.83
121A	1.32	326.77	1.21	326.88	1.21	326.88	1.62	326.47
122	0.65	326.14	0.57	326.22	0.68	326.11	0.82	325.97
122A	0.83	325.98	0.78	326.03	0.86	325.95	0.97	325.84
123	17.46	306.63	17.79	306.30	13.18	310.91	18.71	305.38
124	1.55	320.04	1.22	320.37	1.44	320.15	2.13	319.46
125	4.68	314.55	4.42	314.81	4.35	314.88	5.04	314.19
126	2.94	317.69	2.62	318.01	2.61	318.02	3.80	316.83
127	1.56	318.50	1.23	318.83	1.45	318.61	1.66	318.40
128	1.94	320.28	1.69	320.53	1.84	320.38	2.10	320.12
129	1.13	325.03	0.74	325.42	1.08	325.08	1.29	324.87
130	1.15	322.40	0.80	322.75	1.12	322.43	1.24	322.31
130A	1.03	322.55	0.64	322.94	0.98	322.60	1.13	322.45
131	0.87	325.85	0.68	326.04	0.84	325.88	1.01	325.71
132	7.45	327.53	7.55	327.43	7.22	327.76	7.63	327.35
133	12.23	327.85	12.33	327.75	12.03	328.05	12.42	327.66
134	14.57	326.89	14.53	326.93	14.43	327.03	14.87	326.59
135	6.50	327.04	6.59	326.95	6.35	327.19	6.74	326.80

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Piezometer Groundwater Elevation Data

Piezometer Number	Type	Approximate Ground Elevation (mamsl)	Depth to Groundwater (m) Dec 20/06	Groundwater Elevation (m) Dec 20/06	Depth to Groundwater (m) Jan 23/07	Groundwater Elevation (m) Jan 23/07	Depth to Groundwater (m) Apr 27/07	Groundwater Elevation (m) Apr 27/07	Depth to Groundwater (m) May 28/07	Groundwater Elevation (m) May 28/07
PZ-1	S	327.40	0.80	326.60	frozen	frozen	-0.09	327.49		
PZ-1	D	327.40	0.13	327.27	0.20	327.20	flowing	flowing		
PZ-2	S	326.20	0.35	325.85	0.12	326.08	-0.04	326.24		
PZ-2	D	326.20	0.96	325.24	0.14	326.06	0.09	326.11		
PZ-4	S	322.30	0.52	321.78	frozen	frozen	0.00	322.30		
PZ-4	D	322.30	-0.09	322.39	frozen	frozen	flowing	flowing		
PZ-7	S	321.40	0.27	321.13	-0.01	321.41	destroyed	destroyed		
PZ-7	D	321.40	0.09	321.31	0.00	321.40	destroyed	destroyed		
PZ-8	S	318.50	-0.03	318.53	-0.02	318.52	-0.10	318.60		
PZ-8	D	318.50	-0.03	318.53	-0.02	318.52	flowing	flowing		
PZ-9	S	326.15	n/a	n/a	n/a	n/a	n/a	n/a	-0.28	326.43
PZ-9	D	326.15	n/a	n/a	n/a	n/a	n/a	n/a	-0.25	326.40
PZ-10	S	318.30								
PZ-10	D	318.30								
PZ-11	S	320.25								
PZ-11	D	320.25								
PZ-12	D	326.50								
PZ-13	D	324.20								
PZ-14	D	324.20								

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jul 25, 26/07	Groundwater Elevation (m) July 25, 26/07	Depth to Groundwater (m) Aug 2/07	Groundwater Elevation (m) Aug 2/07	Depth to Groundwater (m) Aug 17/07	Groundwater Elevation (m) Aug 17/07	Depth to Groundwater (m) Oct 1/07	Groundwater Elevation (m) Oct 1/07	Depth to Groundwater (m) Nov 2/07	Groundwater Elevation (m) Nov 2/07
PZ-1	-0.03	327.43							0.34	327.06
PZ-1	0.10	327.30							0.57	326.83
PZ-2	0.56	325.64			0.63	325.57			0.36	325.84
PZ-2	0.47	325.73			0.54	325.66			0.39	325.81
PZ-4	0.20	322.10							0.13	322.17
PZ-4	0.29	322.01							0.12	322.18
PZ-7	installed new	n/a	0.01	321.39			-0.01	321.41	-0.06	321.46
PZ-7	installed new	n/a	0.01	321.39			-0.01	321.41	-0.07	321.47
PZ-8	0.31	318.19							0.38	318.12
PZ-8	0.30	318.20							0.36	318.14
PZ-9	n/a	n/a			dry	dry			dry	dry
PZ-9	n/a	n/a			0.40	325.75			0.66	325.49
PZ-10										
PZ-10										
PZ-11										
PZ-11										
PZ-12										
PZ-13										
PZ-14										

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 25/08	Groundwater Elevation (m) Jan 25/08	Depth to Groundwater (m) Apr 25/08	Groundwater Elevation (m) Apr 25/08	Depth to Groundwater (m) Jul 23/08	Groundwater Elevation (m) Jul 23/08	Depth to Groundwater (m) Oct 28/08	Groundwater Elevation (m) Oct 28/08
PZ-1	0.26	327.14	-0.03	327.43	-0.10	327.50	0.00	327.40
PZ-1	0.20	327.20	-0.14	327.54	-0.07	327.47	0.10	327.30
PZ-2	0.23	325.97	-0.03	326.23	-0.02	326.22	0.19	326.01
PZ-2	0.21	325.99	0.04	326.16	0.10	326.10	0.21	325.99
PZ-4	frozen	frozen	0.02	322.28	0.02	322.28	0.05	322.25
PZ-4	frozen	frozen	-0.06	322.36	-0.05	322.35	-0.02	322.32
PZ-7	-0.08	321.48	-0.08	321.48	-0.07	321.47	-0.13	321.53
PZ-7	-0.04	321.44	-0.09	321.49	-0.08	321.48	-0.13	321.53
PZ-8	-0.17	318.67	-0.08	318.58	0.05	318.45	0.01	318.49
PZ-8	frozen	frozen	-0.10	318.60	0.05	318.45	0.16	318.34
PZ-9	frozen	frozen	-0.38	326.53	-0.13	326.28	0.19	325.96
PZ-9	frozen	frozen	-0.42	326.57	-0.08	326.23	0.23	325.93
PZ-10								
PZ-10								
PZ-11								
PZ-11								
PZ-12								
PZ-13								
PZ-14								

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 2, 3/09	Groundwater Elevation (m) Jan 2, 3/09	Depth to Groundwater (m) Apr 13, May 20/09	Groundwater Elevation (m) Apr 13, May 20/09	Depth to Groundwater (m) Jul 29/09	Groundwater Elevation (m) Jul 29/09	Depth to Groundwater (m) Aug 27/09	Groundwater Elevation (m) Aug 27/09	Depth to Groundwater (m) Oct 26, 27/09	Groundwater Elevation (m) Oct 26, 27/09
PZ-1	frozen	n/a	-0.05	327.45	-0.01	327.41			0.05	327.35
PZ-1	frozen	n/a	-0.13	327.53	-0.08	327.48			0.08	327.32
PZ-2	frozen	n/a	-0.03	326.23	0.00	326.20			0.14	326.06
PZ-2	0.05	326.15	0.04	326.16	0.06	326.14			0.14	326.06
PZ-4	frozen	n/a	-0.02	322.32	n/a	n/a	0.04	322.26	0.03	322.27
PZ-4	frozen	n/a	-0.14	322.44	n/a	n/a	0.01	322.29	-0.06	322.36
PZ-7	frozen	n/a	-0.08	321.48	n/a	n/a	-0.06	321.46	-0.11	321.51
PZ-7	-0.13	321.53	-0.09	321.49	n/a	n/a	-0.07	321.47	-0.11	321.51
PZ-8	frozen	n/a	-0.05	318.55	n/a	n/a	0.10	318.40	0.04	318.46
PZ-8	frozen	n/a	-0.07	318.57	n/a	n/a	0.09	318.41	0.03	318.47
PZ-9	frozen	n/a	-0.42	326.57	-0.24	326.39			0.05	326.10
PZ-9	frozen	n/a	-0.47	326.62	-0.16	326.31			0.13	326.03
PZ-10										
PZ-10										
PZ-11										
PZ-11										
PZ-12										
PZ-13										
PZ-14										

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 28, 29/10	Groundwater Elevation (m) Jan 28, 29/10	Depth to Groundwater (m) Apr 26-28/10	Groundwater Elevation (m) Apr 26-28/10	Depth to Groundwater (m) Jun 16/10	Groundwater Elevation (m) Jun 16/10	Depth to Groundwater (m) Jul 22/10	Groundwater Elevation (m) Jul 22/10	Depth to Groundwater (m) Oct 12-14/10	Groundwater Elevation (m) Oct 12-14/10
PZ-1	frozen	n/a	0.02	327.38			0.21	327.19	0.46	326.94
PZ-1	frozen	n/a	-0.03	327.43			0.26	327.14	0.42	326.98
PZ-2	frozen	n/a	0.05	326.15			0.04	326.16	0.30	325.90
PZ-2	frozen	n/a	0.15	326.05			0.38	325.82	0.33	325.87
PZ-4	frozen	n/a	0.13	322.17			0.23	322.07	0.16	322.14
PZ-4	frozen	n/a	0.02	322.28			0.24	322.06	0.13	322.17
PZ-7	frozen	n/a	-0.06	321.46			-0.02	321.42	-0.07	321.47
PZ-7	frozen	n/a	-0.07	321.47			-0.02	321.42	-0.07	321.47
PZ-8	frozen	n/a	-0.03	318.53	-0.05	318.55	-0.03	318.53	0.13	318.37
PZ-8	frozen	n/a	-0.03	318.53	-0.04	318.54	-0.02	318.52	0.12	318.38
PZ-9	frozen	n/a	-0.27	326.42			0.19	325.96	0.36	325.79
PZ-9	frozen	n/a	-0.18	326.33			0.26	325.89	0.53	325.62
PZ-10					installed	n/a	0.55	317.75	0.42	317.89
PZ-10					installed	n/a	0.78	317.52	0.56	317.75
PZ-11					0.13	320.13	0.37	319.88	0.14	320.11
PZ-11					0.53	319.73	1.10	319.15	0.28	319.97
PZ-12										
PZ-13										
PZ-14										

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 18, 19/11	Groundwater Elevation (m) Jan 18, 19/11	Depth to Groundwater (m) Apr 27, 28/11	Groundwater Elevation (m) Apr 27, 28/11	Depth to Groundwater (m) Jul 18, 19/11	Groundwater Elevation (m) Jul 18, 19/11	Depth to Groundwater (m) Oct 20, 25/11	Groundwater Elevation (m) Oct 20, 25/11
PZ-1	0.57	326.83	0.02	327.38	-0.01	327.41	0.14	327.26
PZ-1	0.62	326.78	-0.07	327.47	-0.10	327.50	0.16	327.24
PZ-2	0.40	325.80	0.00	326.20	-0.02	326.22	-0.01	326.21
PZ-2	0.44	325.76	0.09	326.11	0.11	326.09	0.11	326.09
PZ-4	0.11	322.19	0.13	322.17	0.14	322.16	0.00	322.30
PZ-4	-0.06	322.36	0.00	322.30	0.16	322.14	0.00	322.30
PZ-7	-0.04	321.44	-0.05	321.45	0.02	321.38	-0.10	321.50
PZ-7	-0.06	321.46	-0.07	321.47	0.02	321.38	-0.11	321.51
PZ-8	0.11	318.39	-0.10	318.60	0.09	318.41	n/a	n/a
PZ-8	0.11	318.39	n/a	n/a	0.08	318.42	-0.23	318.73
PZ-9	0.38	325.77	-0.43	326.57	-0.12	326.27	0.17	325.99
PZ-9	0.50	325.66	-0.43	326.58	-0.10	326.25	0.17	325.98
PZ-10	0.42	317.88	-0.16	318.46	0.06	318.24	n/a	n/a
PZ-10	0.55	317.75	-0.17	318.47	0.11	318.19	n/a	n/a
PZ-11	0.11	320.14	-0.02	320.27	0.14	320.11	n/a	n/a
PZ-11	0.26	320.00	-0.03	320.28	0.43	319.83	n/a	n/a
PZ-12					dry	dry	dry	dry
PZ-13								
PZ-14								

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 12, 18/12	Groundwater Elevation (m) Jan 12, 18/12	Depth to Groundwater (m) Apr 13, 16/12	Groundwater Elevation (m) Apr 13, 16/12	Depth to Groundwater (m) Jul 16, 19/12	Groundwater Elevation (m) Jul 16, 19/12	Depth to Groundwater (m) Oct 16, 18/12	Groundwater Elevation (m) Oct 16, 18/12
PZ-1	0.25	327.15	0.22	327.18	0.75	326.65	dry	dry
PZ-1	0.24	327.16	0.21	327.19	0.66	326.74	0.86	326.54
PZ-2	0.22	325.98	0.36	325.84	0.73	325.47	0.47	325.73
PZ-2	0.31	325.89	0.39	325.81	0.70	325.50	0.53	325.67
PZ-4	0.12	322.18	0.17	322.13	0.35	321.95	0.20	322.10
PZ-4	0.00	322.30	0.08	322.22	0.37	321.93	0.13	322.17
PZ-7	-0.03	321.43	0.00	321.40	0.04	321.36	-0.04	321.44
PZ-7	-0.09	321.49	-0.01	321.41	0.04	321.36	-0.05	321.45
PZ-8	0.07	318.43	0.04	318.46	0.35	318.15	0.11	318.39
PZ-8	-0.05	318.55	0.04	318.47	0.35	318.16	0.11	318.40
PZ-9	-0.23	326.38	-0.03	326.18	0.45	325.71	dry	dry
PZ-9	-0.22	326.37	-0.02	326.17	0.57	325.59	0.83	325.32
PZ-10	-0.09	318.39	0.10	318.20	0.56	317.74	0.24	318.07
PZ-10	-0.09	318.39	0.13	318.18	0.94	317.36	0.40	317.90
PZ-11	0.02	320.24	0.15	320.10	0.22	320.03	0.09	320.16
PZ-11	0.28	319.97	0.41	319.85	0.56	319.69	0.34	319.92
PZ-12	0.60	325.91	dry	dry	dry	dry	0.90	325.60
PZ-13								
PZ-14								

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 10, 11/13	Groundwater Elevation (m) Jan 10, 11/13	Depth to Groundwater (m) Apr 25, 26/13	Groundwater Elevation (m) Apr 25, 26/13	Depth to Groundwater (m) Jul 15, 16/13	Groundwater Elevation (m) Jul 15, 16/13	Depth to Groundwater (m) Oct 23, 24/13	Groundwater Elevation (m) Oct 23, 24/13
PZ-1	0.65	326.75	0.03	327.37	0.07	327.33	0.22	327.18
PZ-1	0.69	326.71	-0.06	327.46	0.03	327.37	0.21	327.19
PZ-2	0.39	325.81	0.10	326.10	0.26	325.94	0.20	326.00
PZ-2	0.43	325.77	0.15	326.05	0.32	325.88	0.25	325.95
PZ-4	0.17	322.13	0.12	322.18	0.19	322.11	0.16	322.14
PZ-4	0.05	322.25	-0.01	322.31	0.11	322.19	0.00	322.30
PZ-7	-0.02	321.42	0.00	321.40	0.01	321.39	-0.05	321.45
PZ-7	-0.03	321.43	-0.03	321.43	0.00	321.40	-0.07	321.47
PZ-8	0.03	318.47	-0.13	318.63	0.06	318.44	-0.04	318.54
PZ-8	0.03	318.48	-0.13	318.63	0.05	318.45	-0.05	318.55
PZ-9	0.41	325.74	0.39	325.76	0.33	325.82	0.37	325.78
PZ-9	0.41	325.75	-0.42	326.57	-0.03	326.18	0.11	326.04
PZ-10	0.09	318.21	-0.18	318.48	0.04	318.26	-0.11	318.41
PZ-10	0.11	318.19	-0.18	318.48	0.05	318.25	-0.11	318.41
PZ-11	0.11	320.14	0.04	320.22	0.12	320.13	0.01	320.24
PZ-11	0.37	319.88	0.25	320.00	0.44	319.81	0.30	319.95
PZ-12	0.66	325.84	0.51	326.00	0.52	325.98	0.50	326.01
PZ-13					0.05	324.15	-0.01	324.21
PZ-14					0.45	323.75	0.01	324.19

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 13, 14/14	Groundwater Elevation (m) Jan 13, 14/14	Depth to Groundwater (m) Apr 22, 23/14	Groundwater Elevation (m) Apr 22, 23/14	Depth to Groundwater (m) Jul 14, 15/14	Groundwater Elevation (m) Jul 14, 15/14	Depth to Groundwater (m) Oct 9, 10/14	Groundwater Elevation (m) Oct 9, 10/14
PZ-1	frozen	frozen	-0.03	327.43	0.04	327.36	0.16	327.24
PZ-1	frozen	frozen	-0.08	327.48	0.03	327.37	0.17	327.23
PZ-2	frozen	frozen	0.04	326.16	0.23	325.97	0.23	325.97
PZ-2	frozen	frozen	0.13	326.07	0.29	325.91	0.28	325.92
PZ-4	frozen	frozen	0.18	322.12	0.27	322.03	0.21	322.09
PZ-4	frozen	frozen	0.07	322.23	0.17	322.13	0.05	322.25
PZ-7	frozen	frozen	0.00	321.40	0.03	321.37	-0.05	321.45
PZ-7	frozen	frozen	-0.02	321.42	0.01	321.39	-0.06	321.46
PZ-8	-0.15	318.65	-0.10	318.60	0.09	318.41	0.00	318.50
PZ-8	-0.16	318.66	-0.15	318.65	0.09	318.41	-0.01	318.51
PZ-9	frozen	frozen	0.39	325.76	0.36	325.79	0.32	325.83
PZ-9	frozen	frozen	-0.42	326.57	-0.01	326.16	0.10	326.05
PZ-10	frozen	frozen	-0.14	318.44	0.34	317.96	-0.03	318.33
PZ-10	frozen	frozen	-0.14	318.44	0.36	317.94	-0.03	318.33
PZ-11	0.01	320.24	0.05	320.20	0.15	320.10	0.11	320.14
PZ-11	0.22	320.03	0.28	319.97	0.46	319.79	0.39	319.86
PZ-12	frozen	frozen	0.41	326.09	0.57	325.93	0.50	326.01
PZ-13	frozen	frozen	0.06	324.15	-	-	0.08	324.12
PZ-14	frozen	frozen	0.02	324.19	-	-	0.04	324.16

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Piezometer Groundwater Elevation Data

Piezometer Number	Depth to Groundwater (m) Jan 9, 14/15	Groundwater Elevation (m) Jan 9, 14/15	Depth to Groundwater (m) Apr 10, 13/15	Groundwater Elevation (m) Apr 10, 13/15	Depth to Groundwater (m) Jul 15, 16/15	Groundwater Elevation (m) Jul 15, 16/15	Depth to Groundwater (m) Oct 23, 24/15	Groundwater Elevation (m) Oct 23, 24/15
PZ-1	frozen	frozen	0.19	327.21	0.22	327.18	0.57	326.83
PZ-1	frozen	frozen	0.13	327.27	0.22	327.18	0.62	326.78
PZ-2	frozen	frozen	0.10	326.10	0.29	325.91	0.45	325.75
PZ-2	frozen	frozen	0.14	326.06	0.31	325.89	0.48	325.72
PZ-4	frozen	frozen	0.14	322.16	0.16	322.14	0.22	322.08
PZ-4	frozen	frozen	0.12	322.18	0.13	322.17	0.17	322.13
PZ-7	frozen	frozen	-0.04	321.44	0.02	321.38	-0.03	321.43
PZ-7	frozen	frozen	-0.02	321.42	-0.02	321.42	-0.04	321.44
PZ-8	frozen	frozen	-0.19	318.69	-0.02	318.52	0.11	318.39
PZ-8	frozen	frozen	-0.18	318.68	-0.03	318.53	0.10	318.40
PZ-9	frozen	frozen	0.28	325.87	0.25	325.90	0.25	325.90
PZ-9	frozen	frozen	-0.28	326.43	0.08	326.07	0.54	325.61
PZ-10	frozen	frozen	-0.24	318.54	0.04	318.26	0.55	317.75
PZ-10	frozen	frozen	-0.23	318.53	0.05	318.25	0.75	317.55
PZ-11	frozen	frozen	0.03	320.22	-0.03	320.28	0.10	320.15
PZ-11	frozen	frozen	0.26	319.99	0.38	319.87	0.45	319.80
PZ-12	frozen	frozen	0.54	325.97	0.58	325.93	dry	dry
PZ-13	frozen	frozen	0.10	324.10	-	-	0.18	324.02
PZ-14	frozen	frozen	0.09	324.12	-	-	0.15	324.05

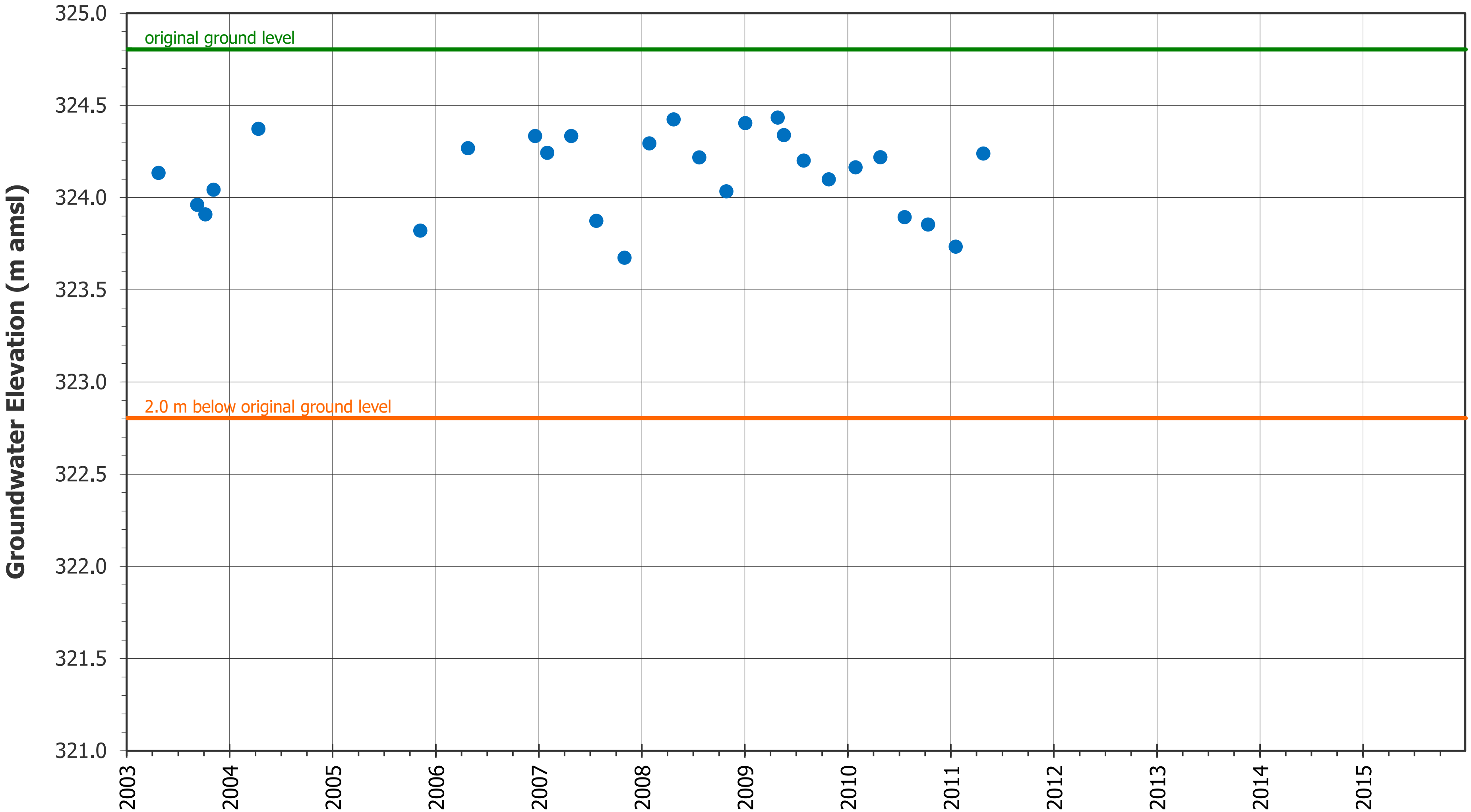
Appendix C

Groundwater Monitoring Graphs
2003 – 2015

MW 001

Shallow Overburden Monitor (Decommissioned 2011)

Ground Elevation: 324.80 m amsl   Screened Interval: 4.0 - 6.1 m bgl



Banks Groundwater Engineering Limited

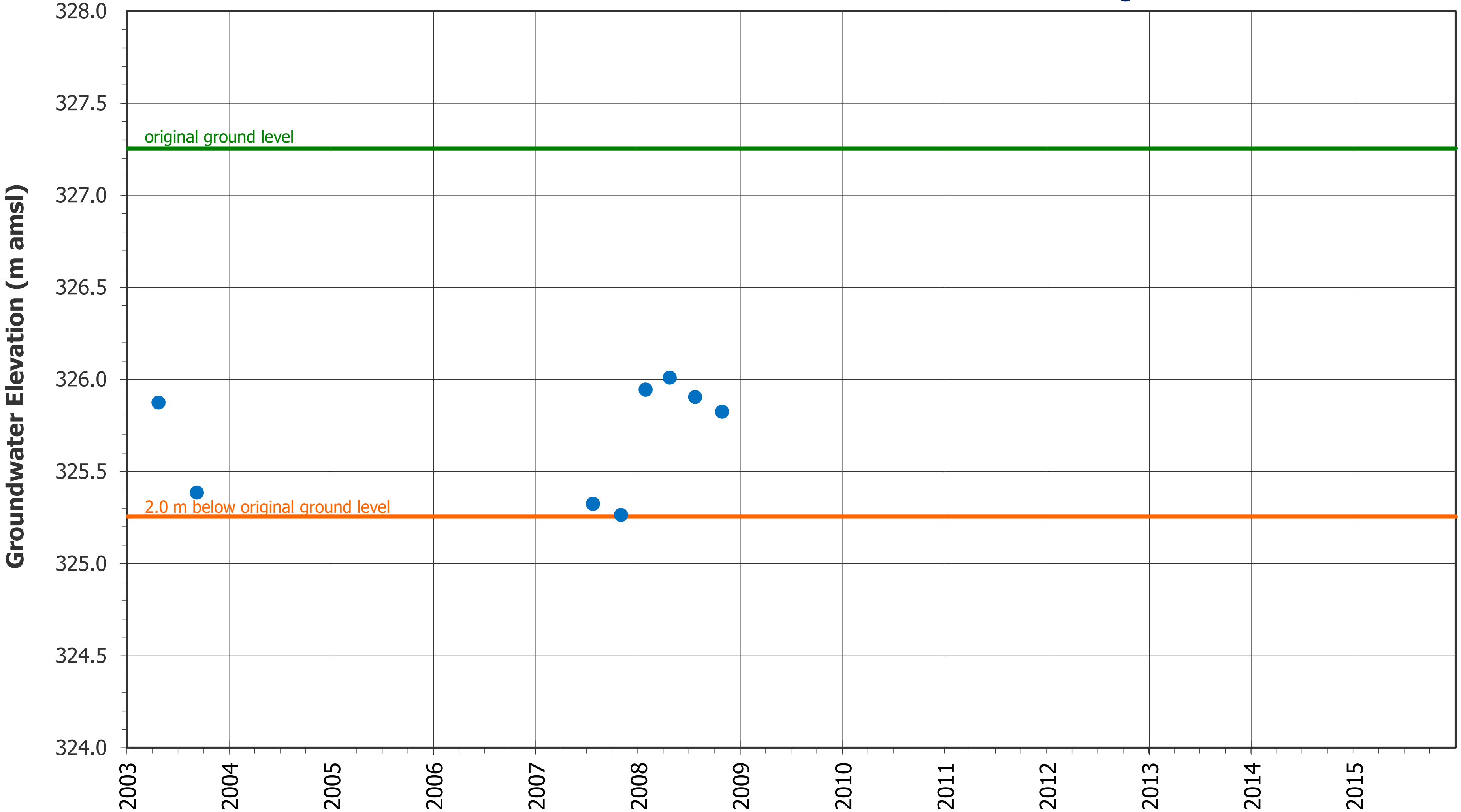
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 1 - Core PSW**   **Graph C 1**

MW 002

Shallow Overburden Monitor (Decommissioned 2010)

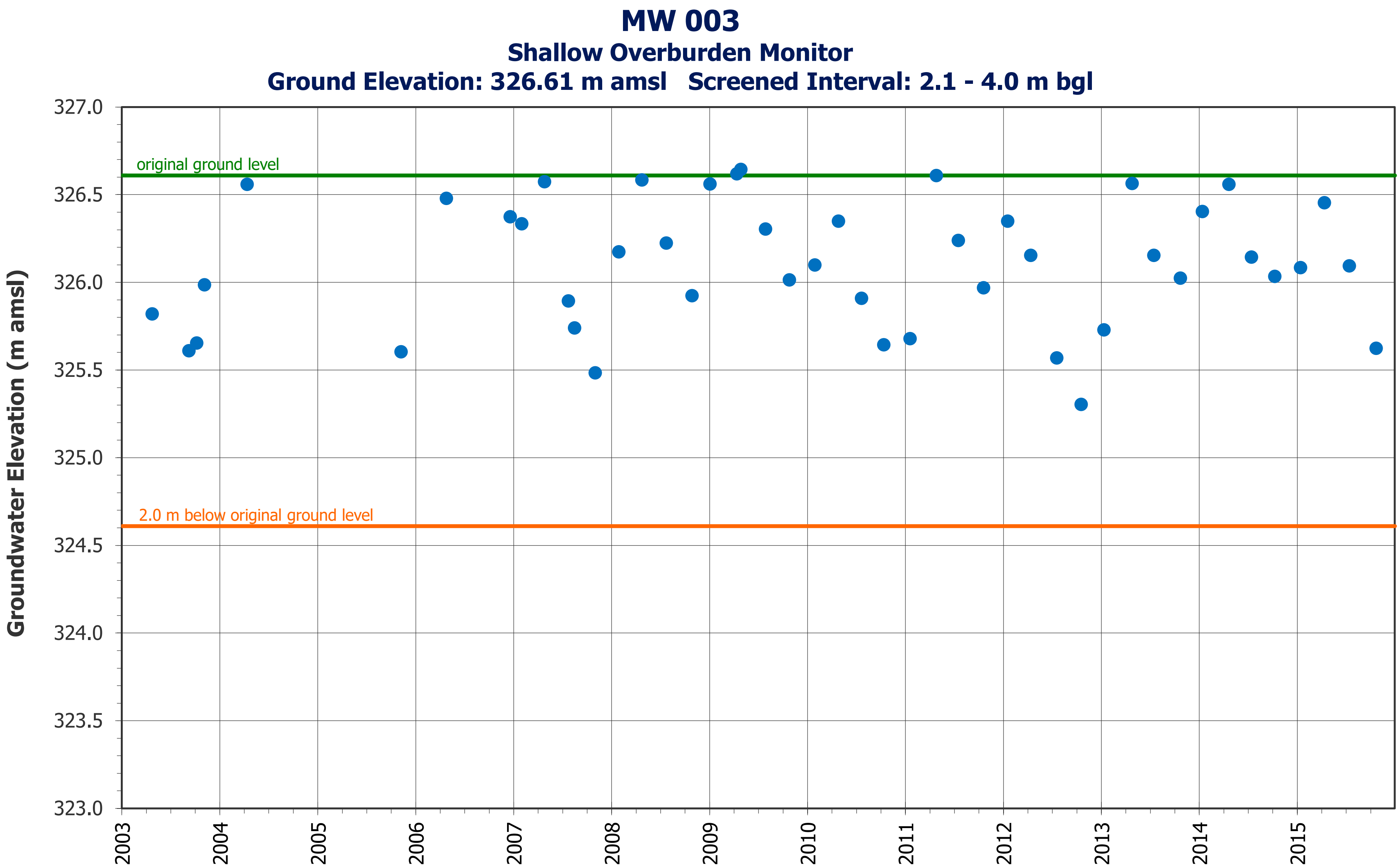
Ground Elevation: 327.26 m amsl   Screened Interval: 2.2 - 4.0 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 2 - Core PSW**   **Graph C 2**

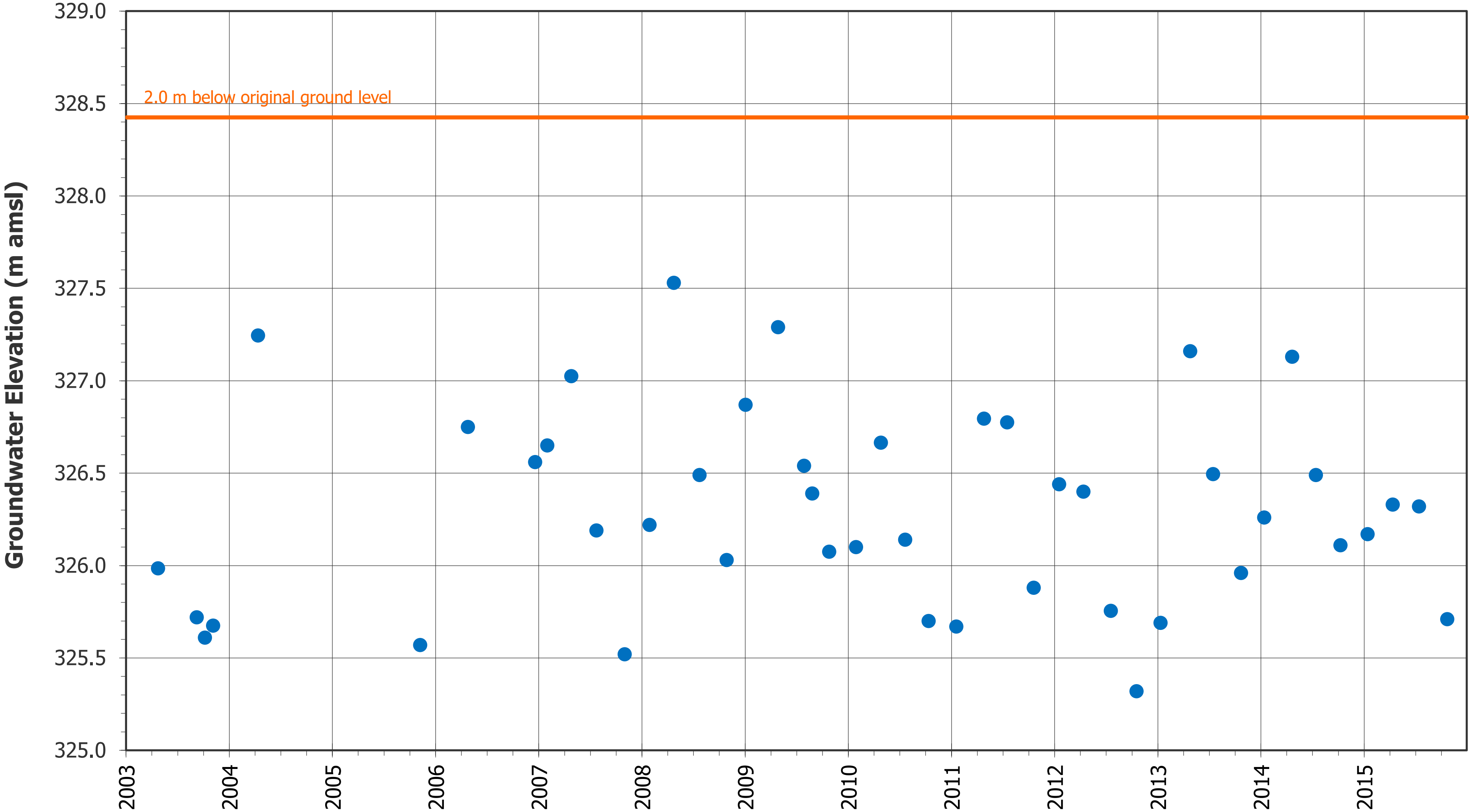


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph C 3**

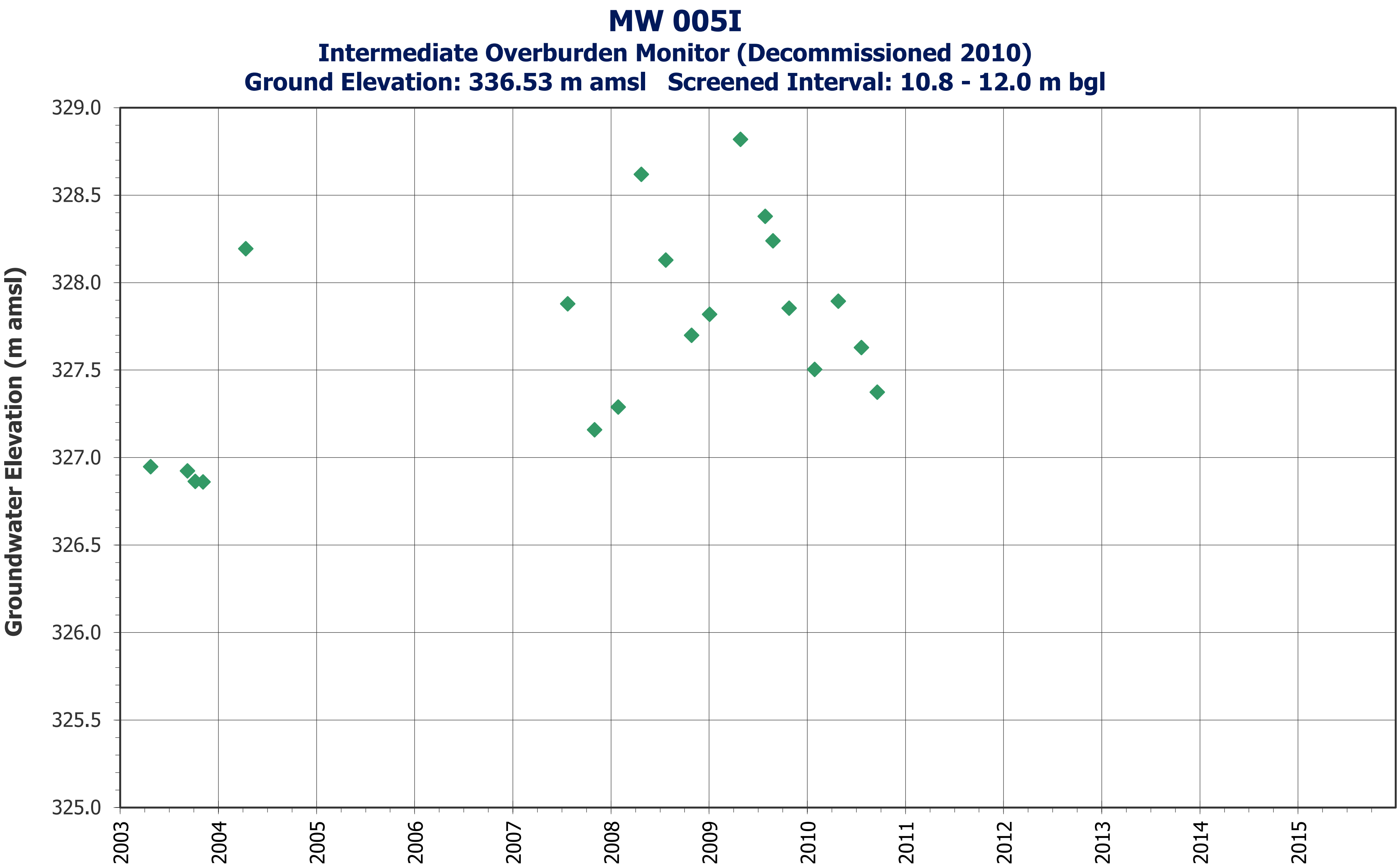
MW 004
Shallow Overburden Monitor
Ground Elevation: 330.43 m amsl   Screened Interval: 5.1 - 7.0 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph C 4**



Banks Groundwater Engineering Limited

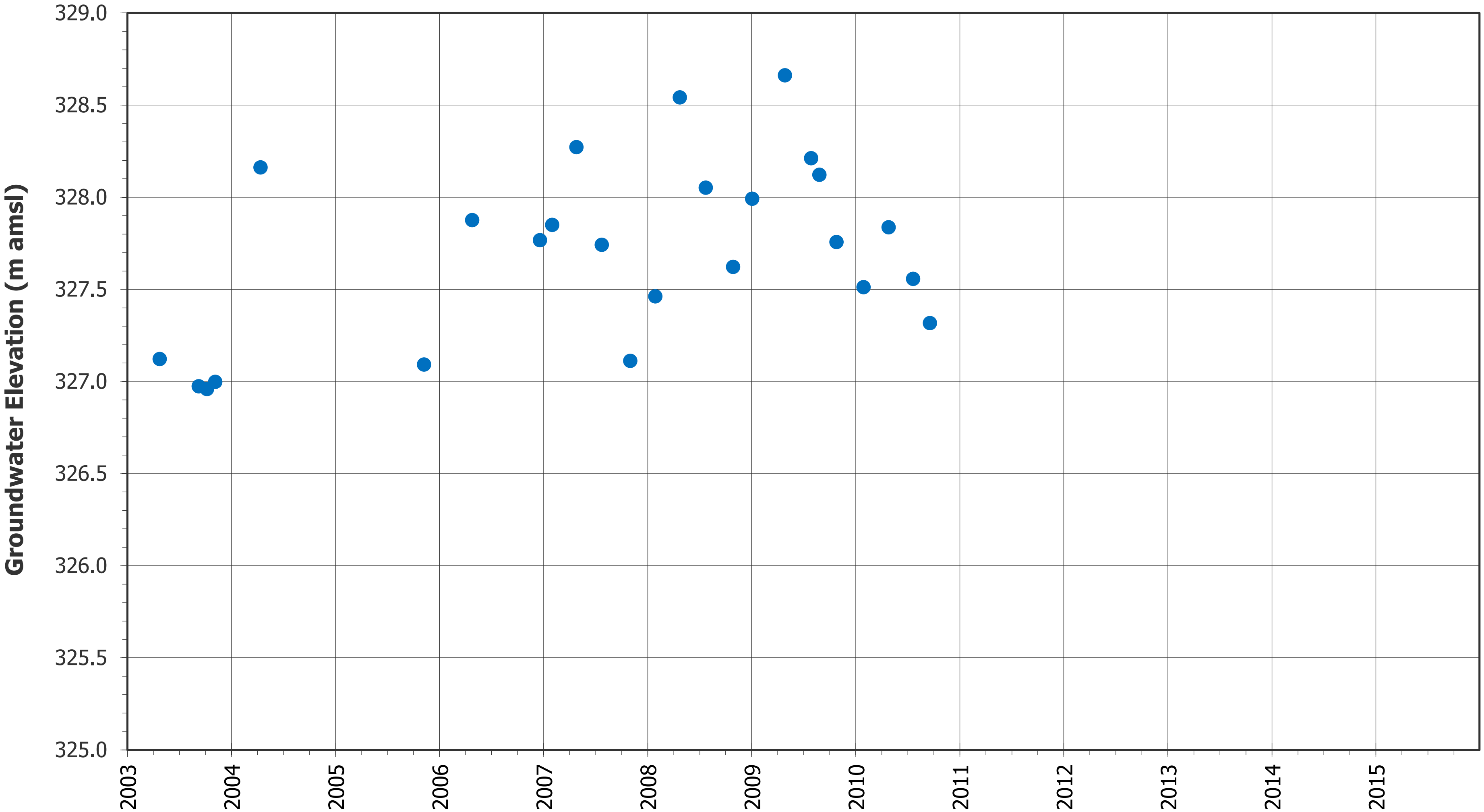
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph C 5**

MW 006

Shallow Overburden Monitor (Decommissioned 2010)

Ground Elevation: 334.70 m amsl   Screened Interval: 7.5 - 9.0 m bgl



Banks Groundwater Engineering Limited

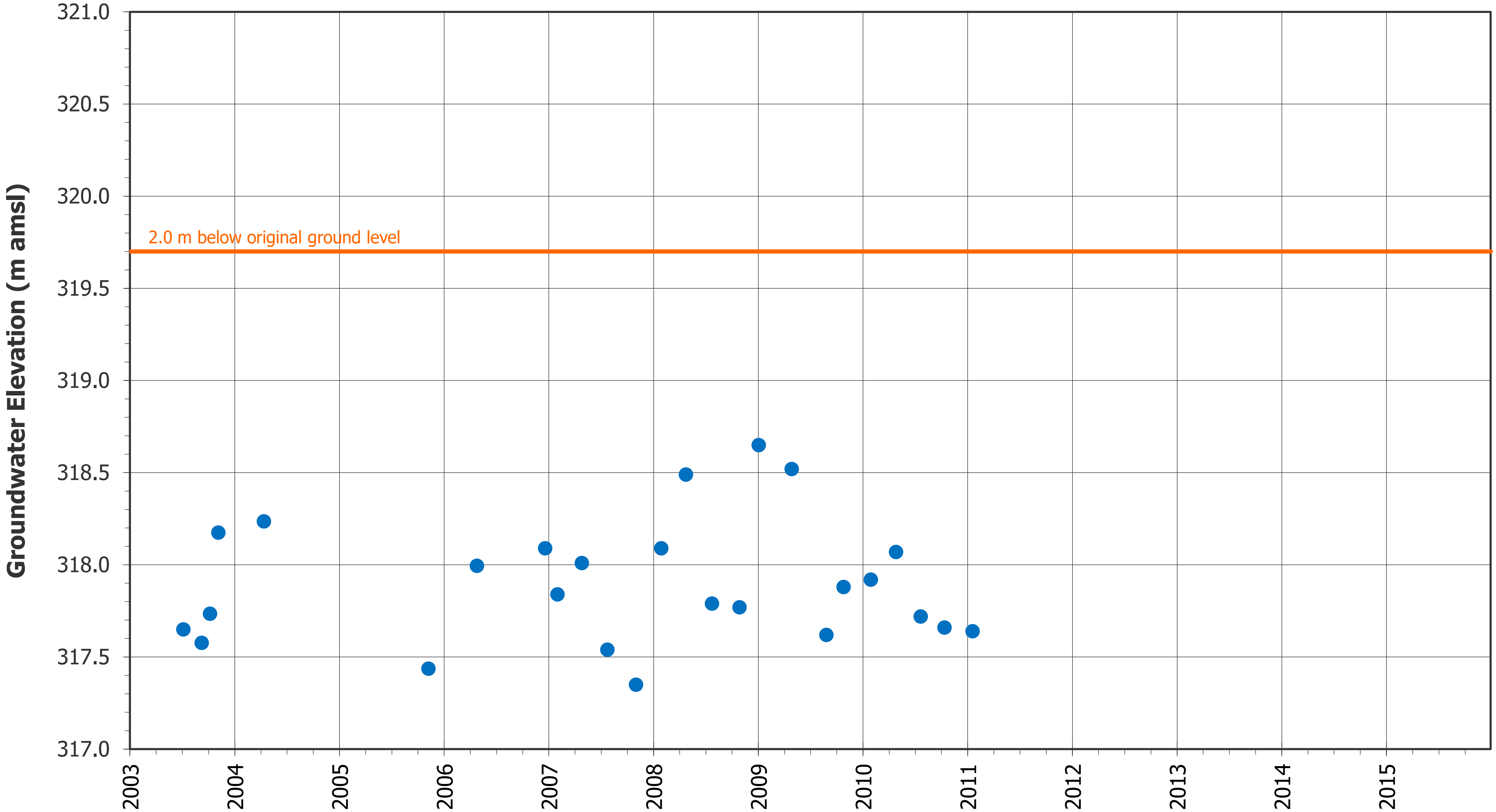
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 2 - Perimeter**   **Graph C 6**

MW 101

Shallow Overburden Monitor (Decommissioned 2011)

Ground Elevation: 321.70 m amsl   Screened Interval: 4.0 - 6.0 m bgl

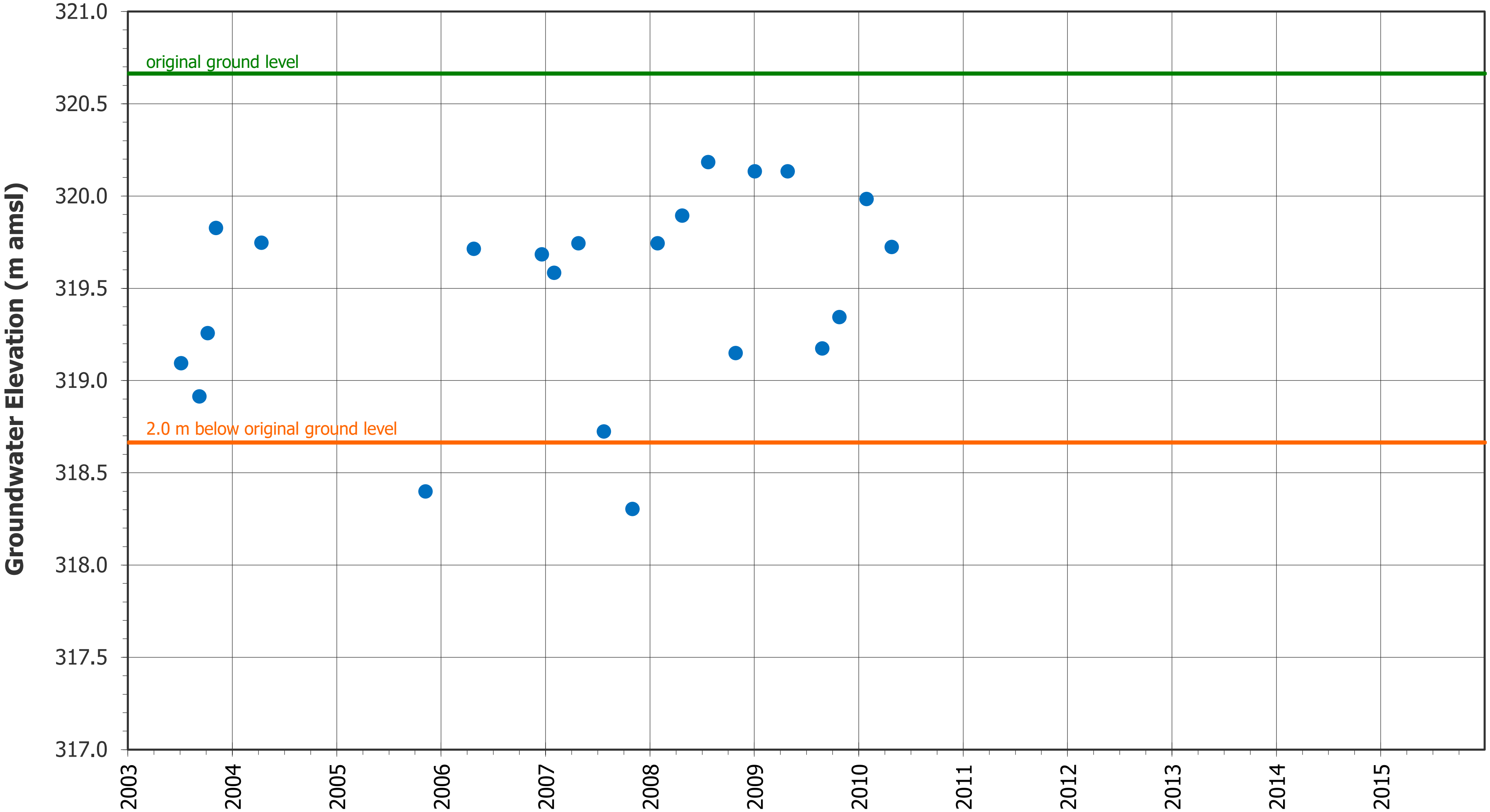


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 1 - Core PSW**   **Graph C 7**

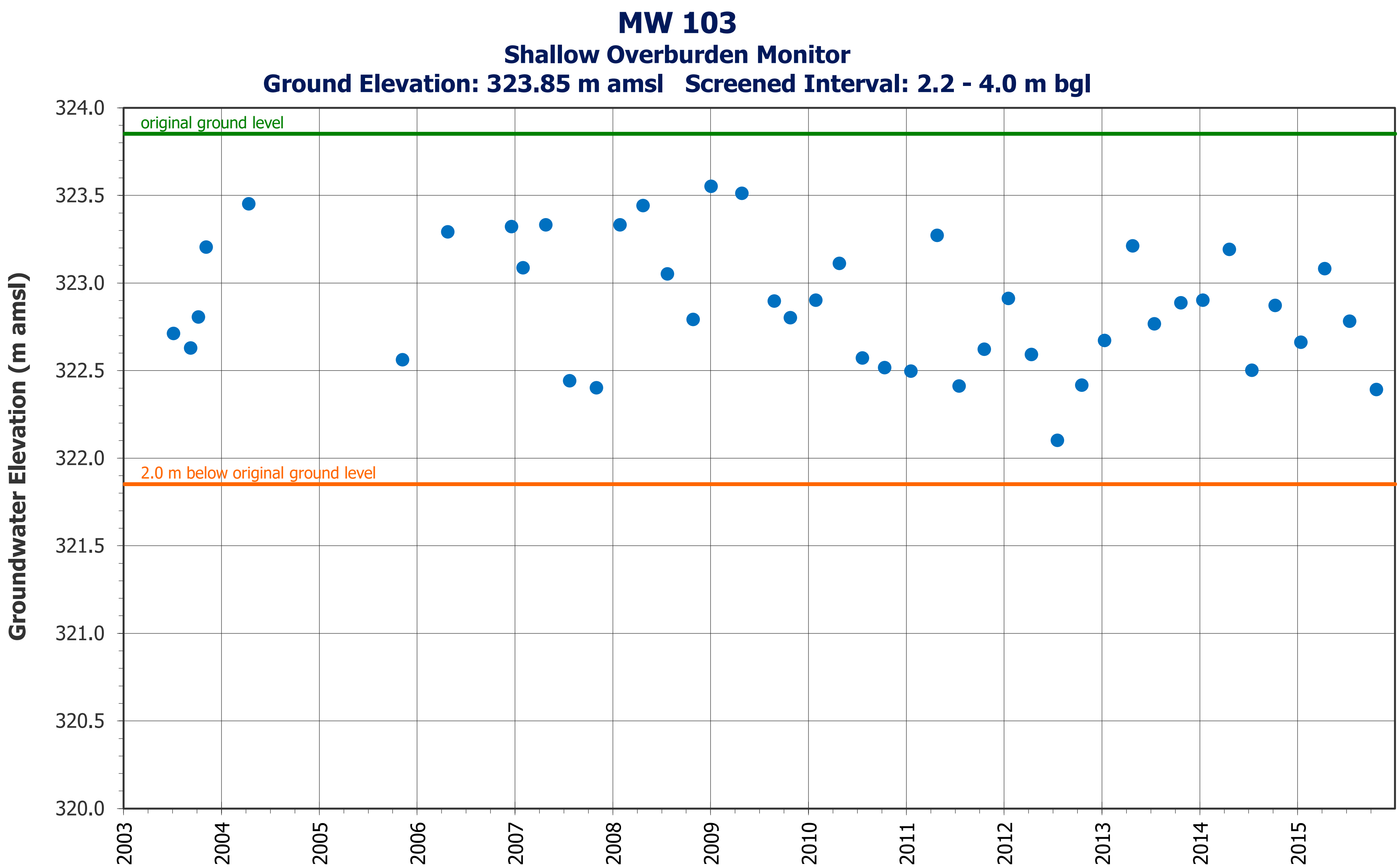
MW 102
Shallow Overburden Monitor (Decommissioned 2010)
Ground Elevation: 320.66 m amsl   Screened Interval: 3.0 - 4.5 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 1 - Perimeter**   **Graph C 8**



Banks Groundwater Engineering Limited

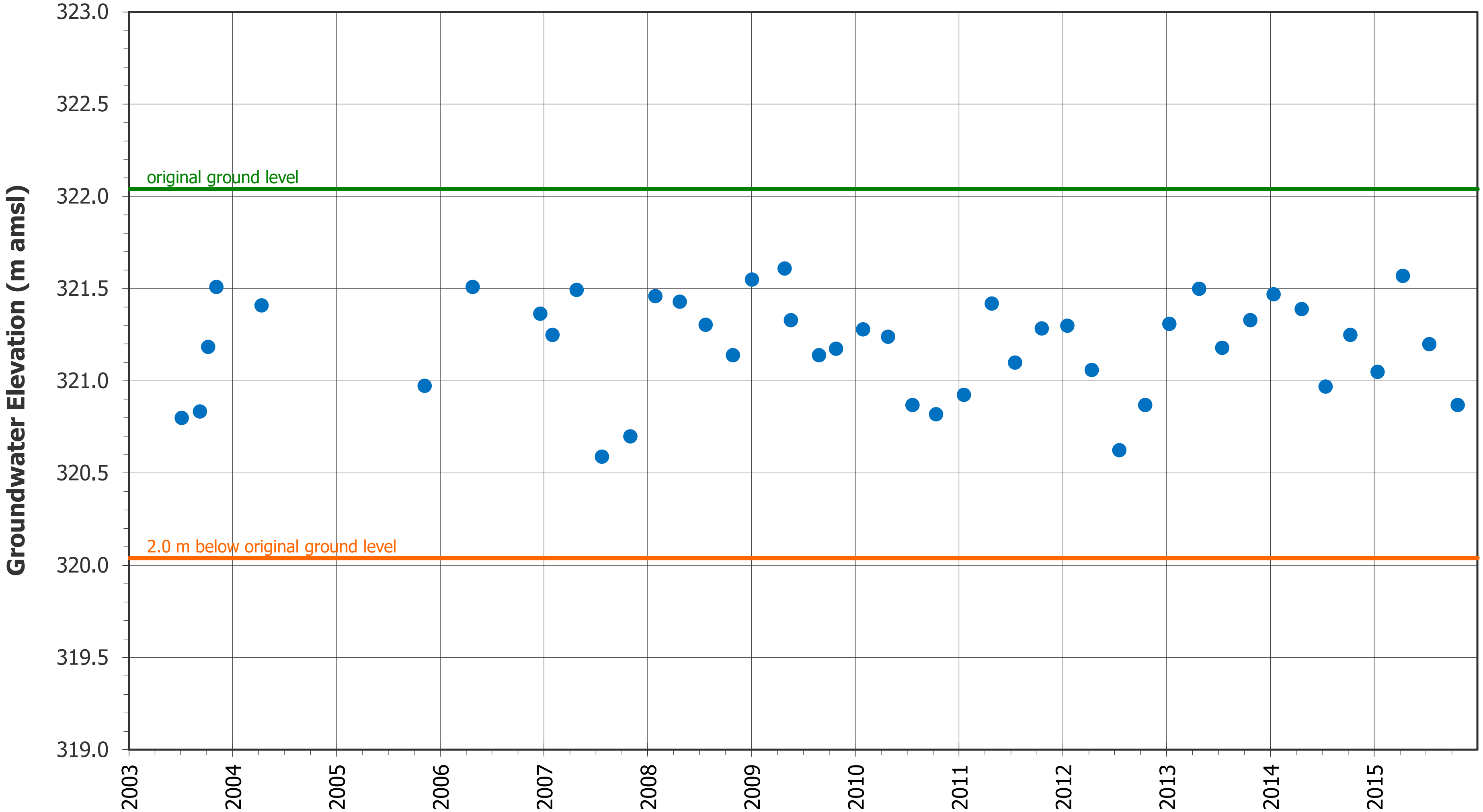
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 9**

MW 104

Shallow Overburden Monitor

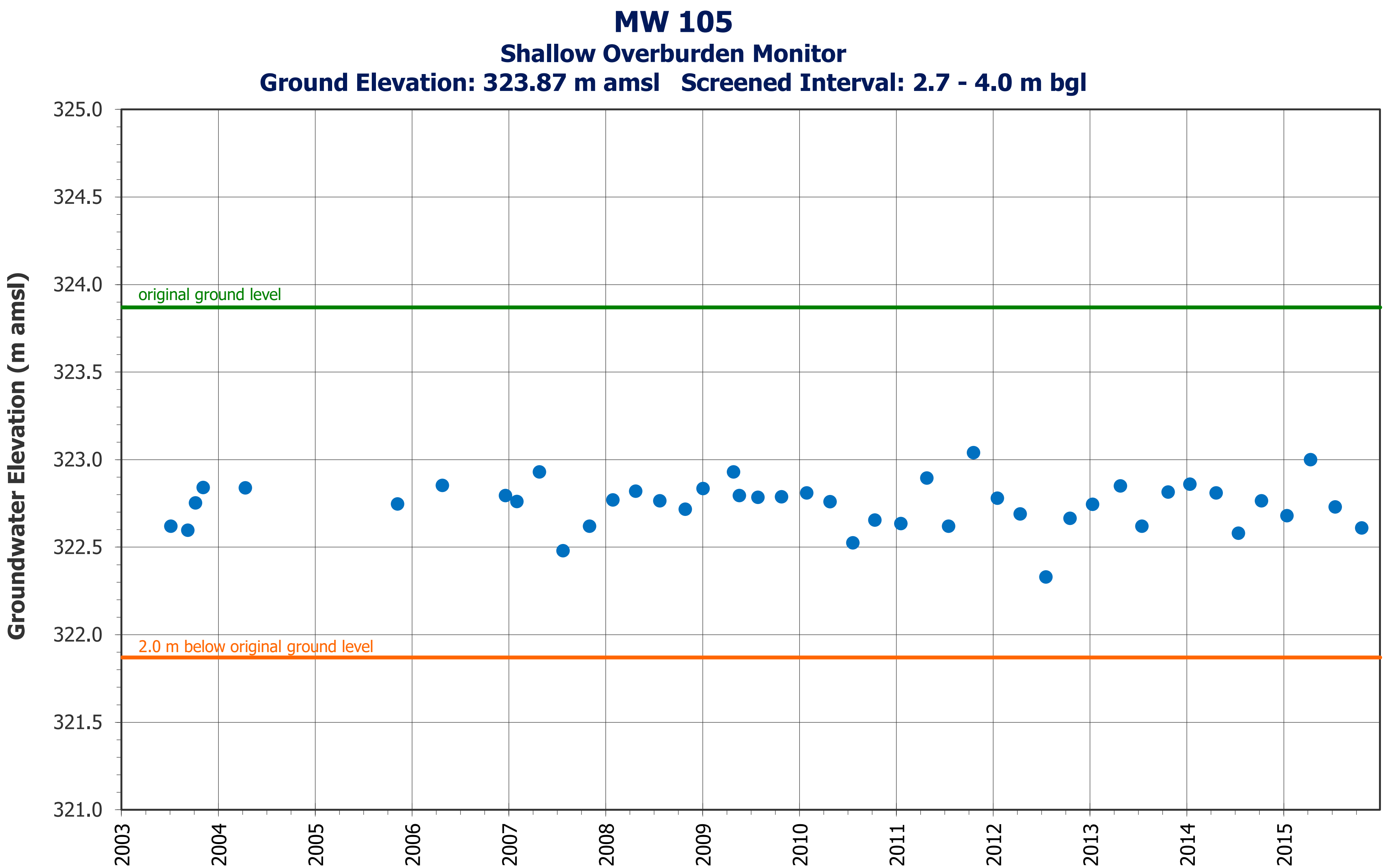
Ground Elevation: 322.04 m amsl   Screened Interval: 2.3 - 4.1 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

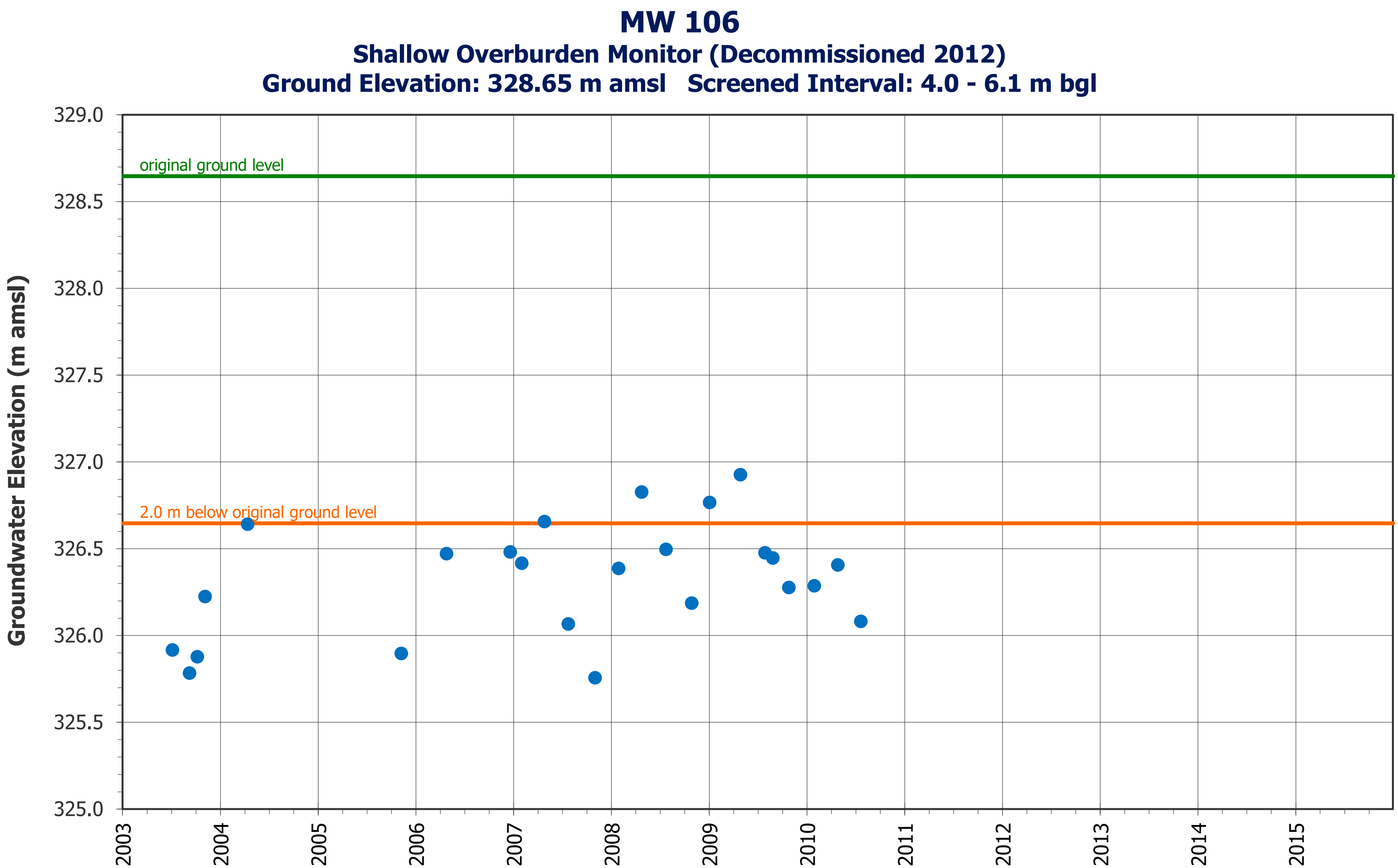
December 2015   **Phase 1 - Core PSW**   **Graph C 10**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

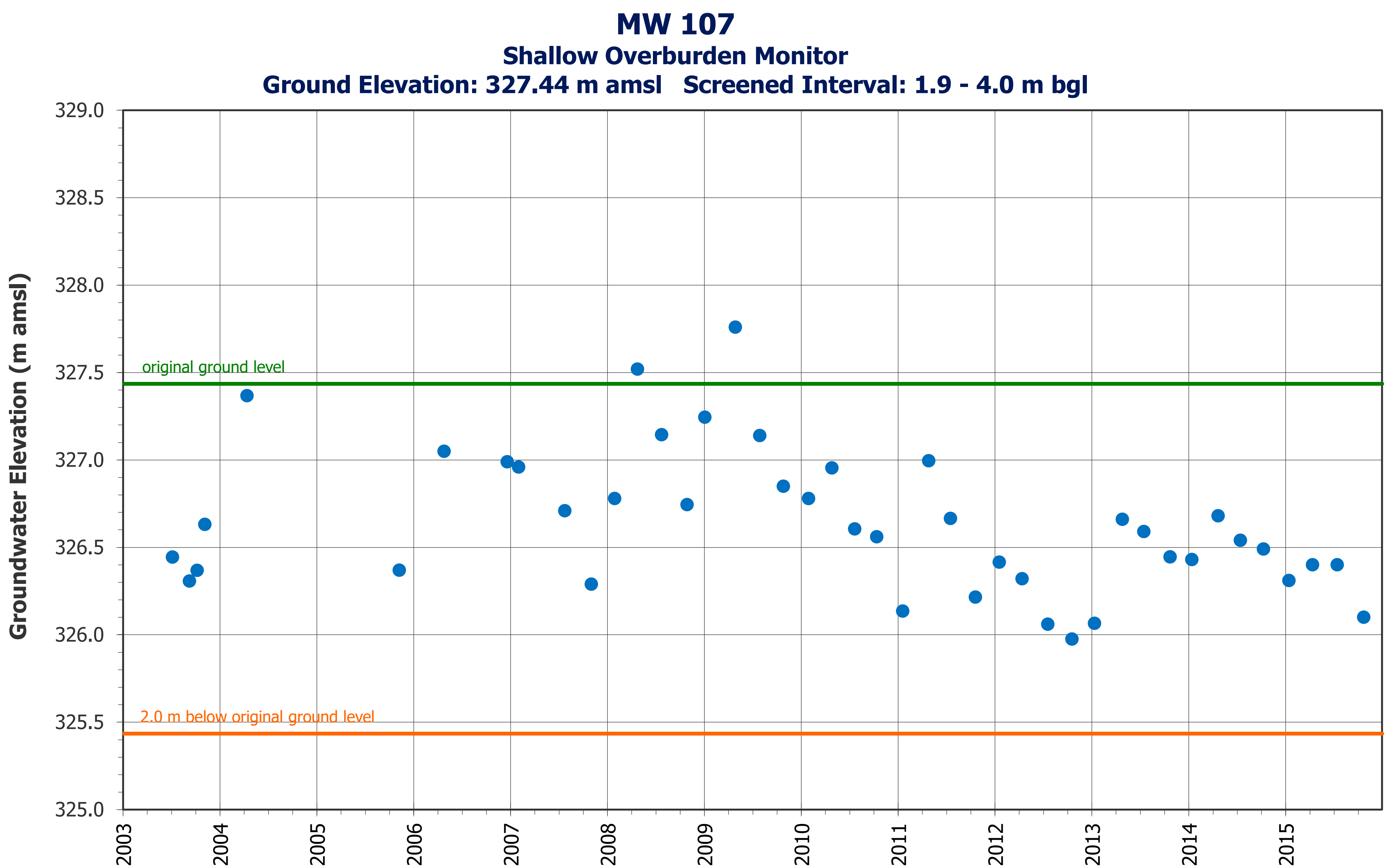
December 2015 **Phase 1 - Core PSW** **Graph C 11**

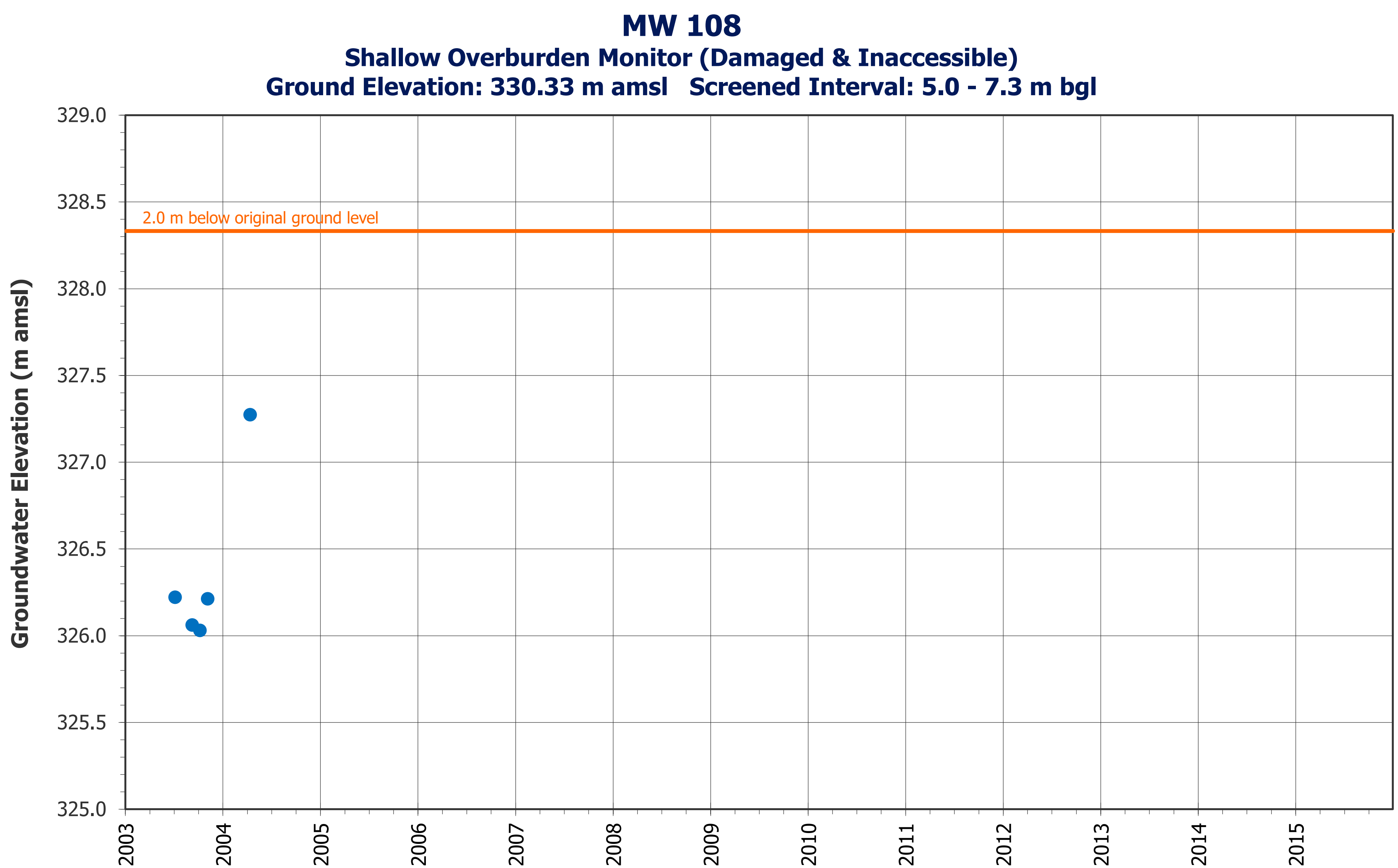


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph C 12**

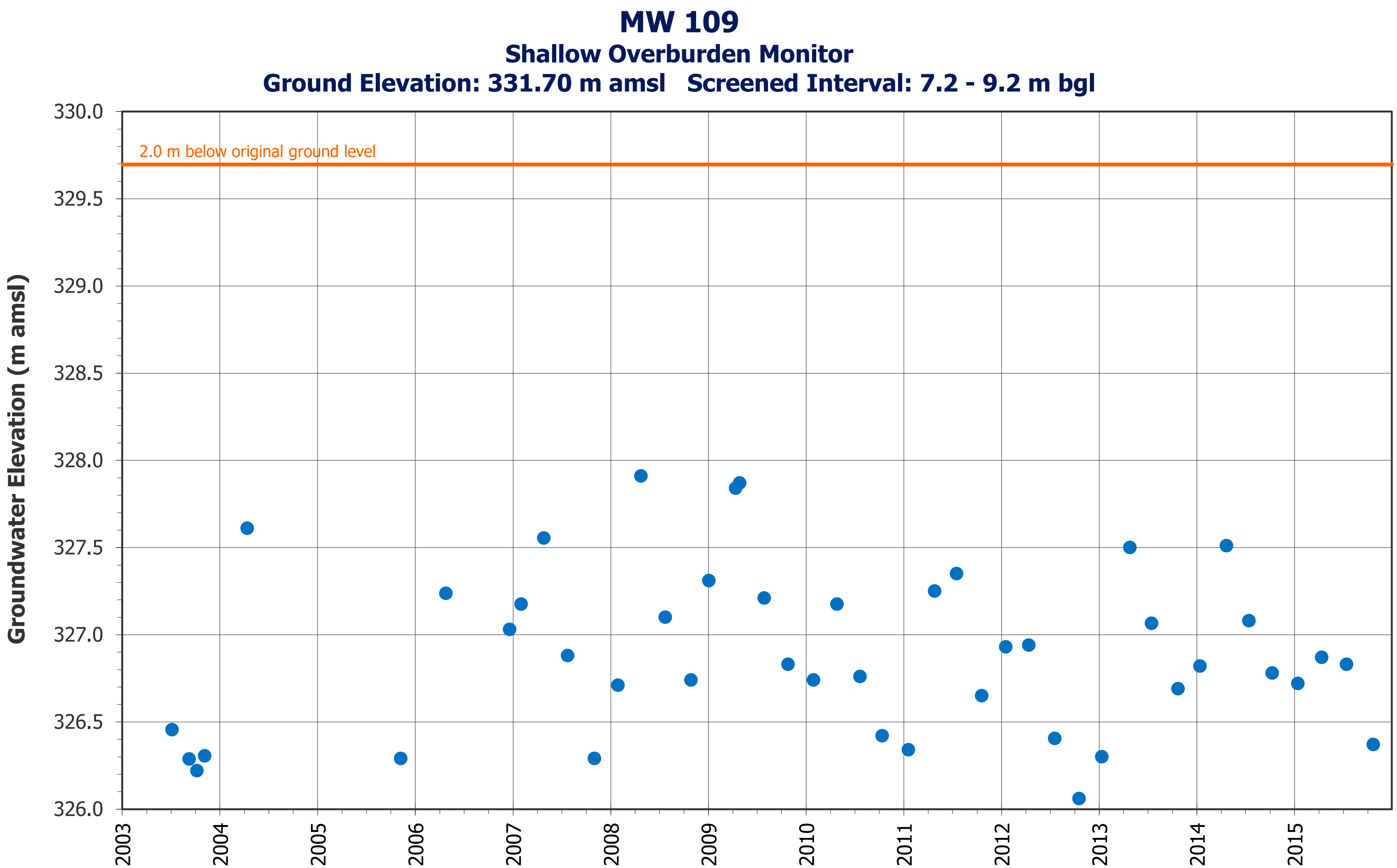

MW 107
Shallow Overburden Monitor
Ground Elevation: 327.44 m amsl   Screened Interval: 1.9 - 4.0 m bgl
Groundwater Elevation (m amsl)
329.0
328.5
328.0
327.5
327.0
326.5
326.0
325.5
325.0
original ground level
2.0 m below original ground level
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph C 14**

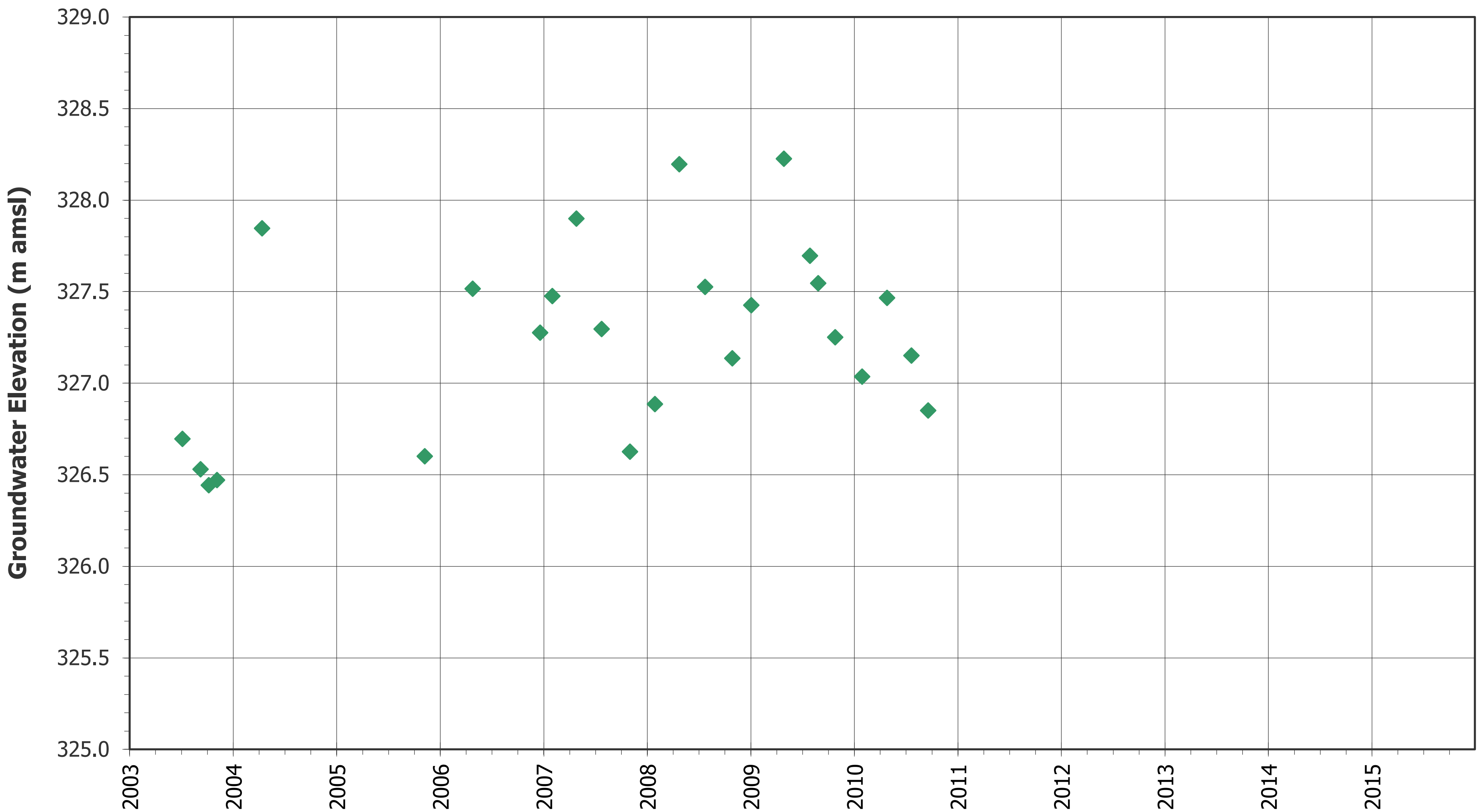


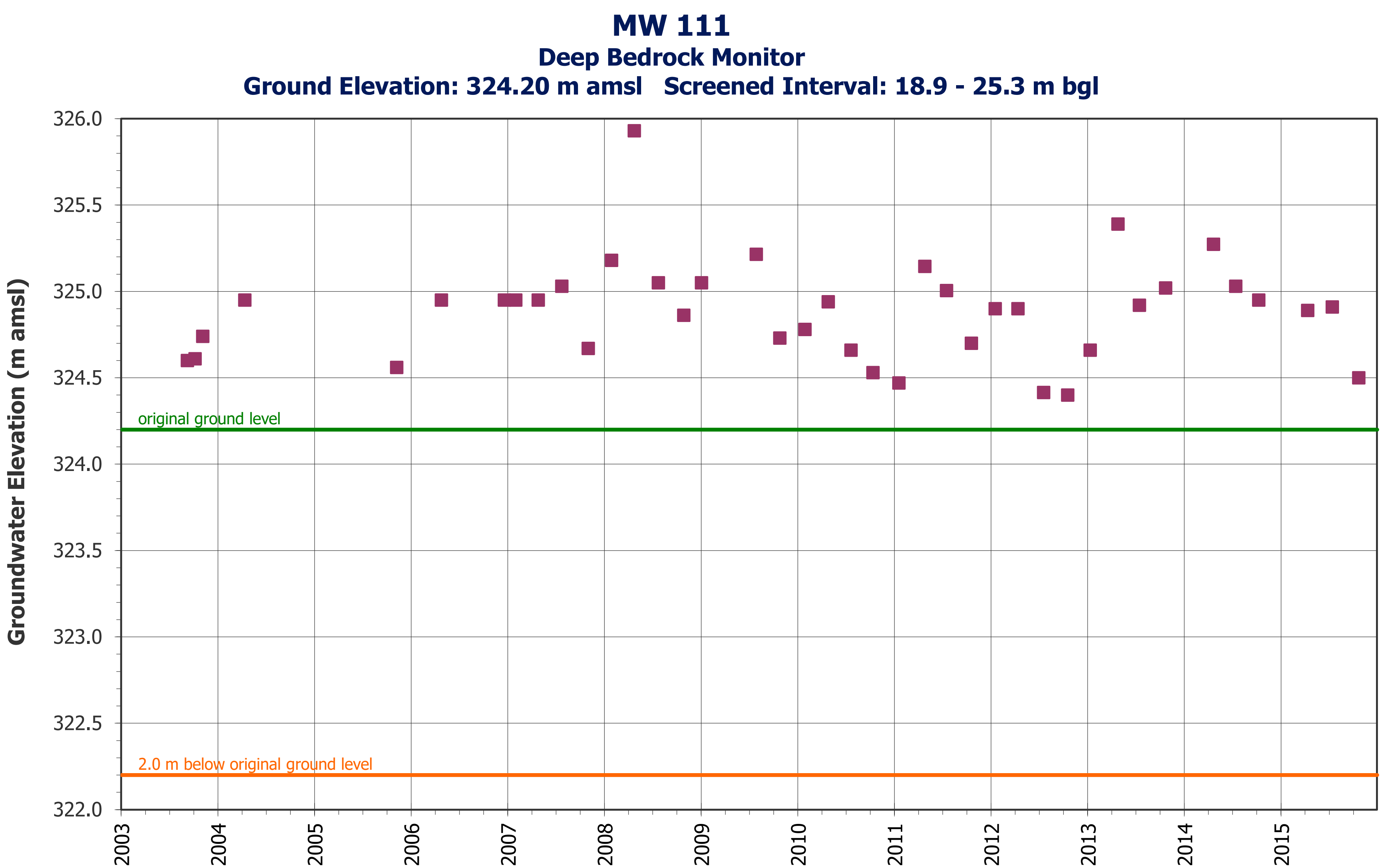
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph C 15**

MW 110
Intermediate Overburden Monitor (Decommissioned 2010)
Ground Elevation: 339.59 m amsl   Screened Interval: 14.8 - 16.8 m bgl

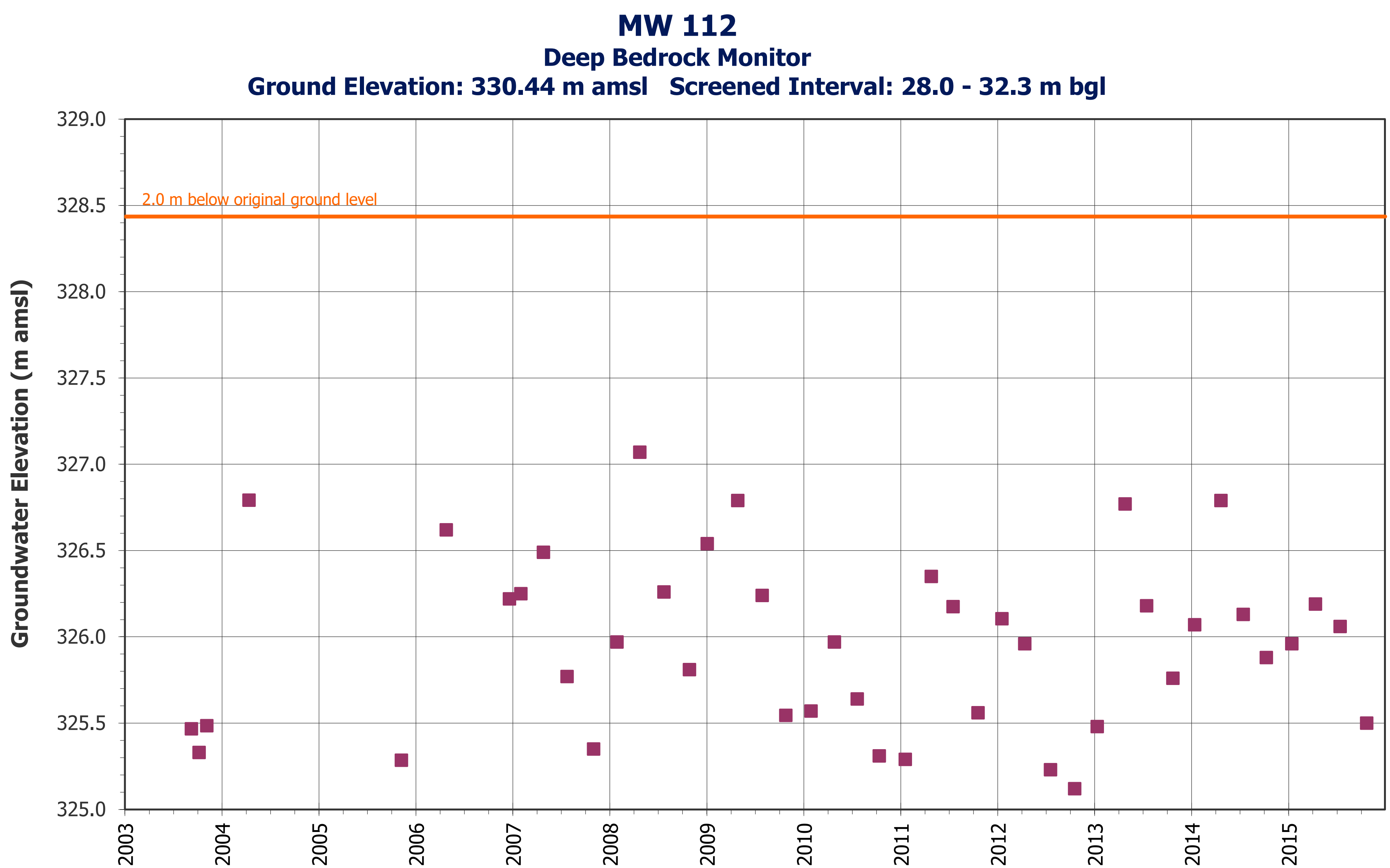




Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 17**



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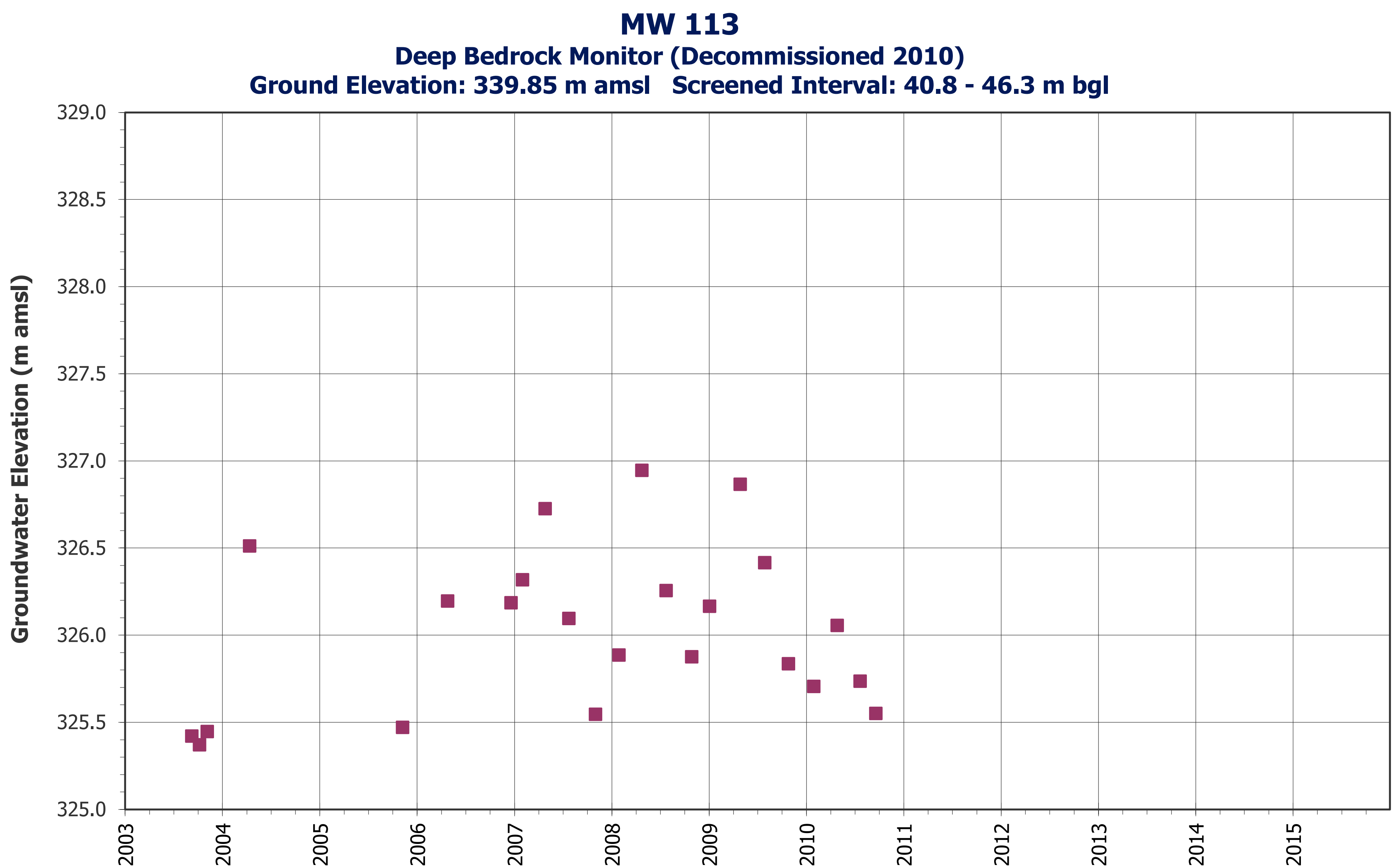
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph C 18**



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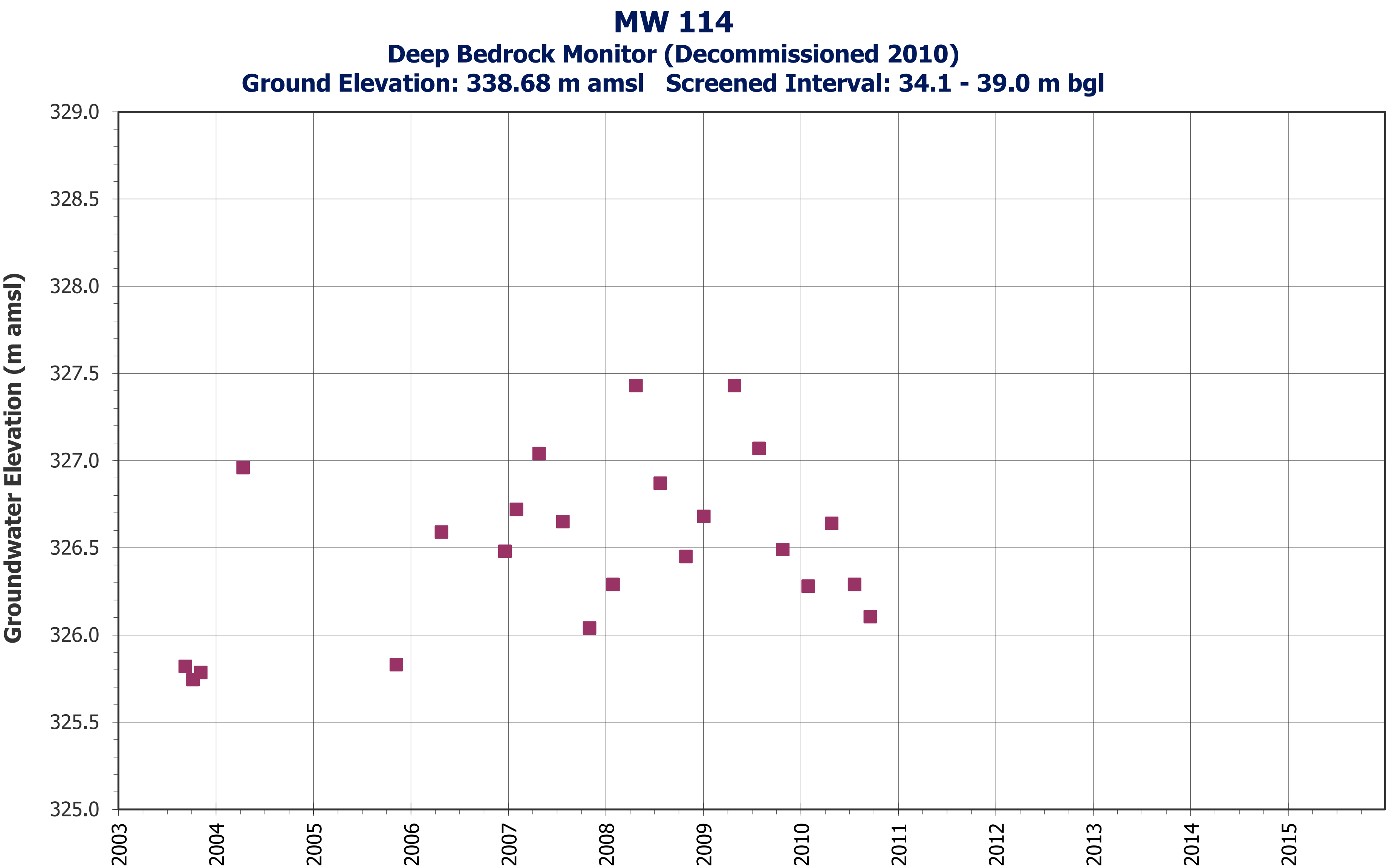
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

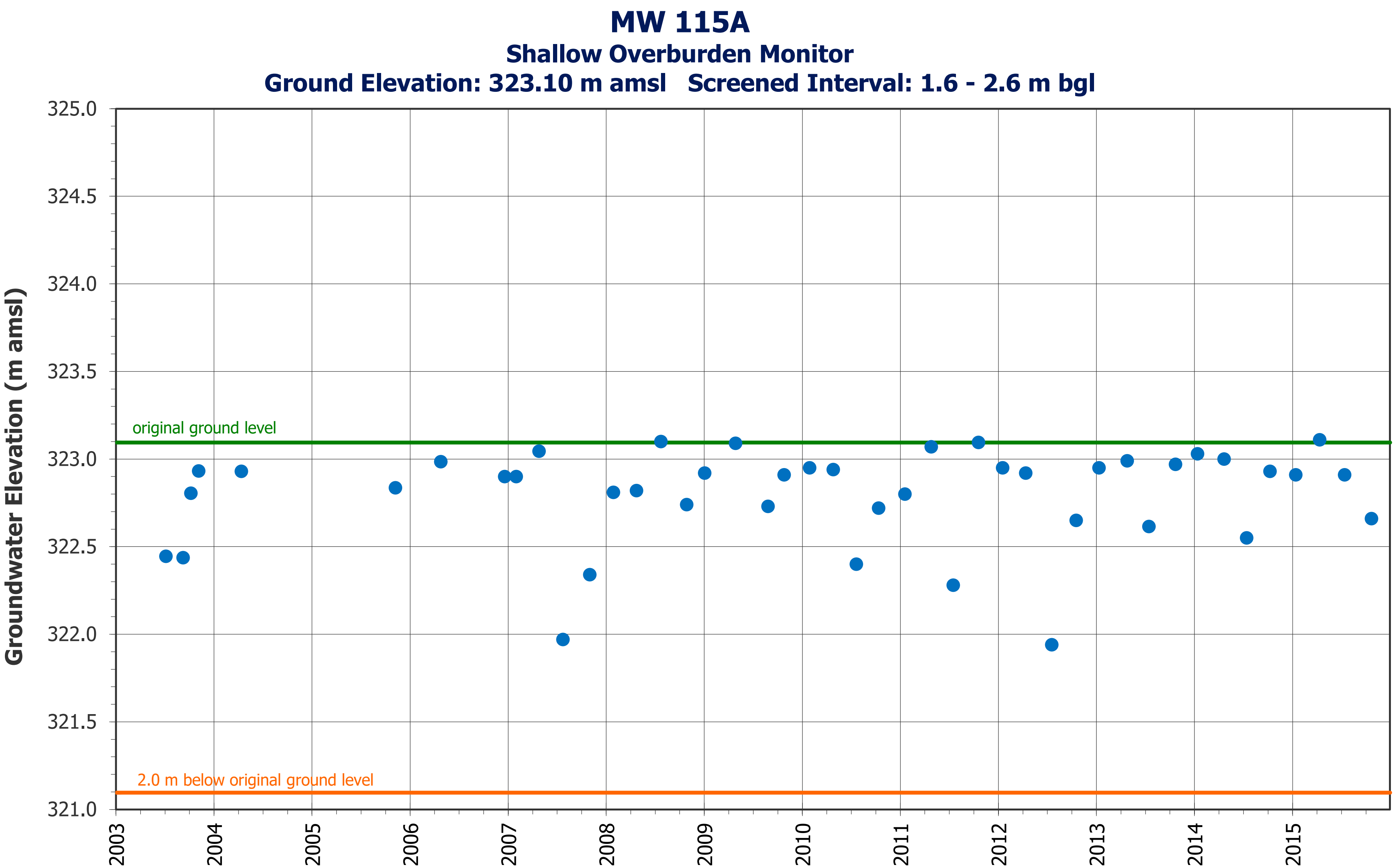
Phase 2 - Perimeter Graph C 19



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph C 20**



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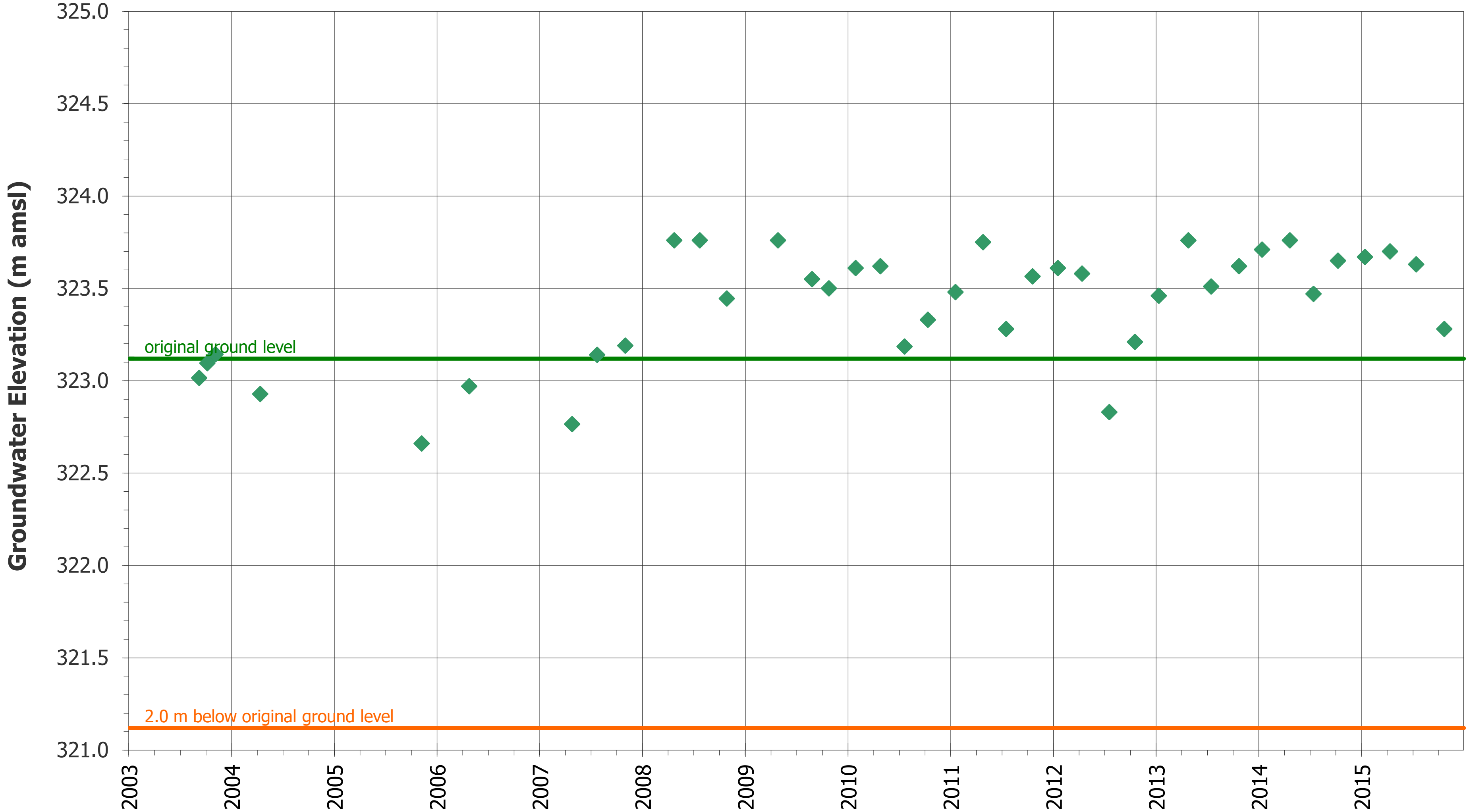
Hanlon Creek Business Park - Groundwater Monitoring Program

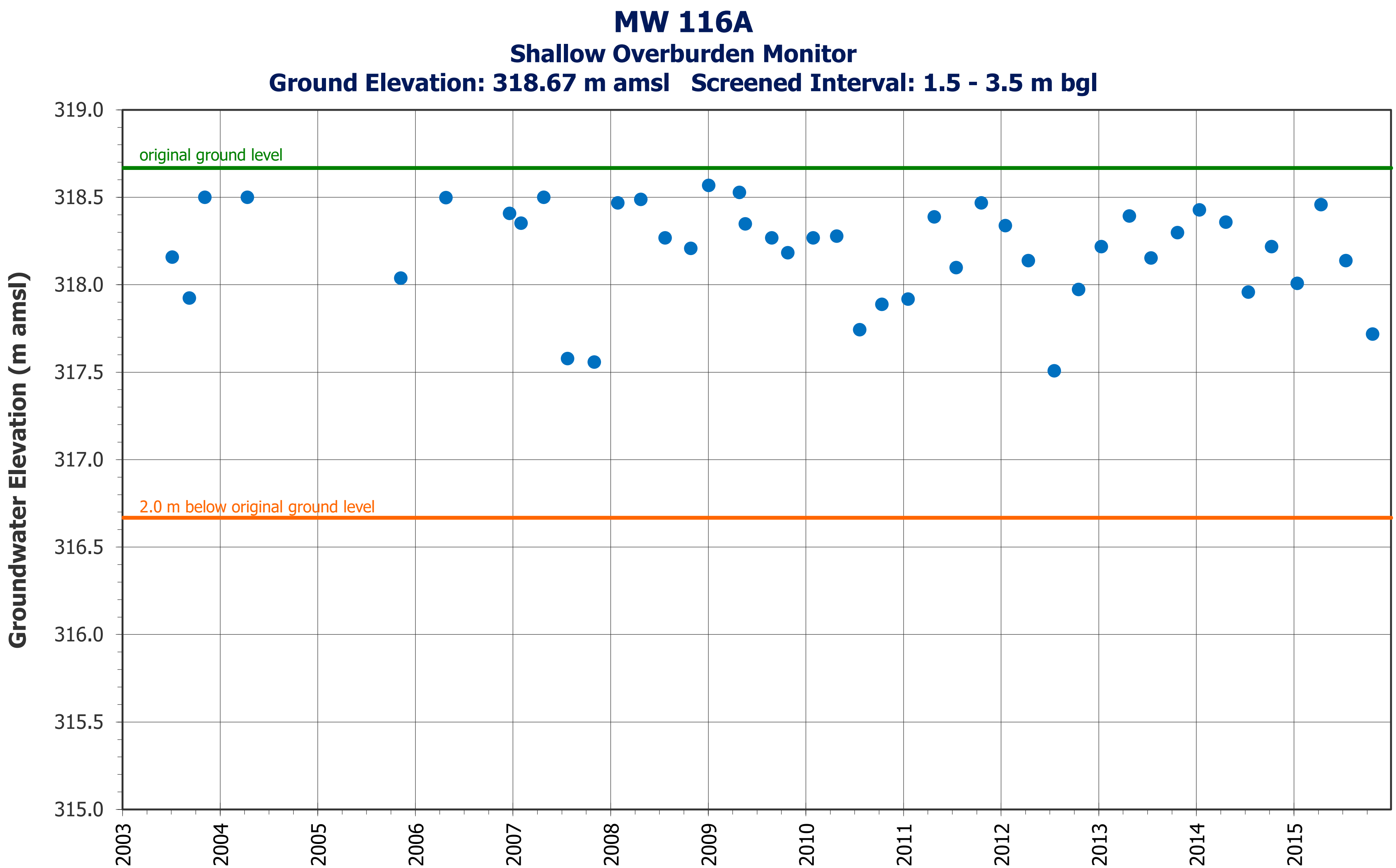
December 2015 **Phase 1 - Core PSW** **Graph C 21**

MW 115

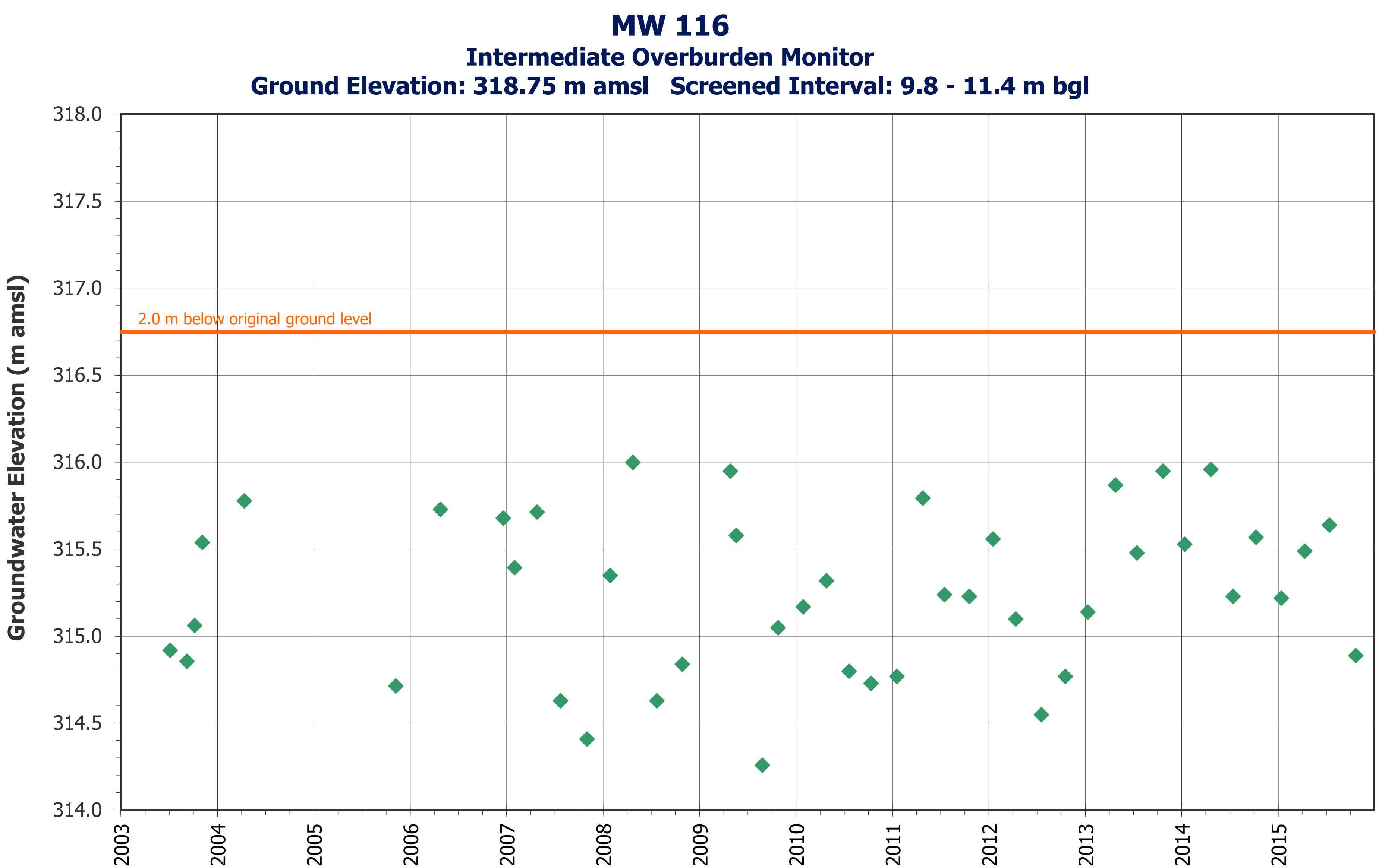
Intermediate Overburden Monitor

Ground Elevation: 323.12 m amsl   Screened Interval: 7.1 - 9.0 m bgl





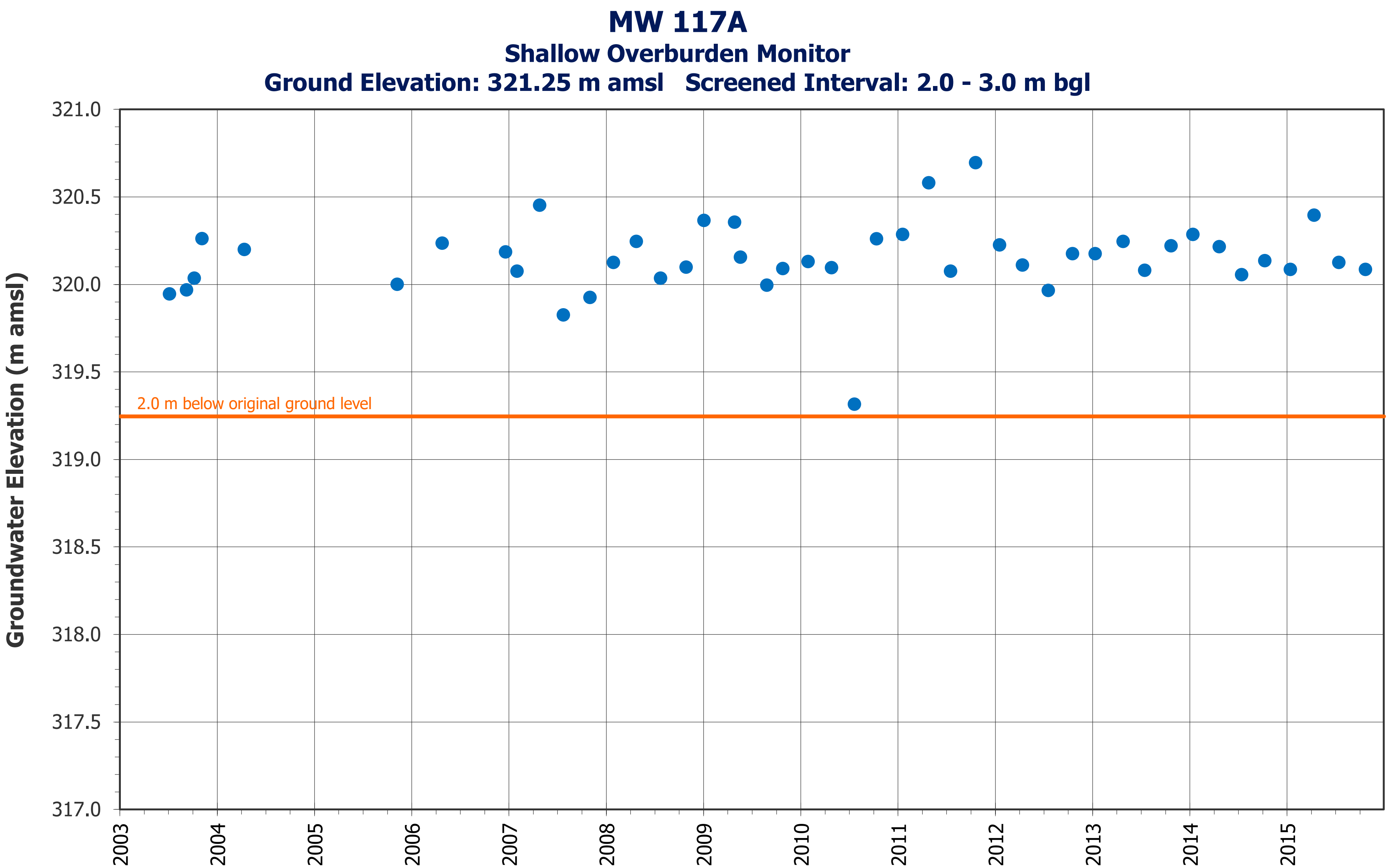
MW 116A
Shallow Overburden Monitor
Ground Elevation: 318.67 m amsl   Screened Interval: 1.5 - 3.5 m bgl
Groundwater Elevation (m amsl)
original ground level
2.0 m below original ground level
319.0
318.5
318.0
317.5
317.0
316.5
316.0
315.5
315.0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

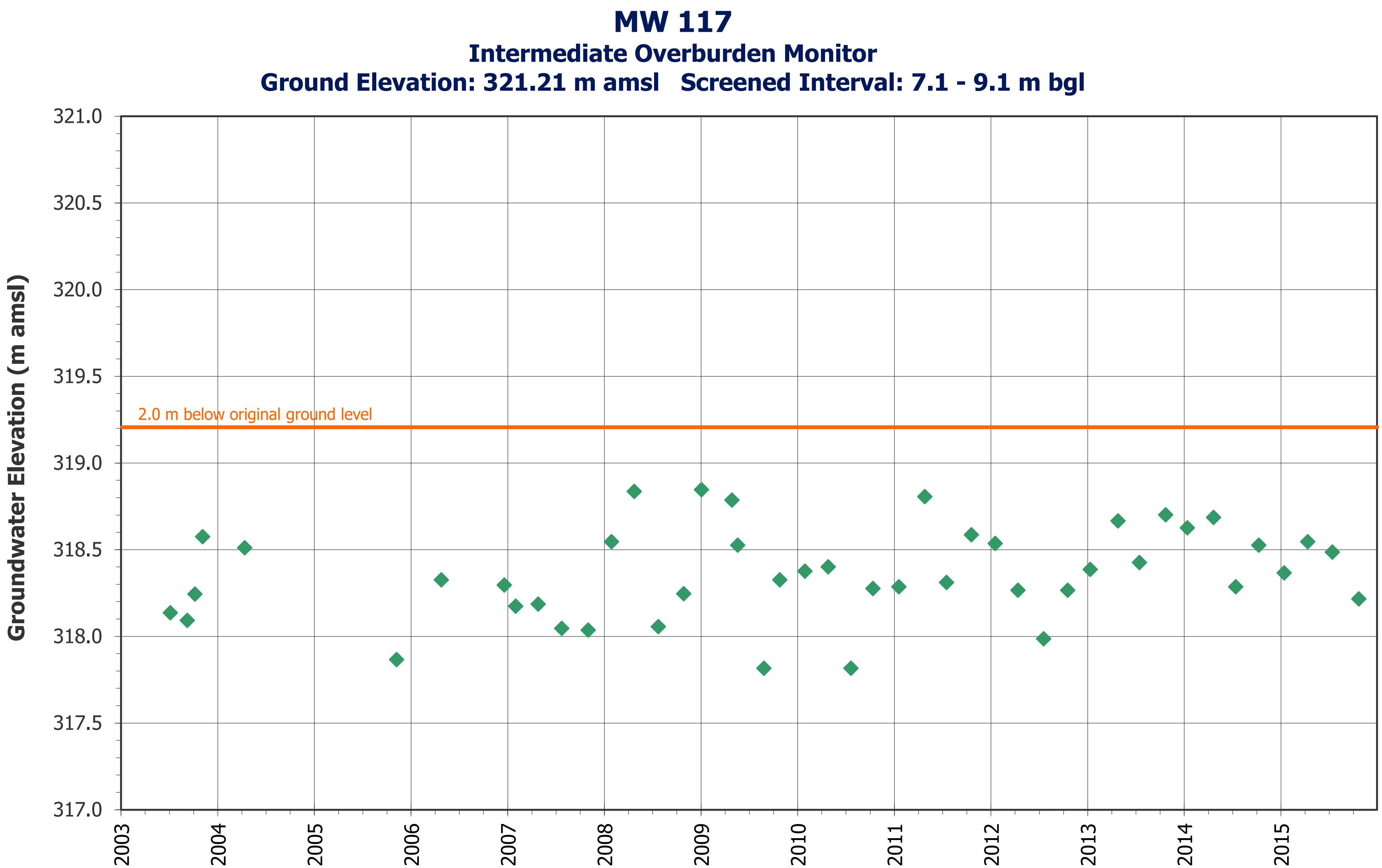
December 2015 **Phase 1 - Core PSW** **Graph C 24**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

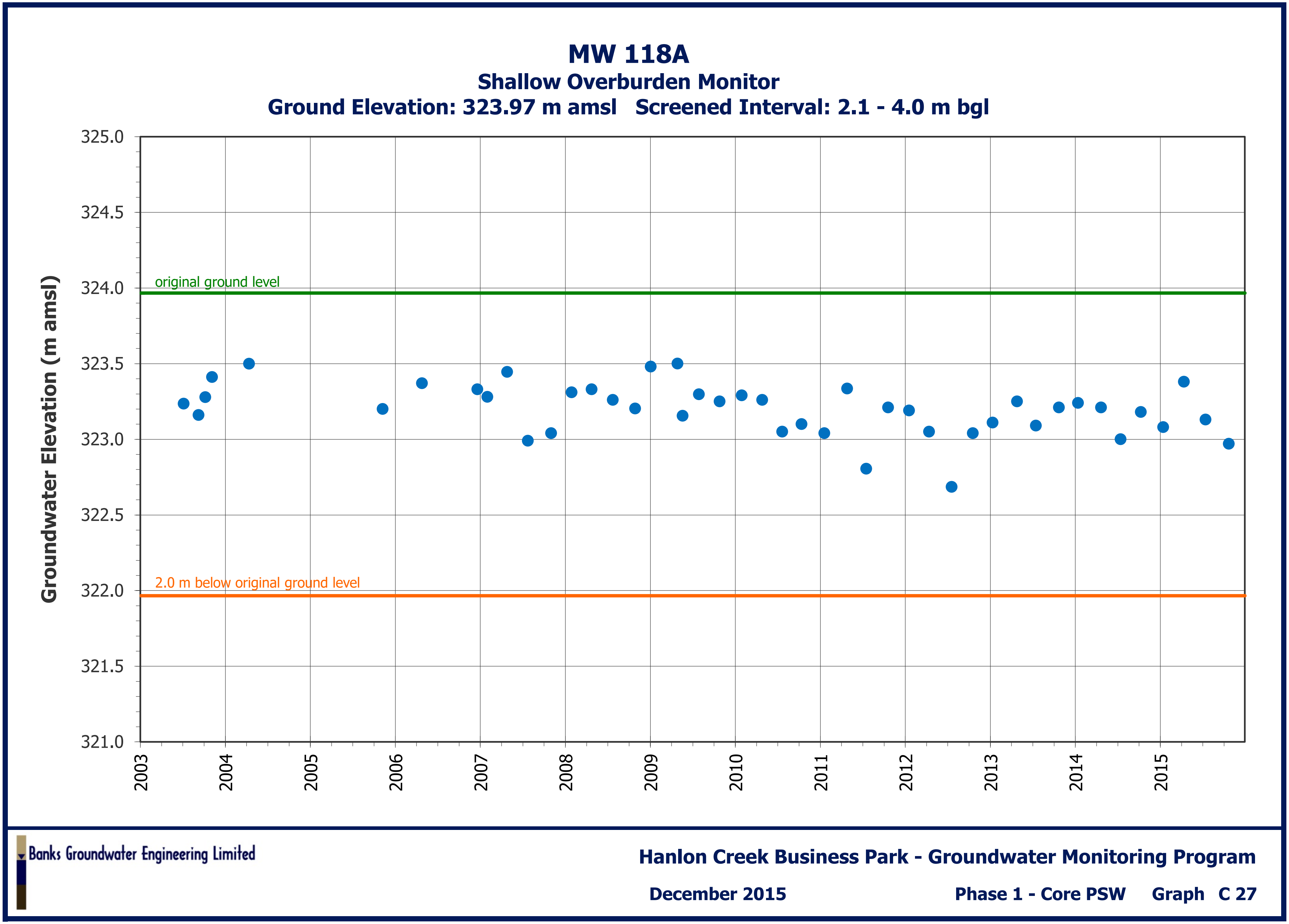
December 2015 **Phase 1 - Core PSW** **Graph C 25**



Banks Groundwater Engineering Limited

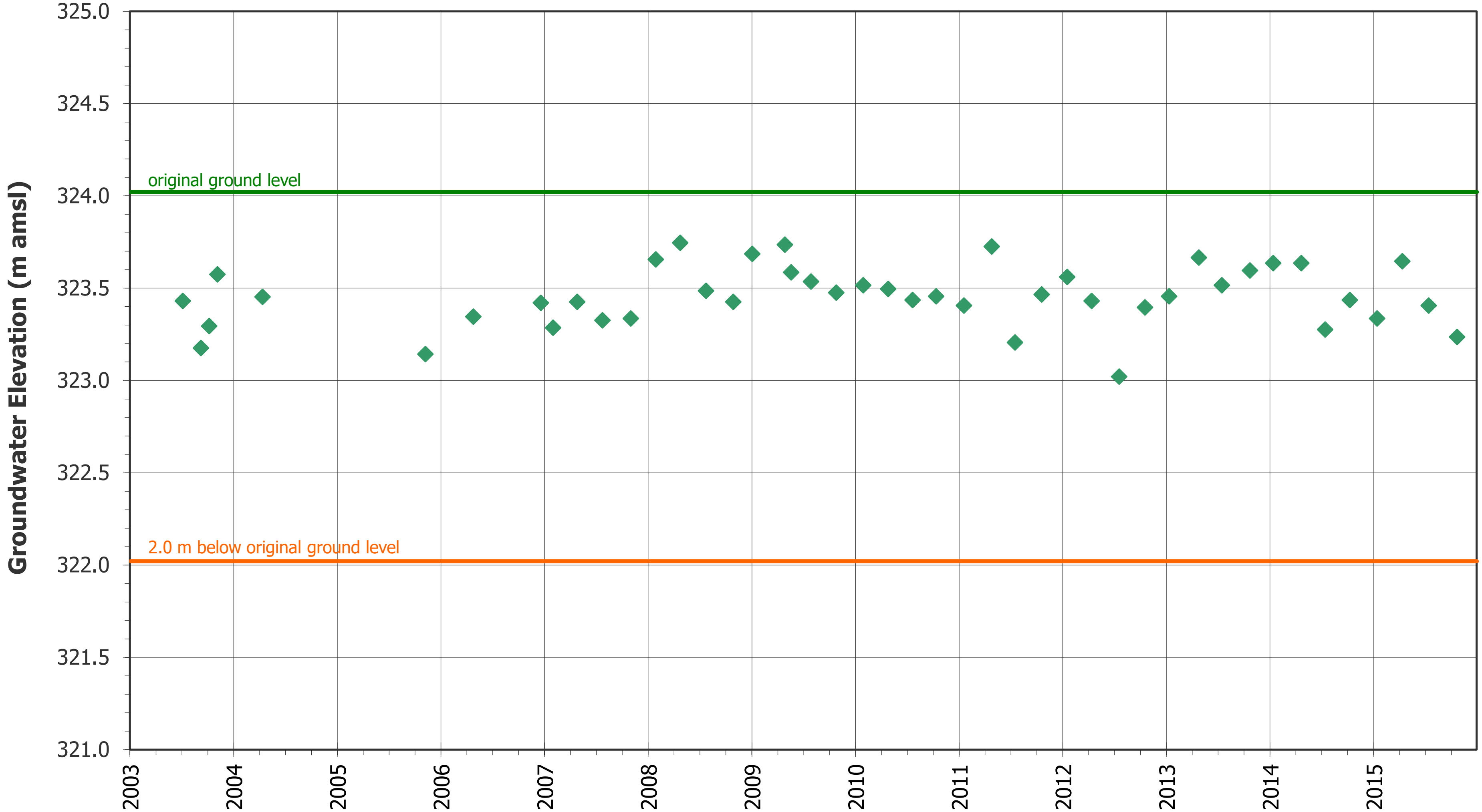
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 26**



MW 118A
Shallow Overburden Monitor
Ground Elevation: 323.97 m amsl   Screened Interval: 2.1 - 4.0 m bgl
Groundwater Elevation (m amsl)
325.0
324.5
324.0
323.5
323.0
322.5
322.0
321.5
321.0
original ground level
2.0 m below original ground level
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Banks Groundwater Engineering Limited
Hanlon Creek Business Park - Groundwater Monitoring Program
December 2015
Phase 1 - Core PSW
Graph C 27

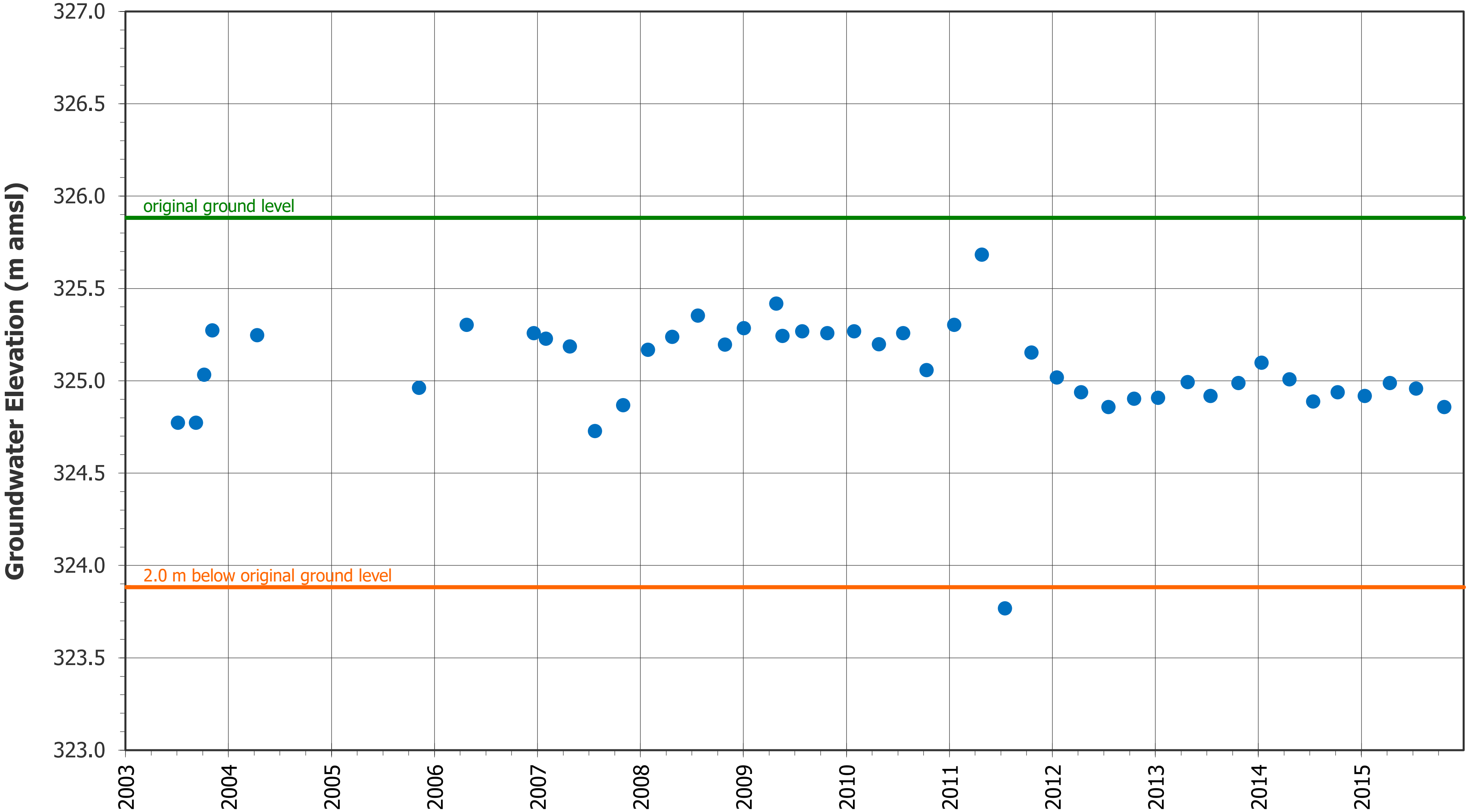
MW 118
Intermediate Overburden Monitor
Ground Elevation: 324.02 m amsl   Screened Interval: 7.3 - 9.2 m bgl



MW 119A

Shallow Overburden Monitor

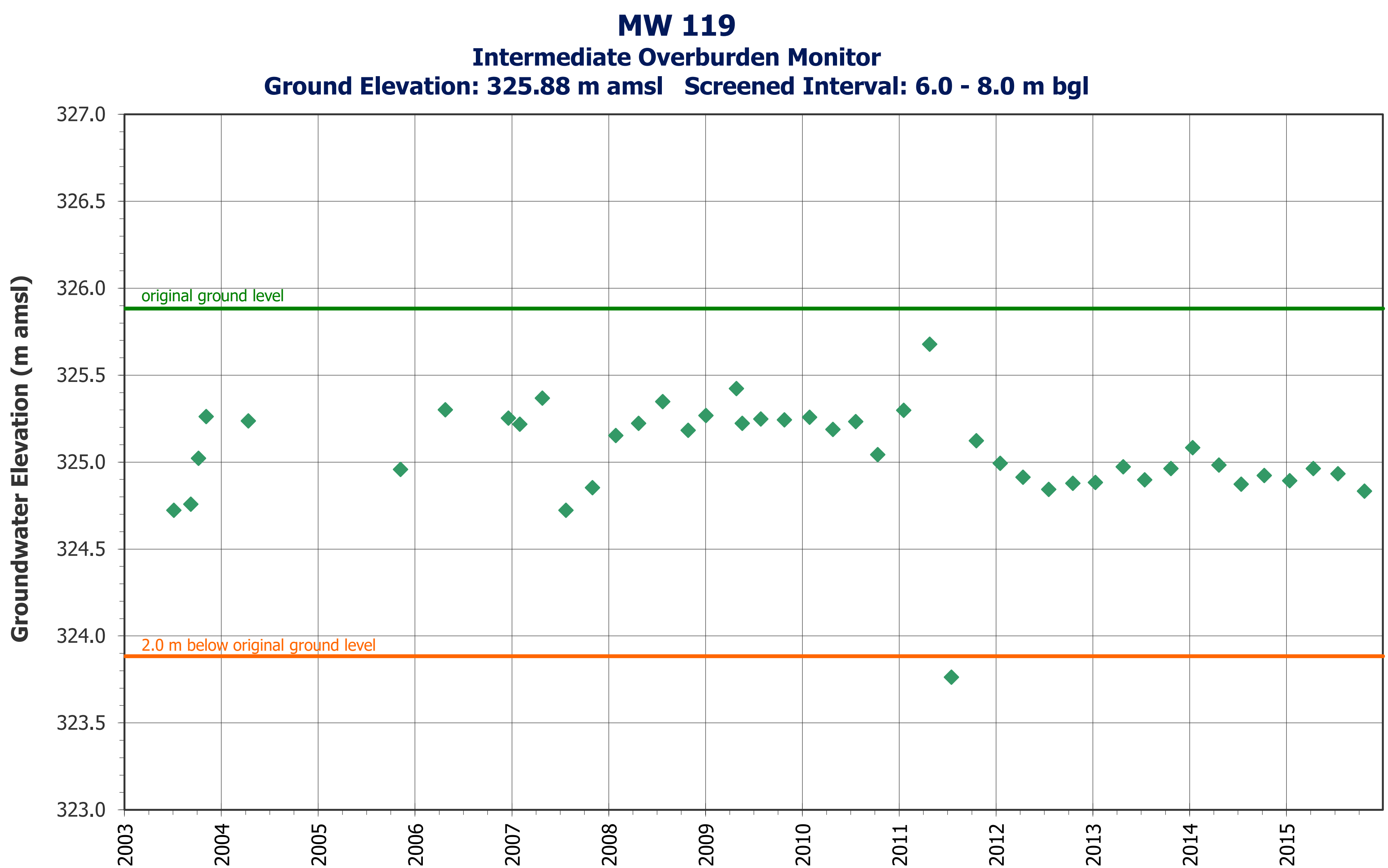
Ground Elevation: 325.88 m amsl   Screened Interval: 2.8 - 3.9 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 2 - Core PSW**   **Graph C 29**

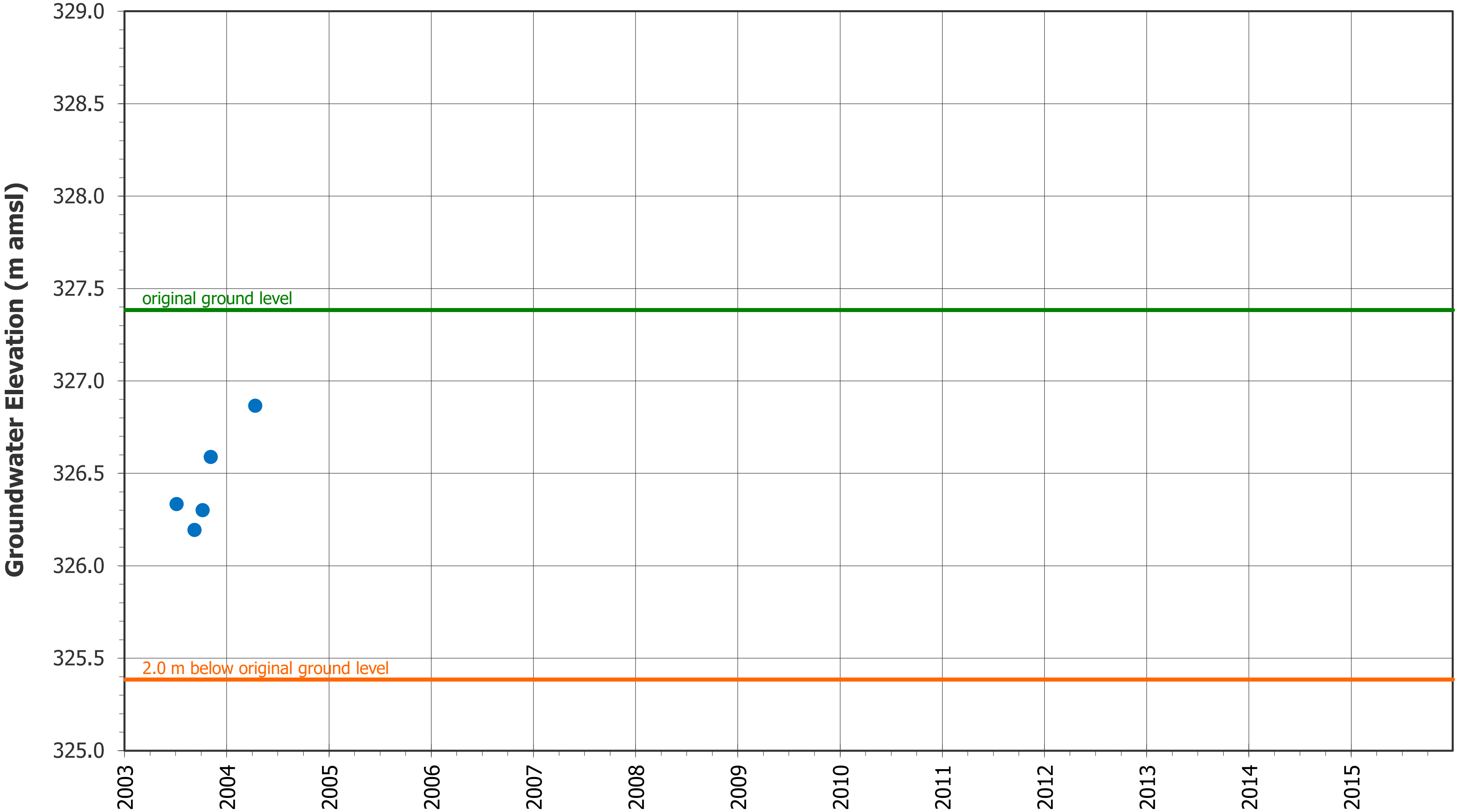


MW 119
Intermediate Overburden Monitor
Ground Elevation: 325.88 m amsl   Screened Interval: 6.0 - 8.0 m bgl
Groundwater Elevation (m amsl)
original ground level
2.0 m below original ground level
327.0
326.5
326.0
325.5
325.0
324.5
324.0
323.5
323.0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

MW 120A

Shallow Overburden Monitor (Destroyed 2004, Decommissioned 2010)

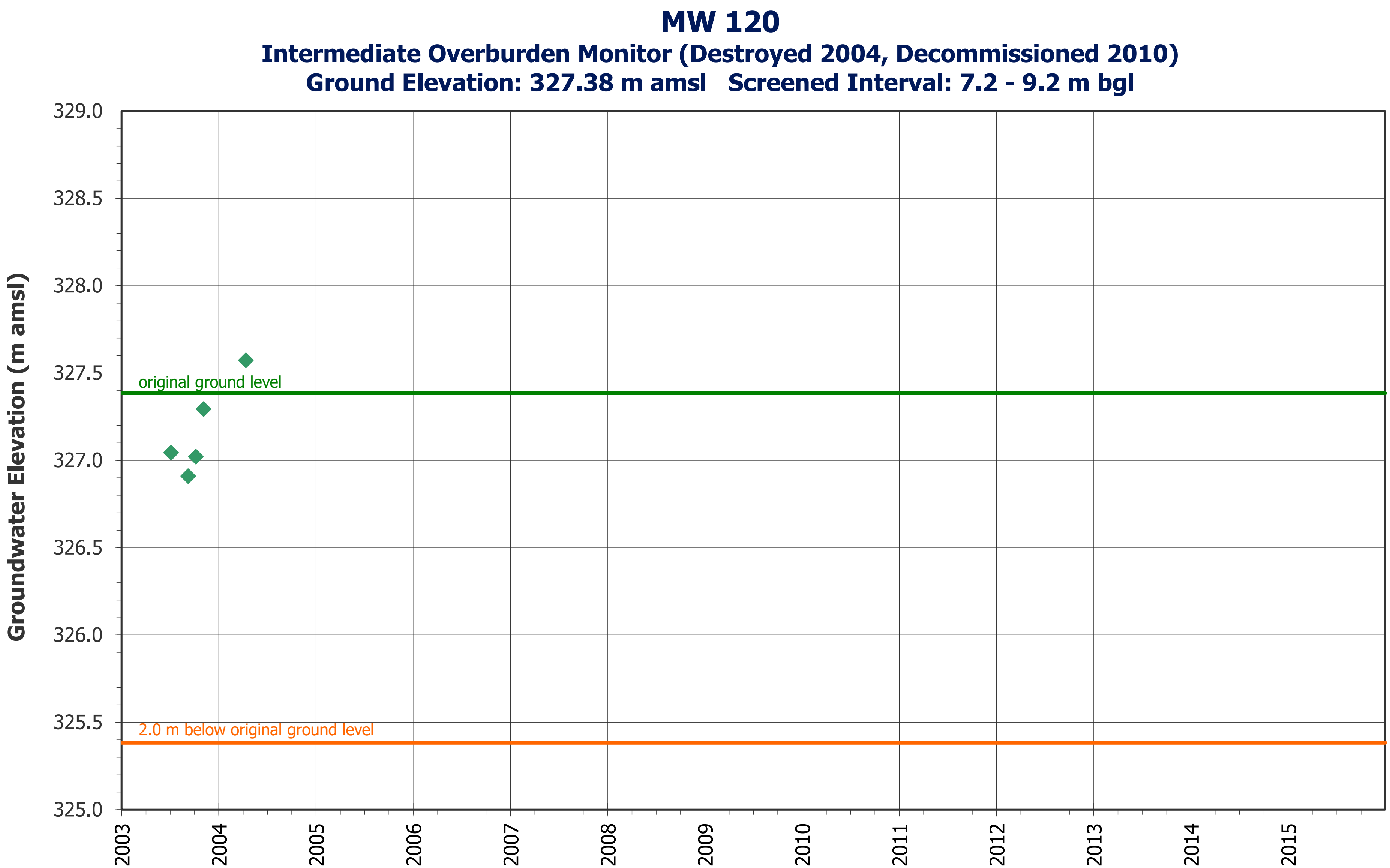
Ground Elevation: 327.38 m amsl   Screened Interval: 2.5 - 4.0 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph C 31**

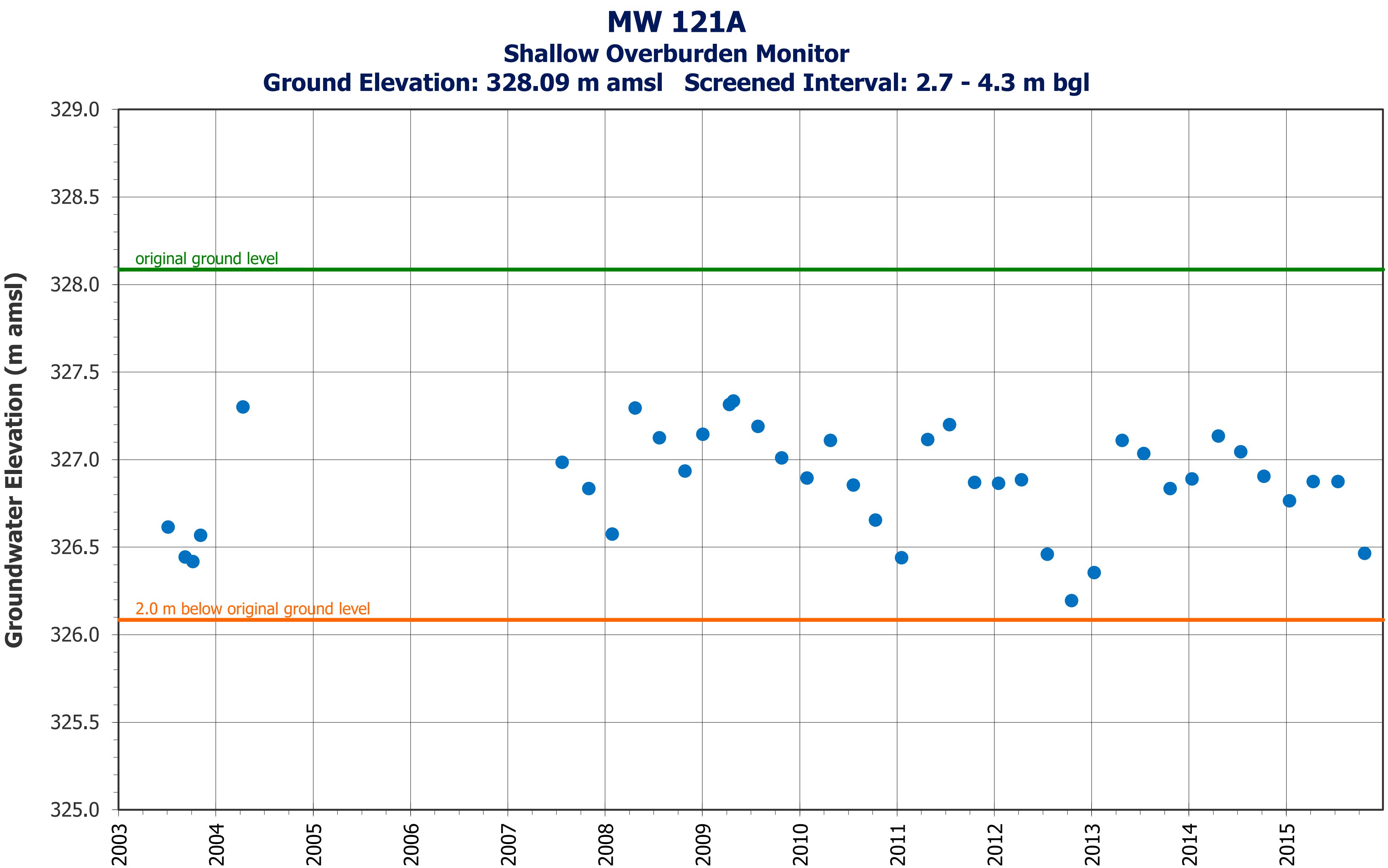


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

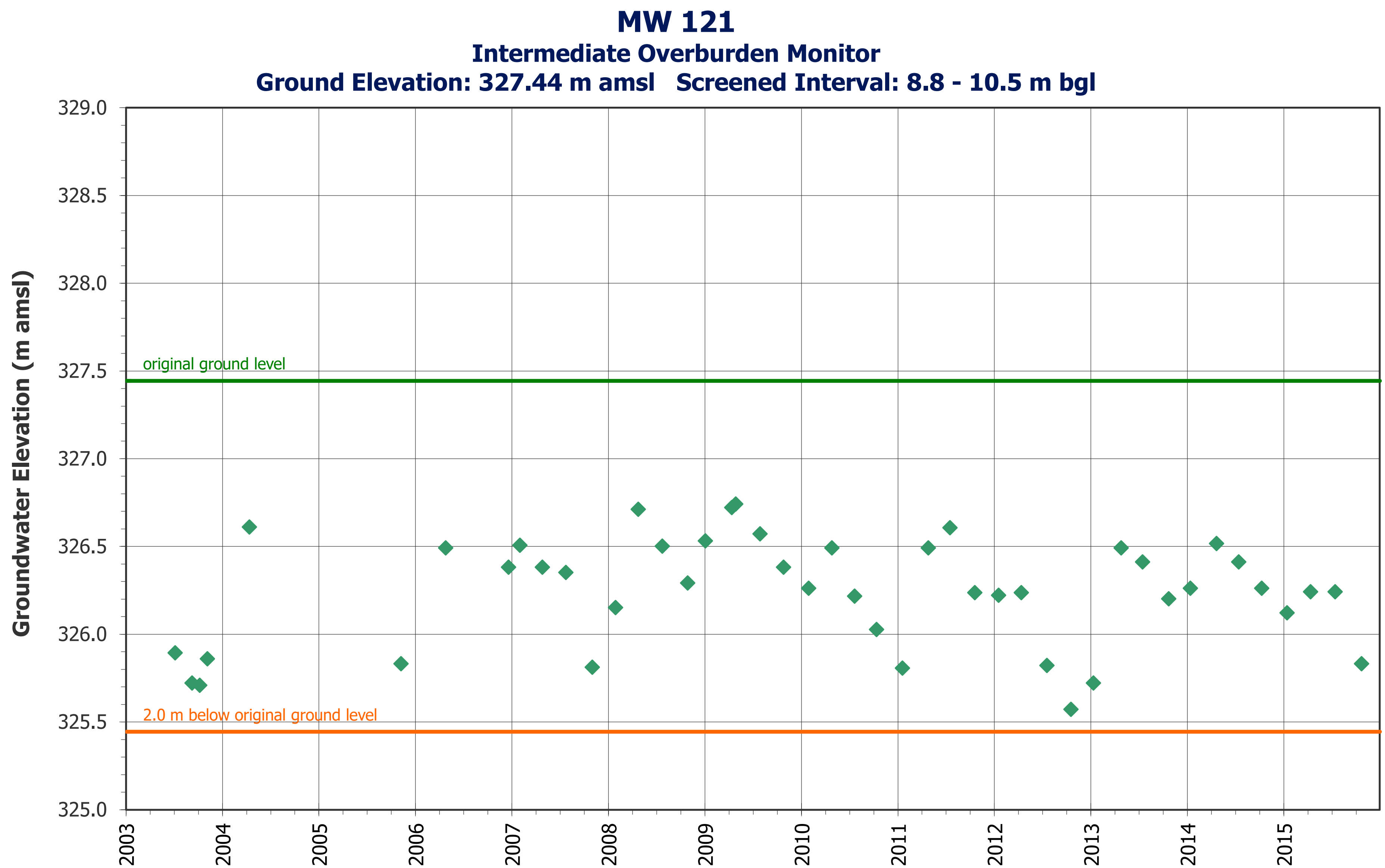
Phase 2 - Core PSW   Graph C 32



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph C 33**



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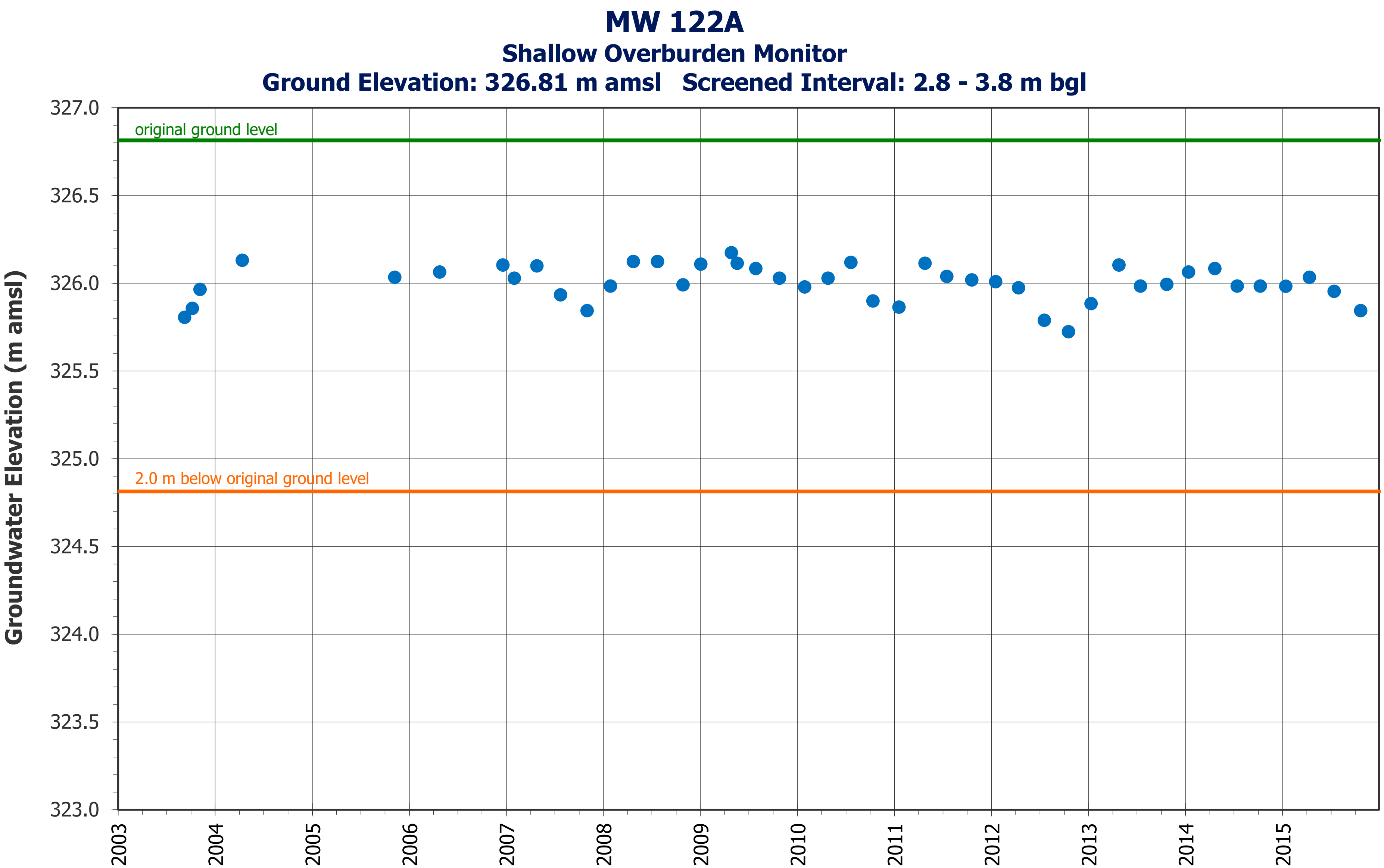
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph C 34**



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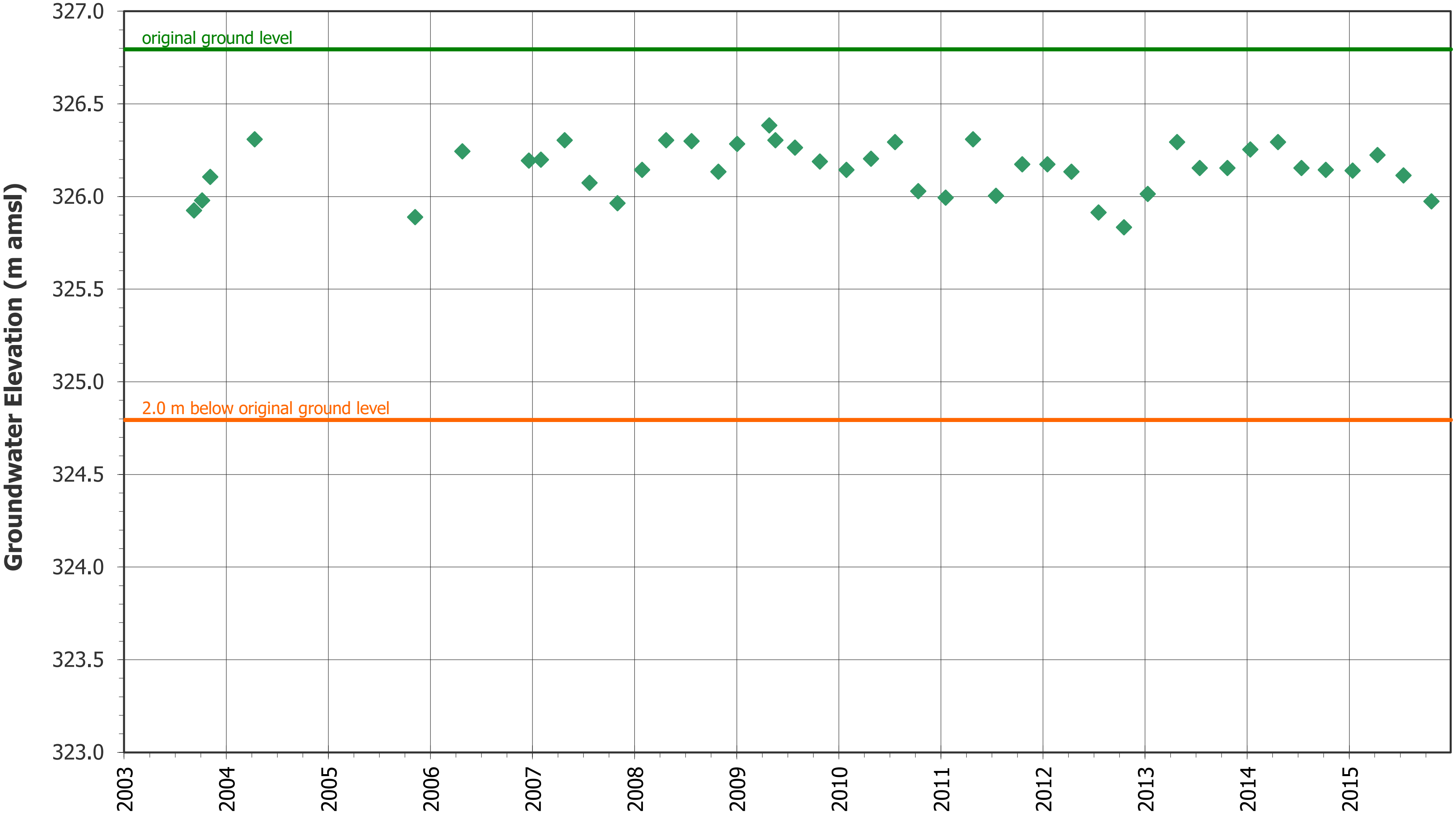
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Core PSW** **Graph C 35**

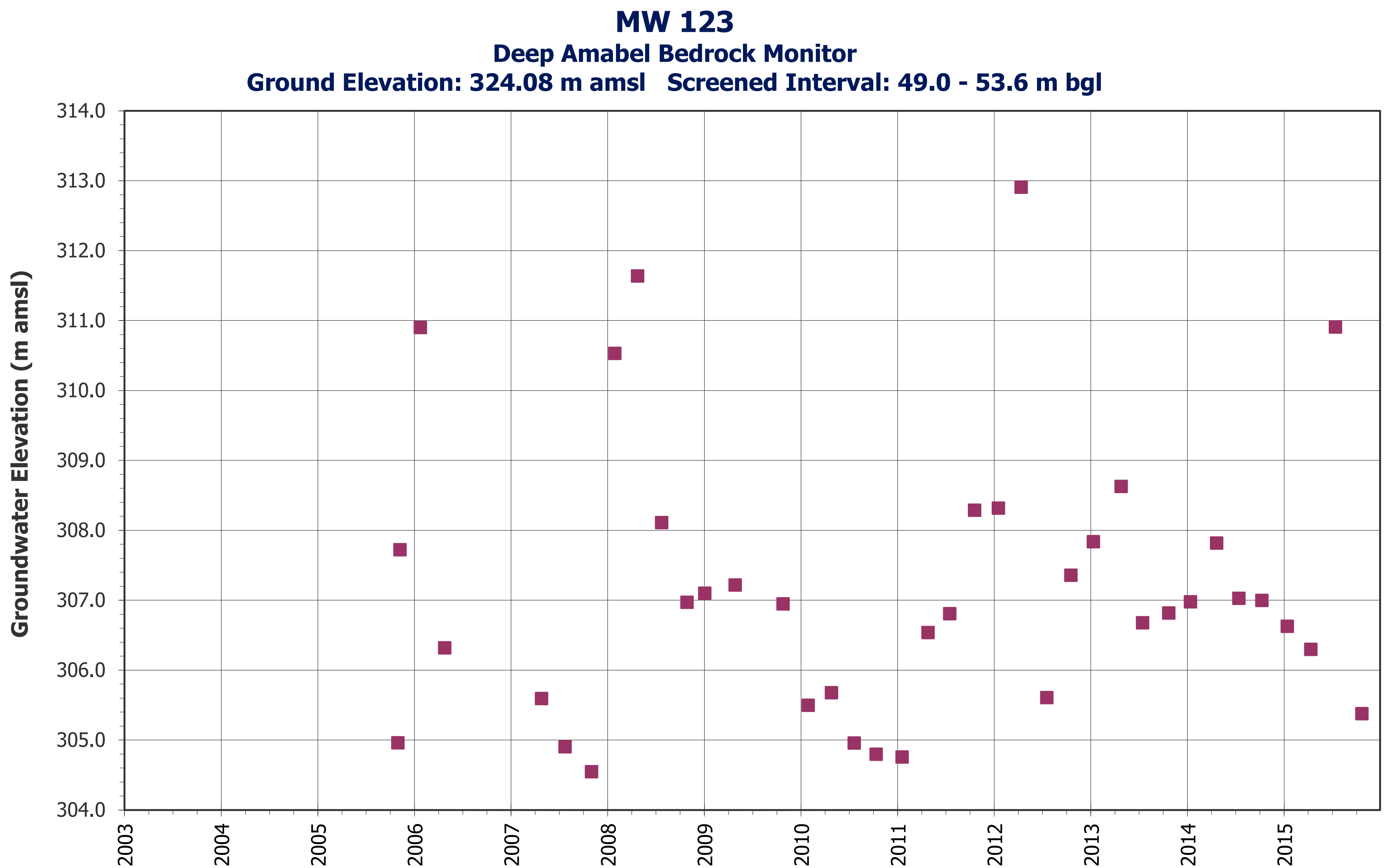
MW 122
Intermediate Overburden Monitor
Ground Elevation: 326.79 m amsl   Screened Interval: 5.8 - 7.6 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Core PSW** **Graph C 36**



Banks Groundwater Engineering Limited

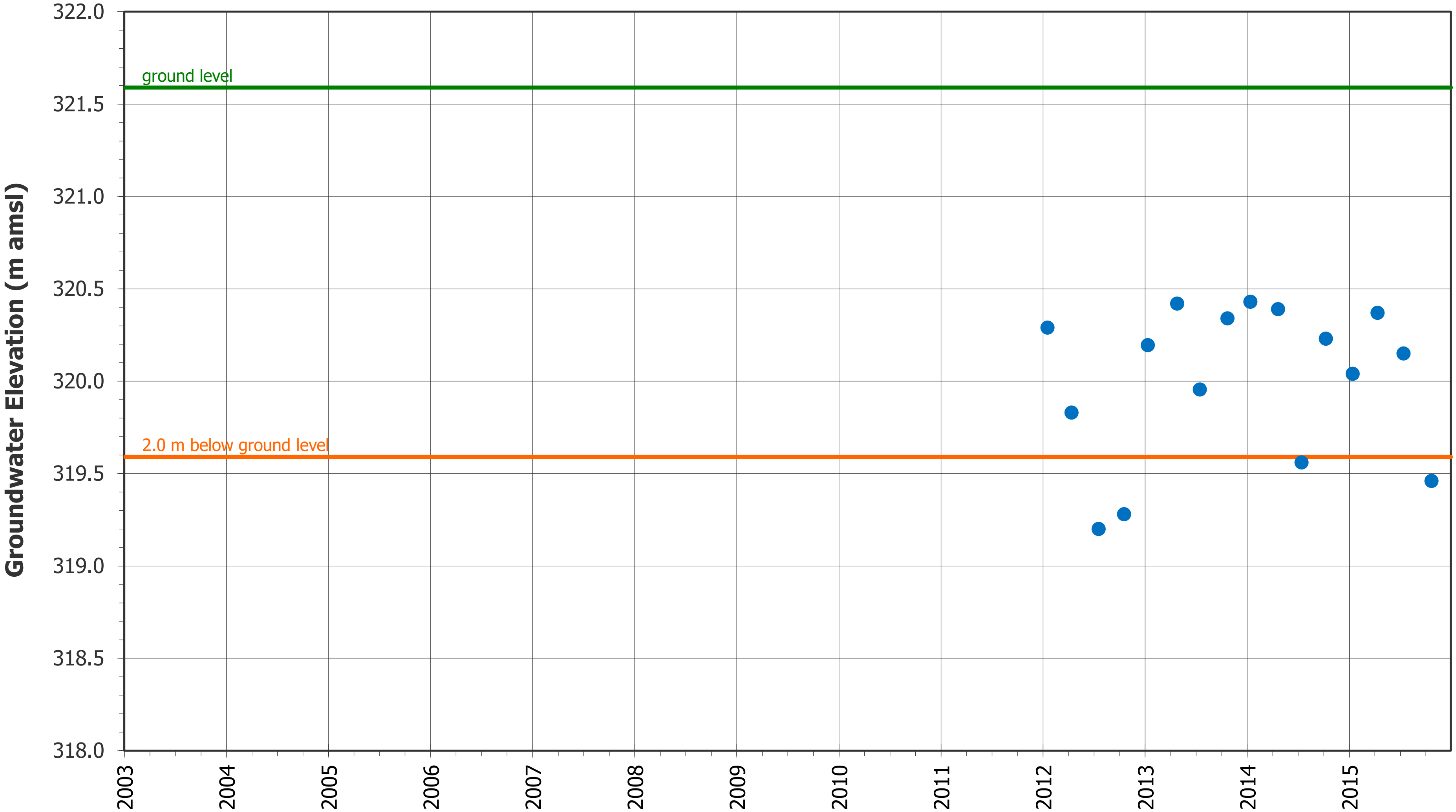
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 Phase 1 - Core PSW Graph C 37

MW 124

Shallow Overburden Monitor (Installed 2011)

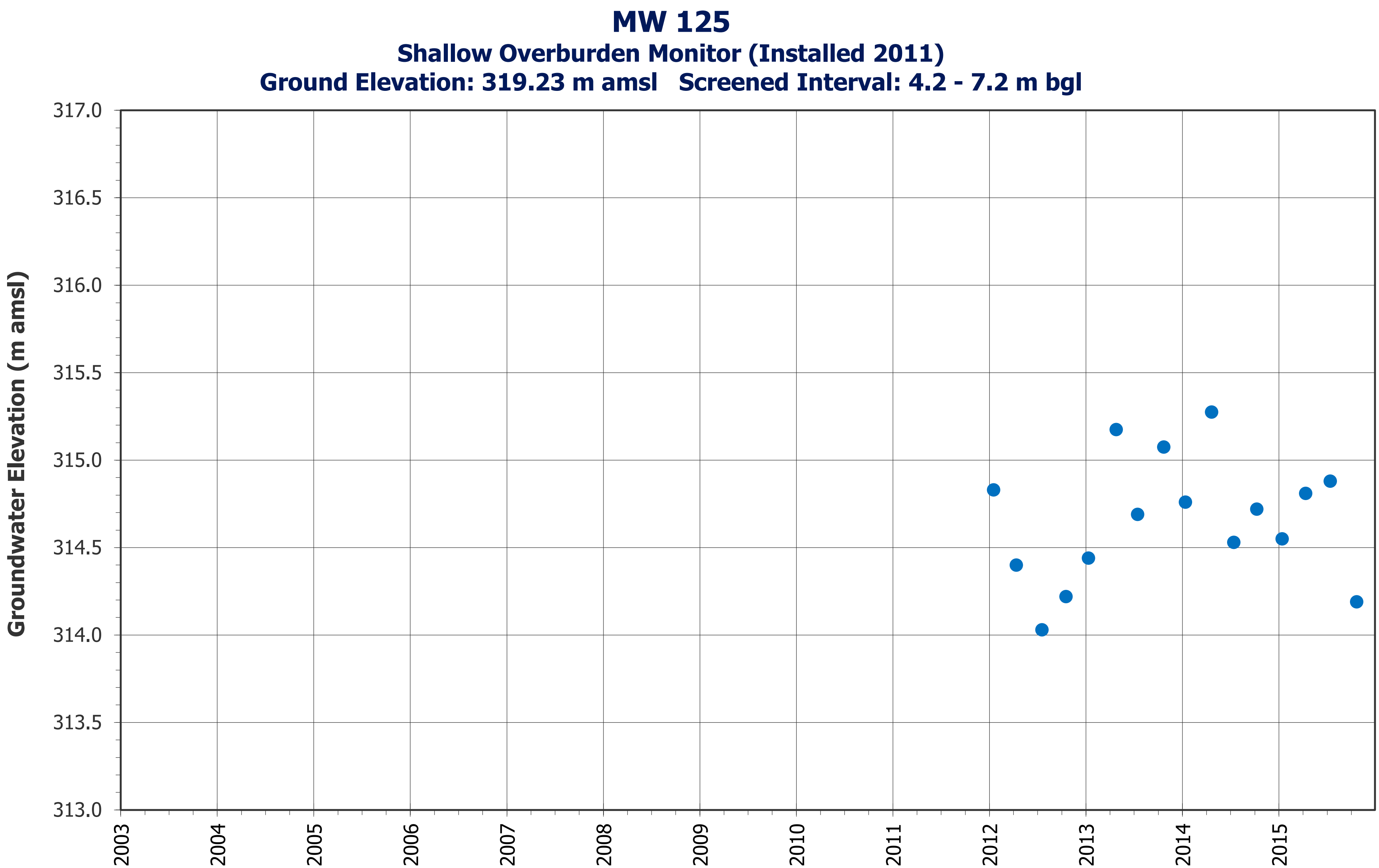
Ground Elevation: 321.59 m amsl   Screened Interval: 4.6 - 7.6 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

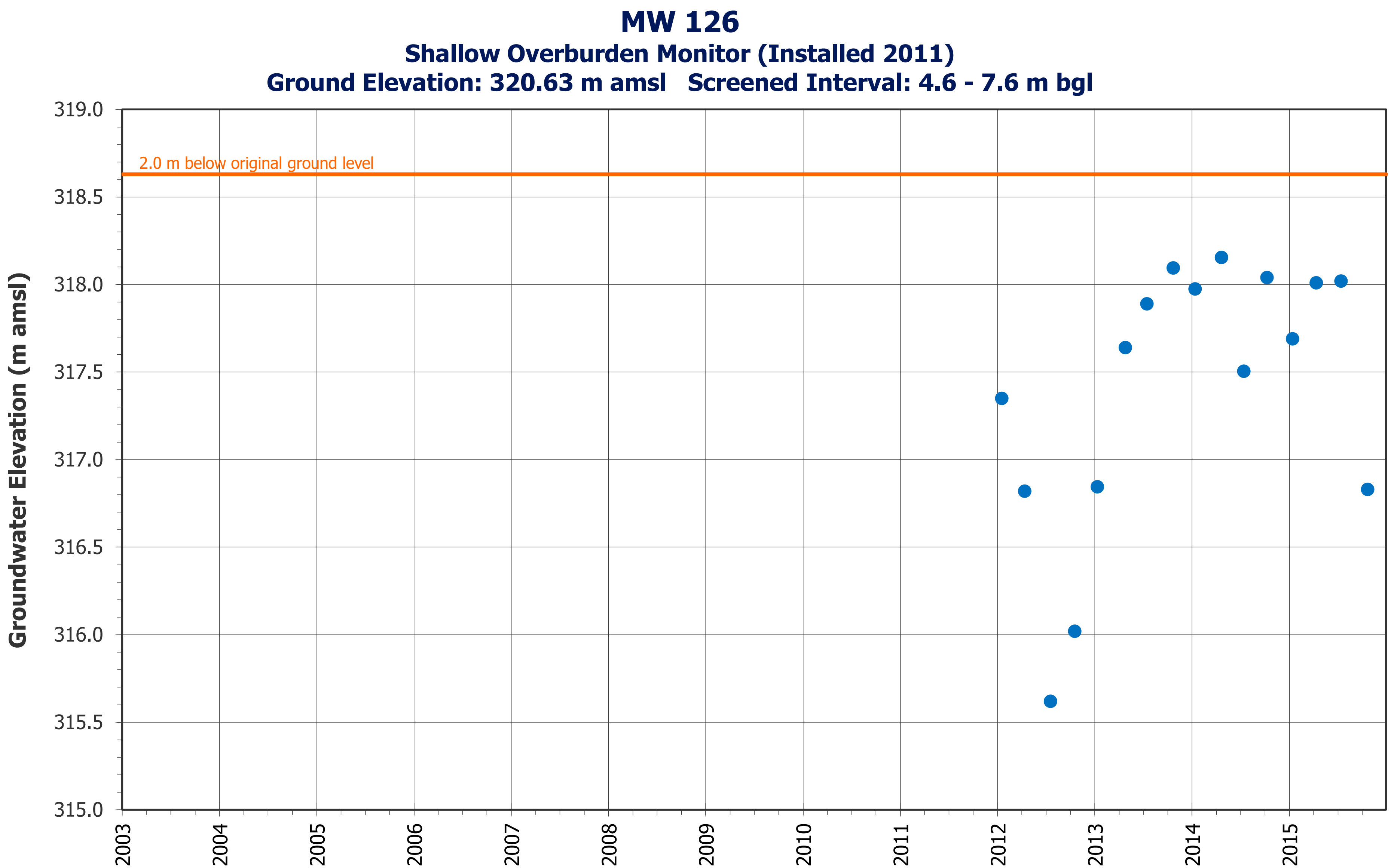
December 2015   **Phase 1 - Perimeter**   **Graph C 38**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

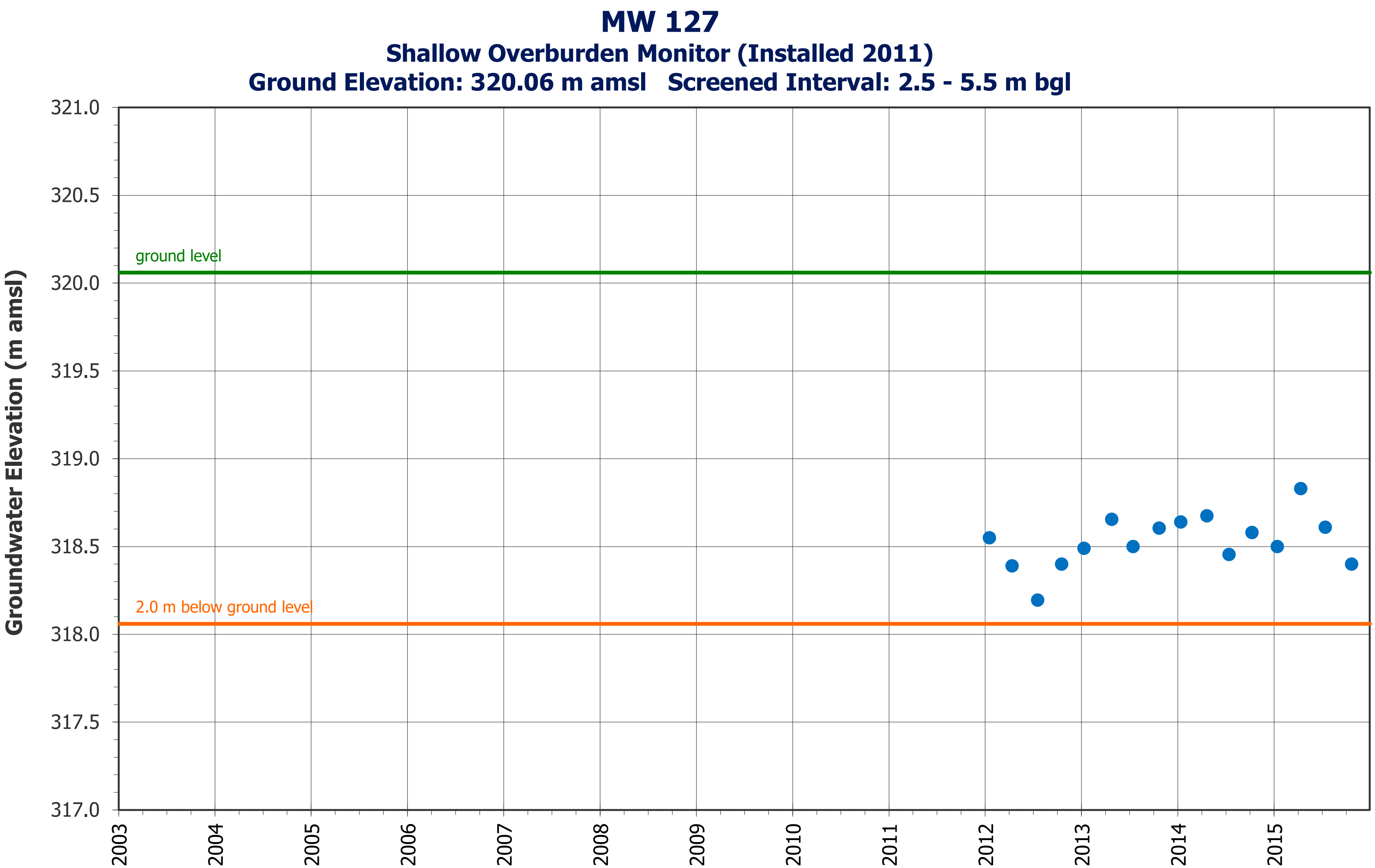
December 2015 **Phase 1 - Perimeter** **Graph C 39**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

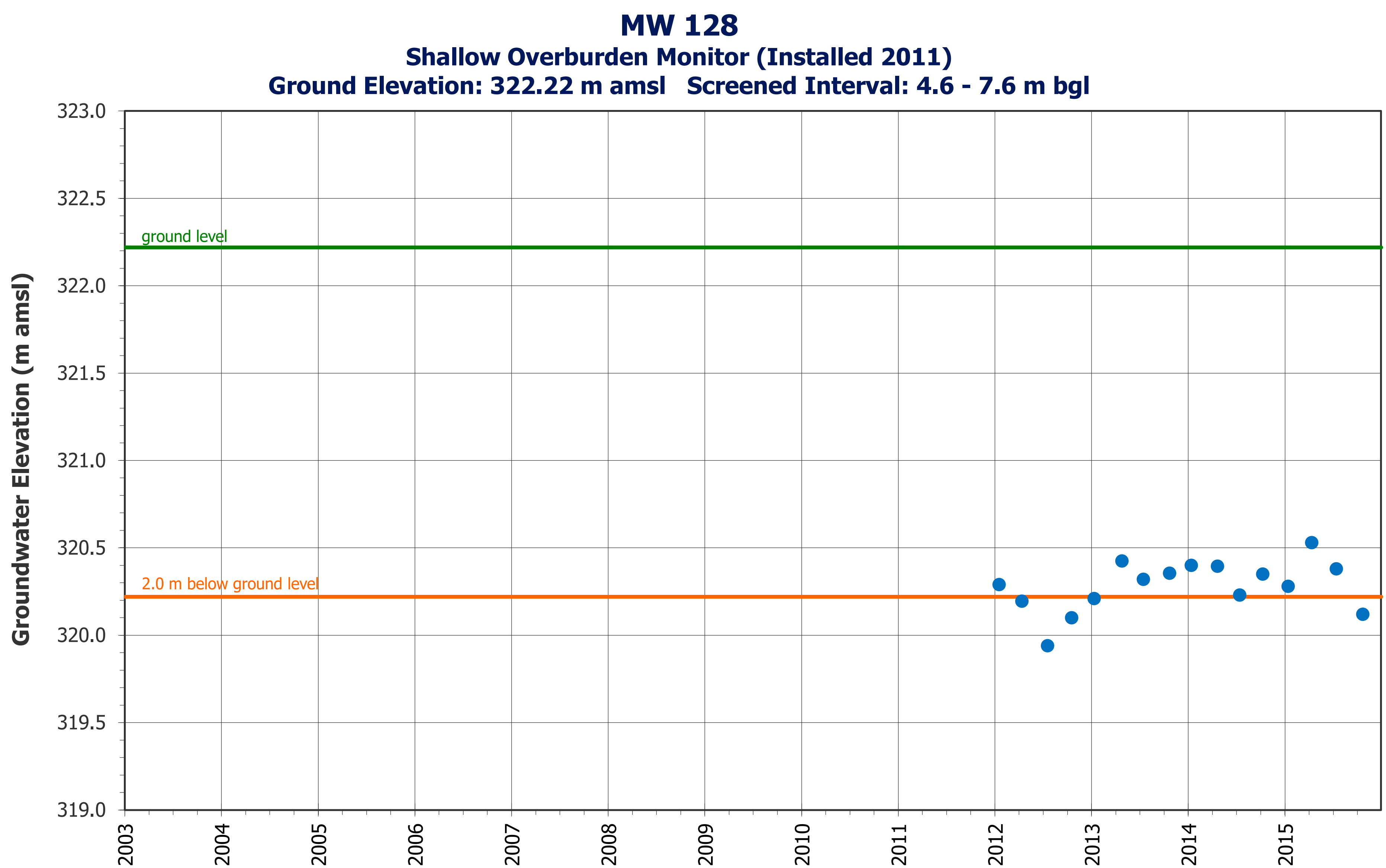
December 2015 **Phase 1 - Perimeter** **Graph C 40**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015　　**Phase 1 - Core PSW**　　**Graph C 41**



Banks Groundwater Engineering Limited

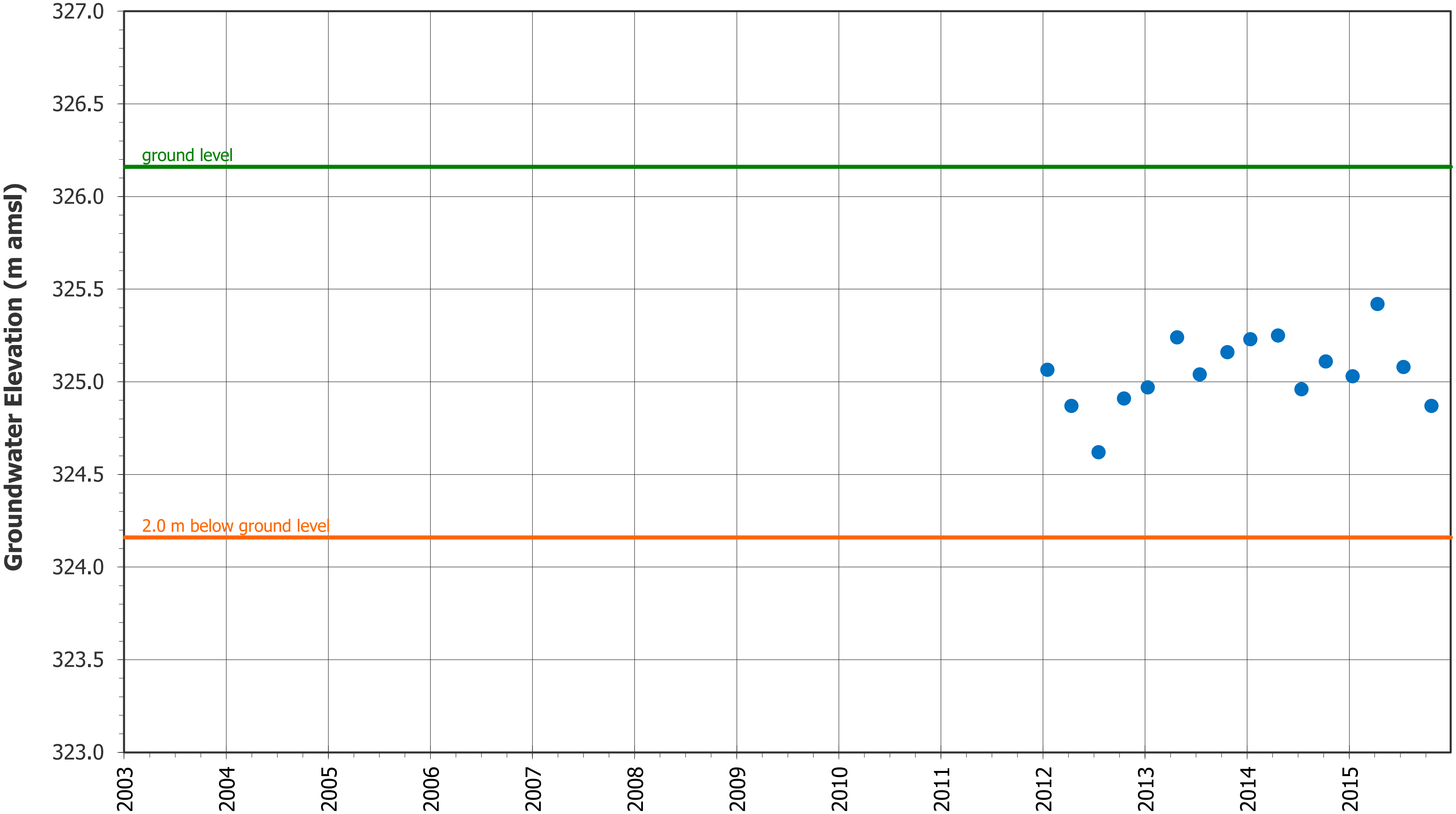
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph C 42**

MW 129

Shallow Overburden Monitor (Installed 2011)

Ground Elevation: 326.16 m amsl   Screened Interval: 4.6 - 7.6 m bgl



Banks Groundwater Engineering Limited

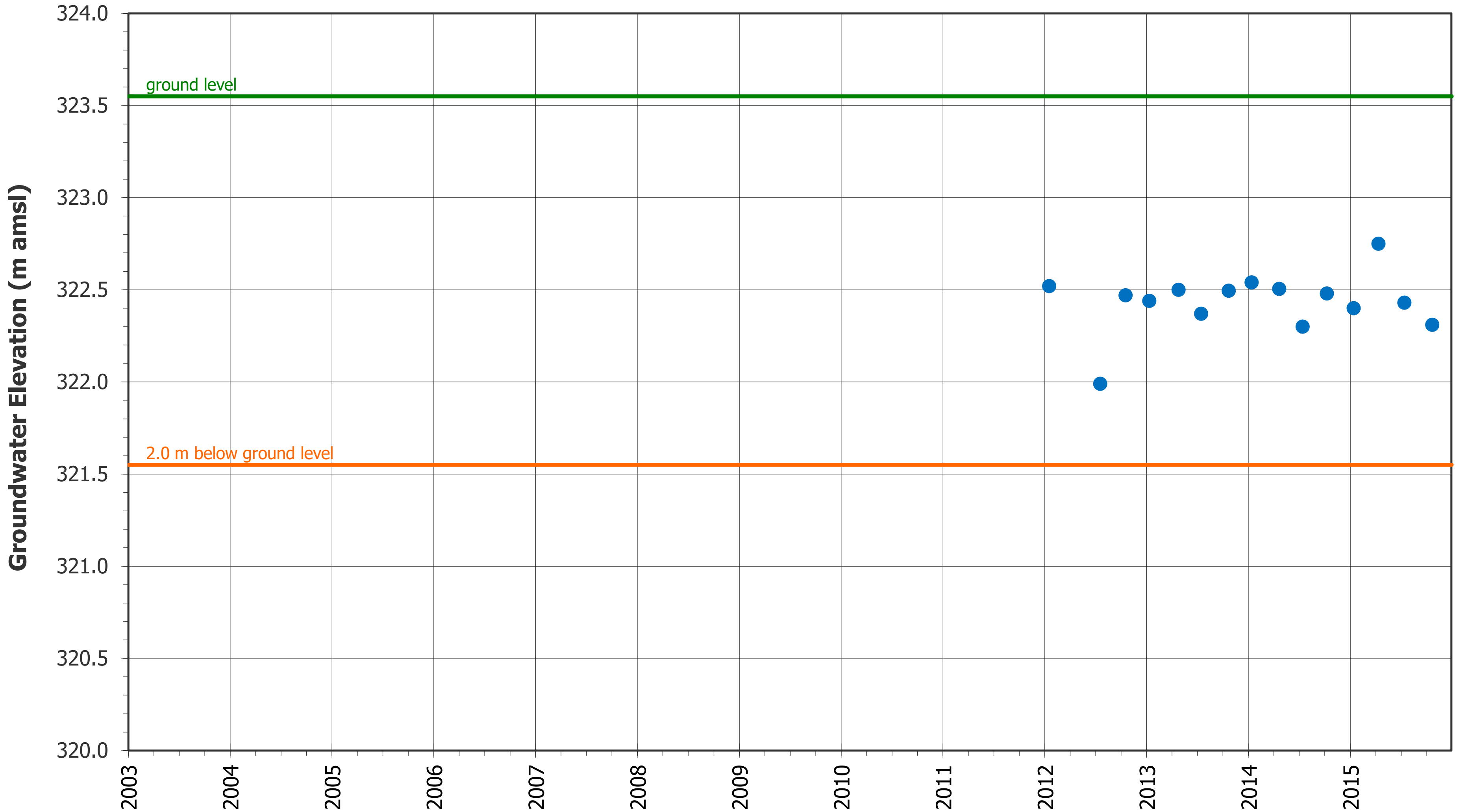
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 1 - Core PSW**   **Graph C 43**

MW 130

Shallow Overburden Monitor

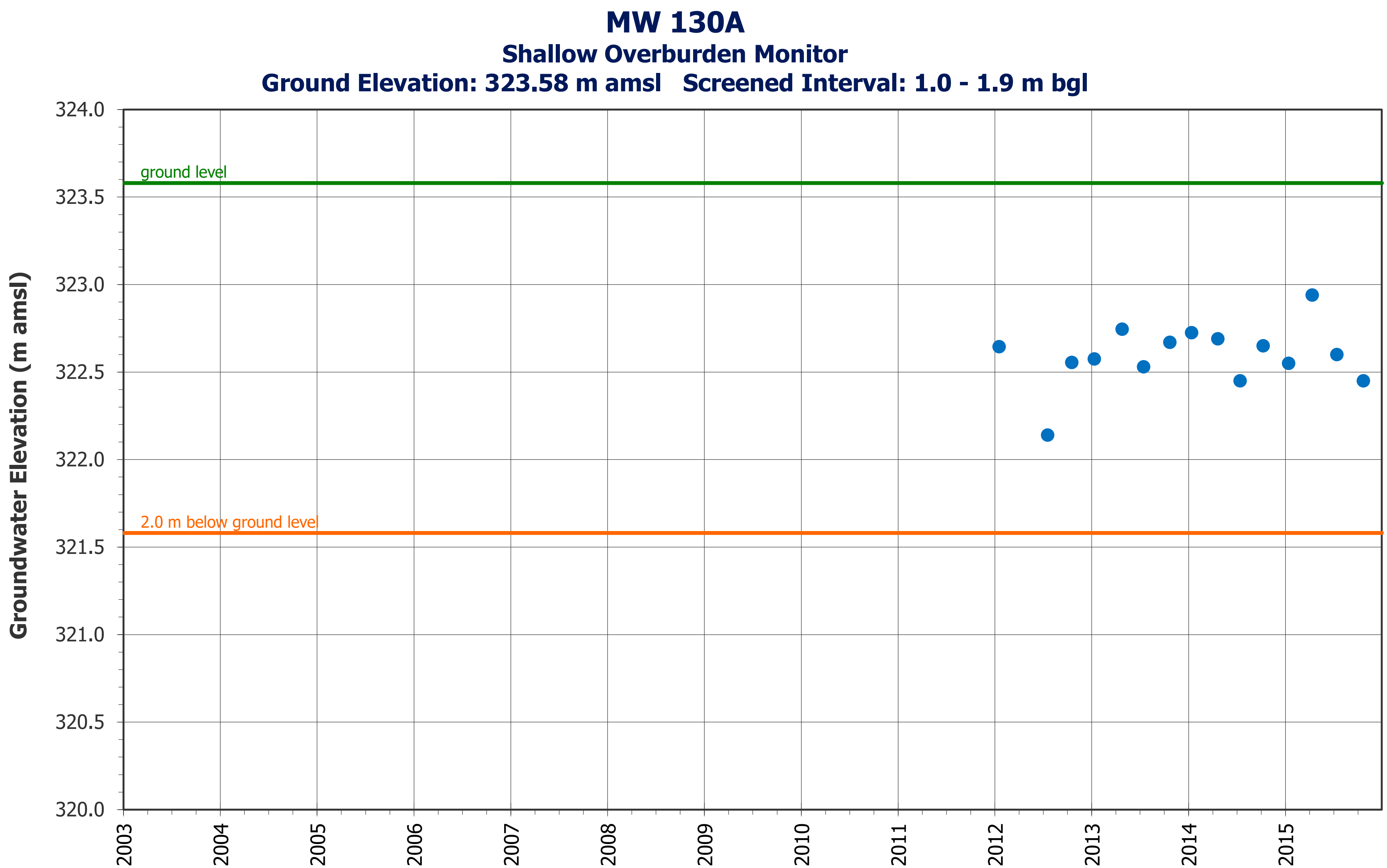
Ground Elevation: 323.55 m amsl   Screened Interval: 2.0 - 3.0 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

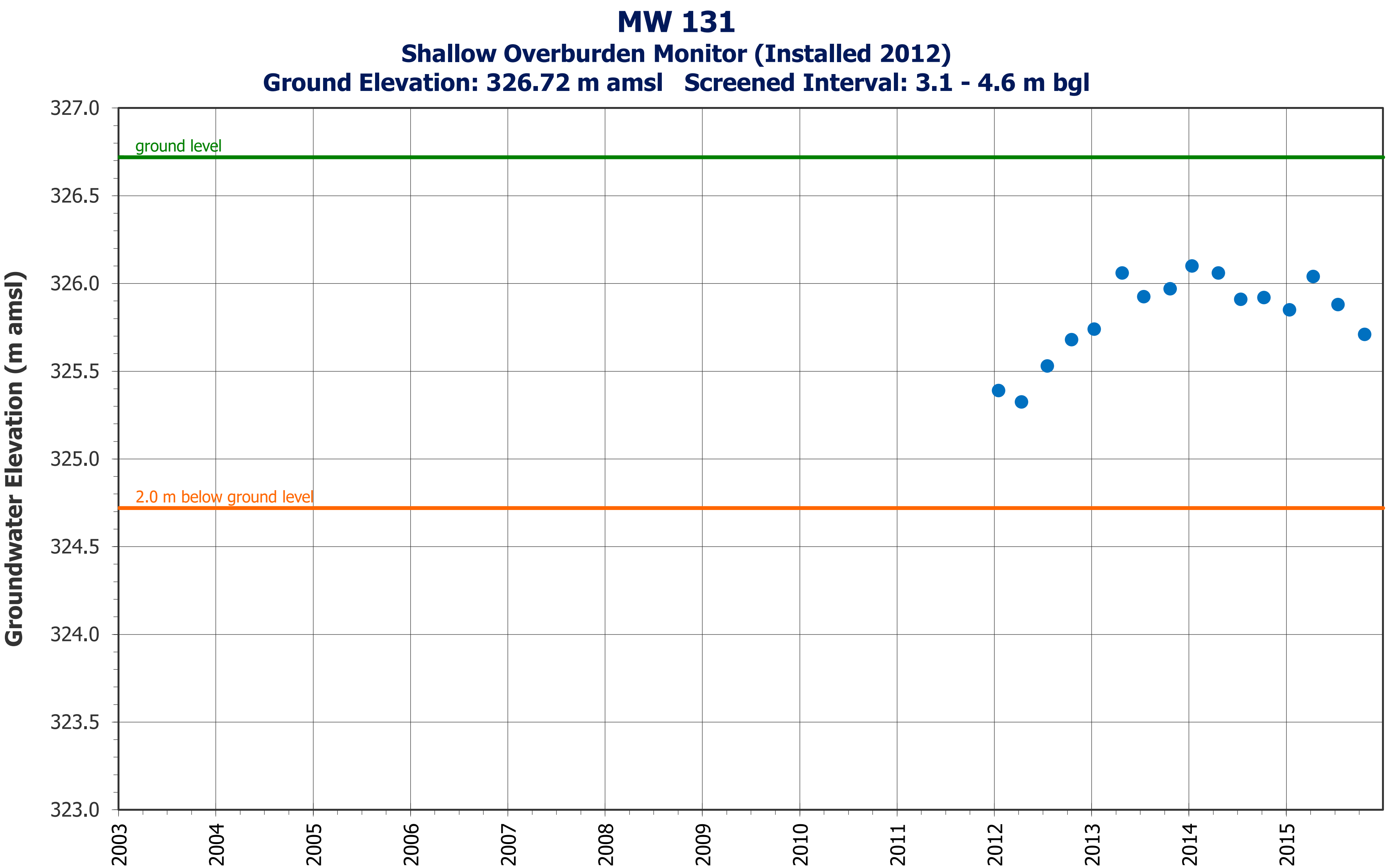
December 2015   **Phase 1 - Core PSW**   **Graph C 44**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 45**

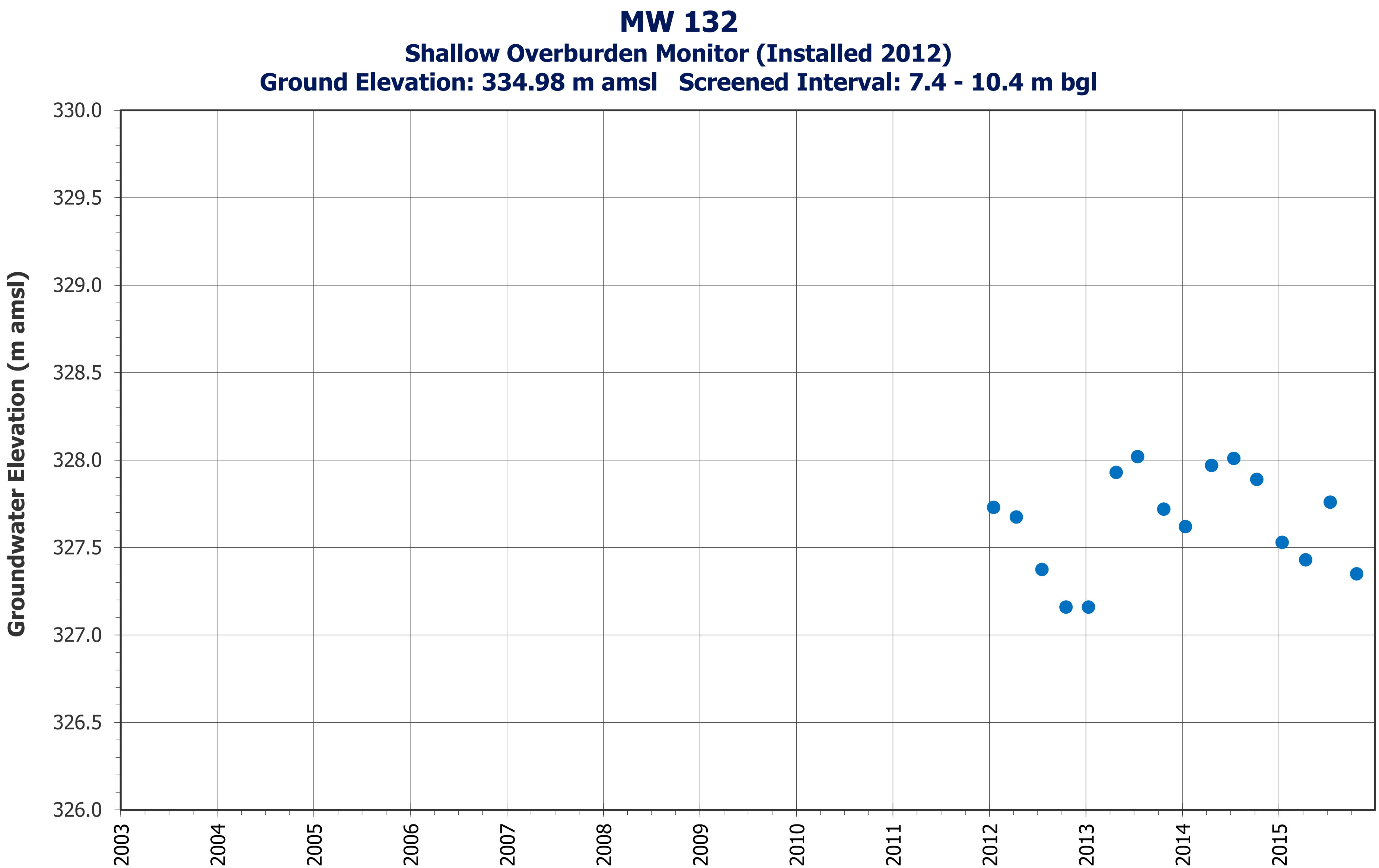


Banks Groundwater Engineering Limited

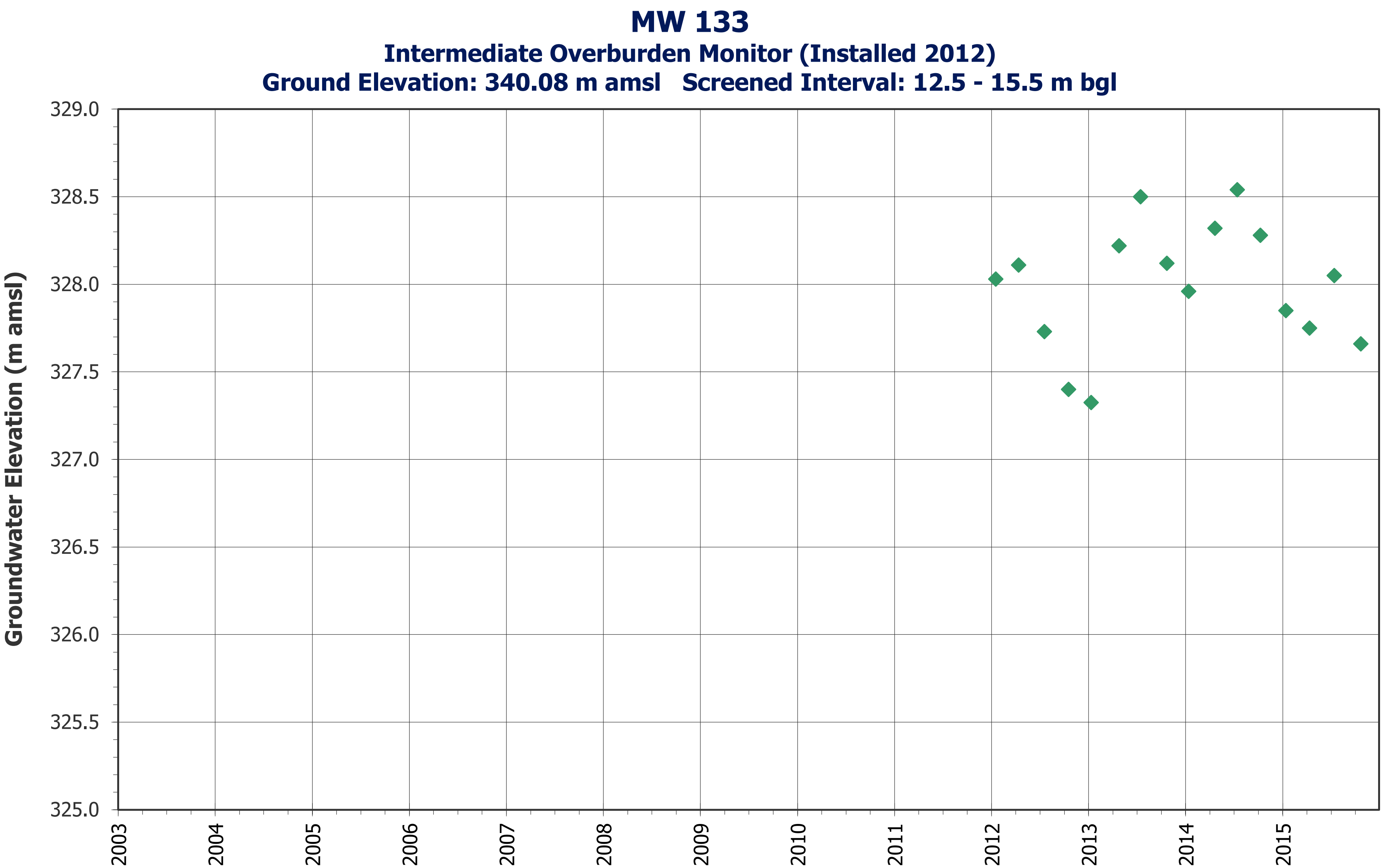
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Phase 2 - Core PSW   Graph C 46



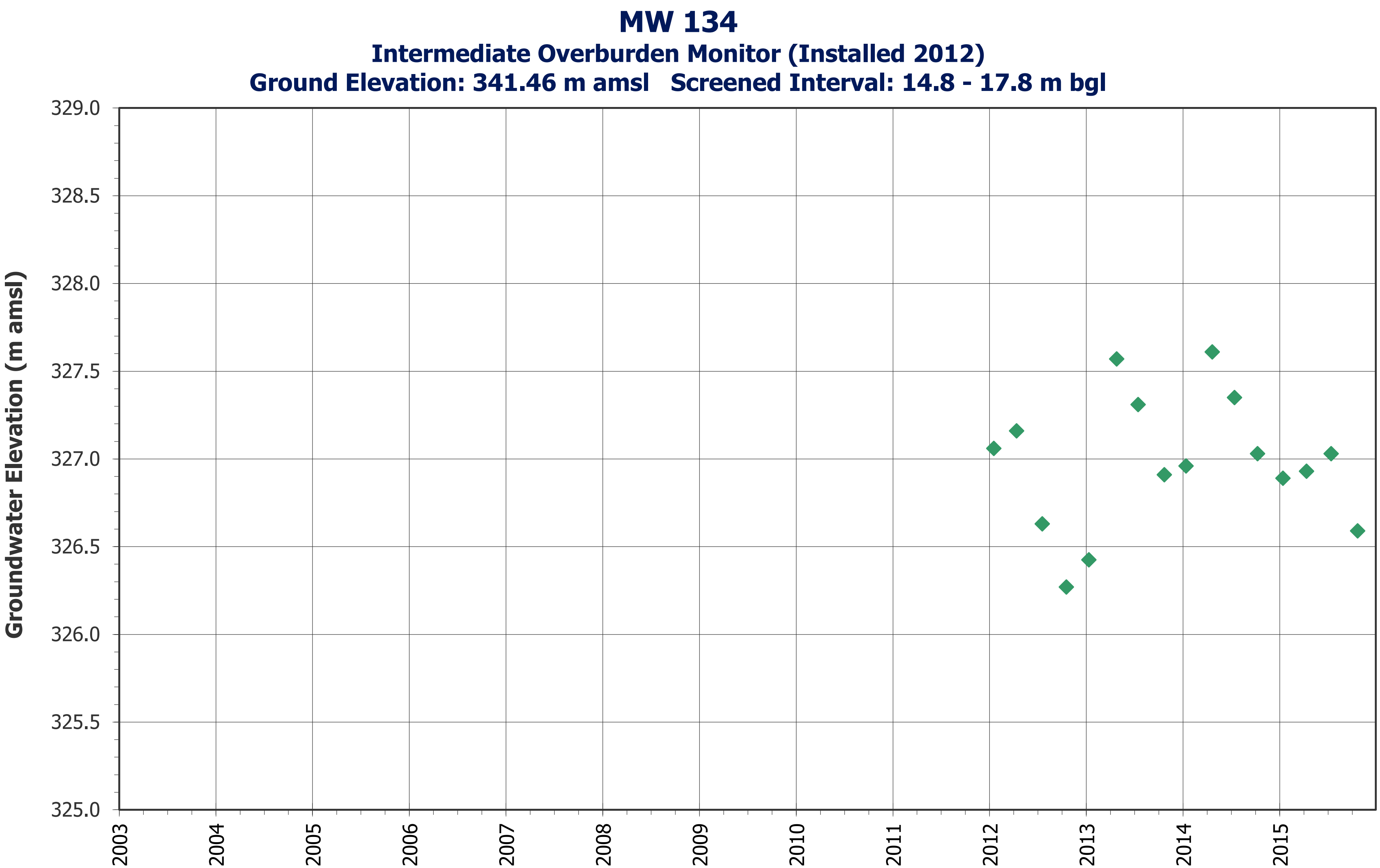
MW 132
Shallow Overburden Monitor (Installed 2012)
Ground Elevation: 334.98 m amsl Screened Interval: 7.4 - 10.4 m bgl
Groundwater Elevation (m amsl)
330.0
329.5
329.0
328.5
328.0
327.5
327.0
326.5
326.0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph C 48**



Banks Groundwater Engineering Limited

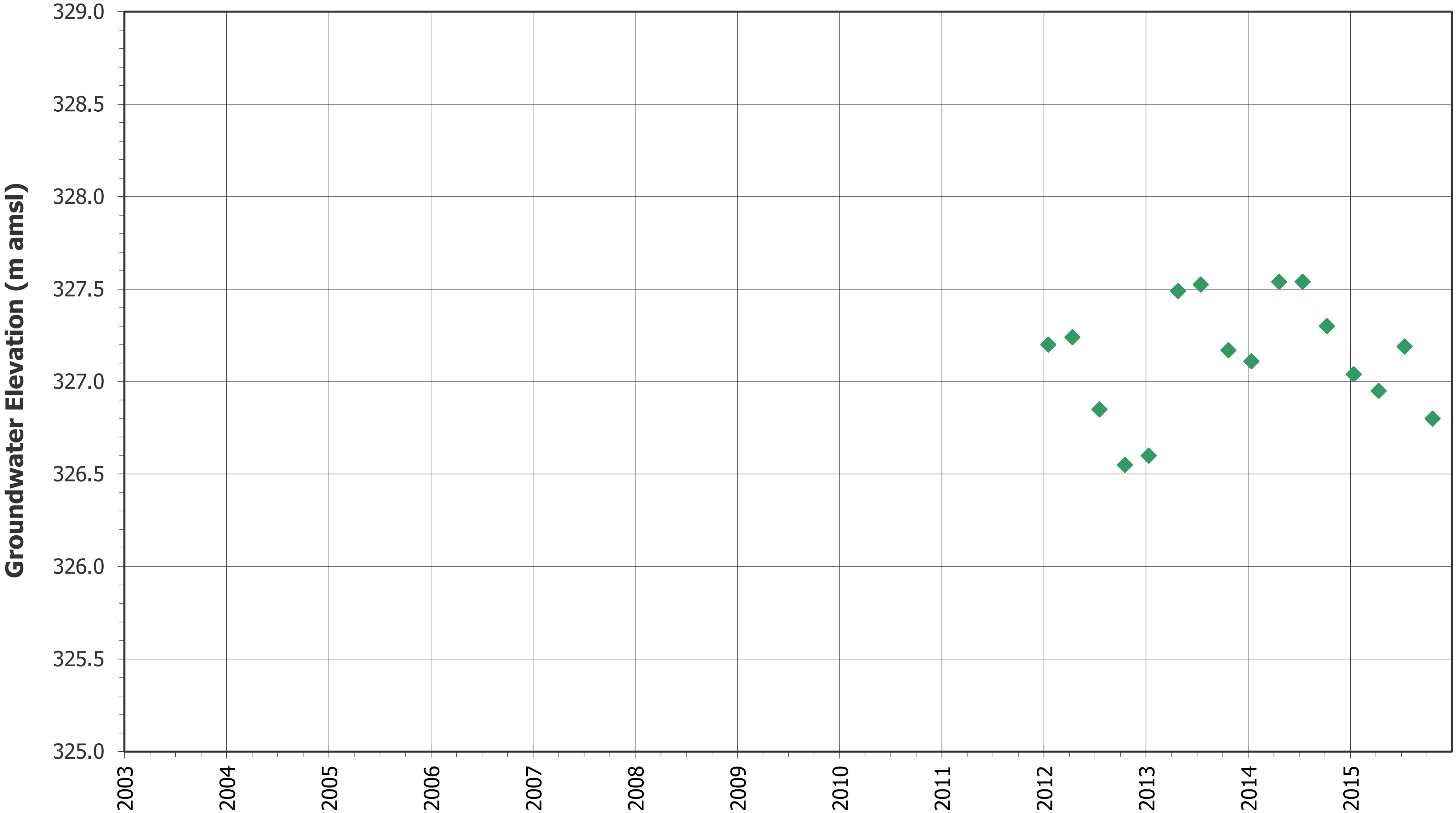
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph C 49**

MW 135

Intermediate Overburden Monitor (Installed 2012)

Ground Elevation: 333.54 m amsl   Screened Interval: 9.2 - 12.2 m bgl

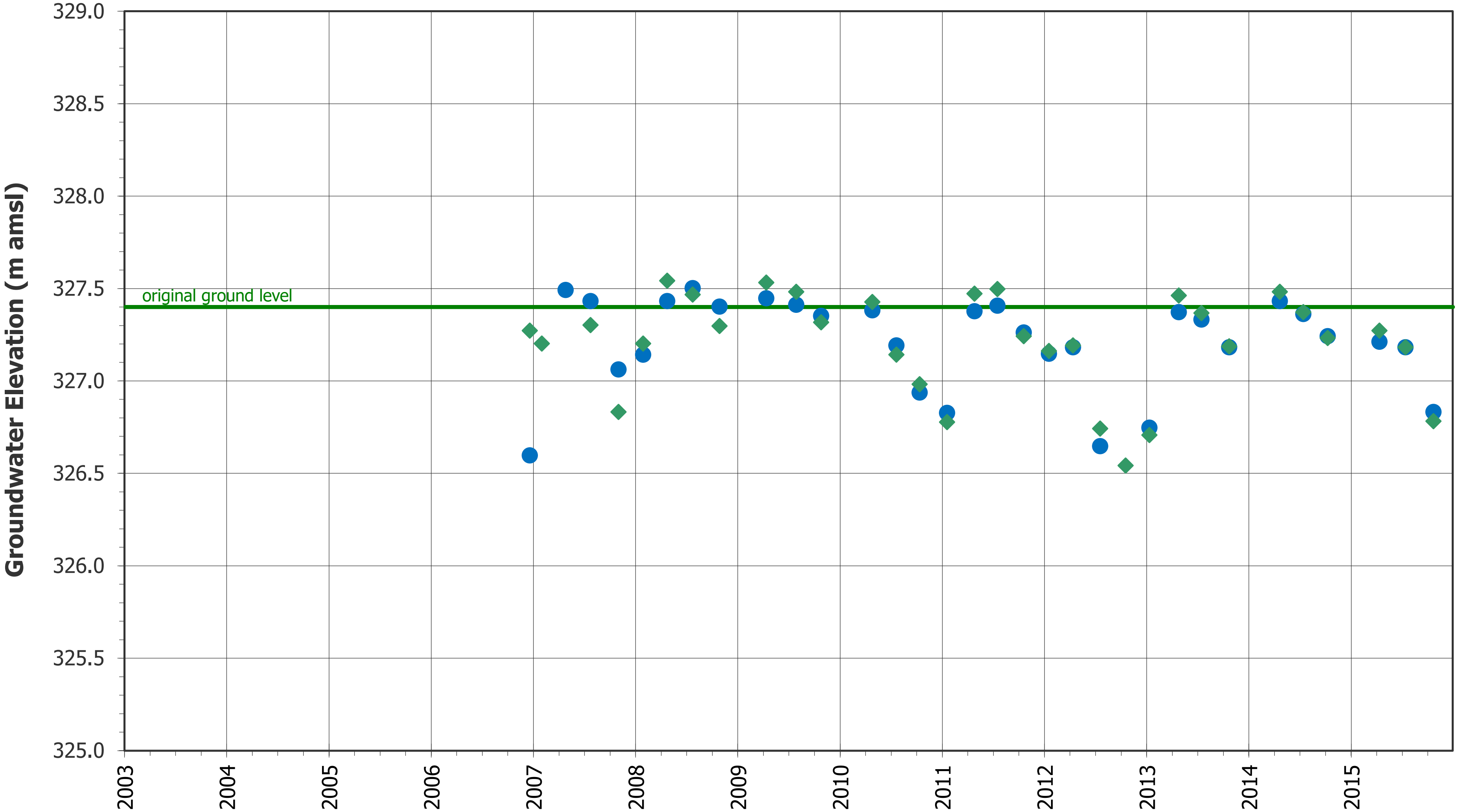


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015   **Phase 2 - Perimeter**   **Graph C 50**

PZ-1S&D
Shallow Overburden Mini-Piezometers
Ground Elevation (est.): 327.4 m amsl



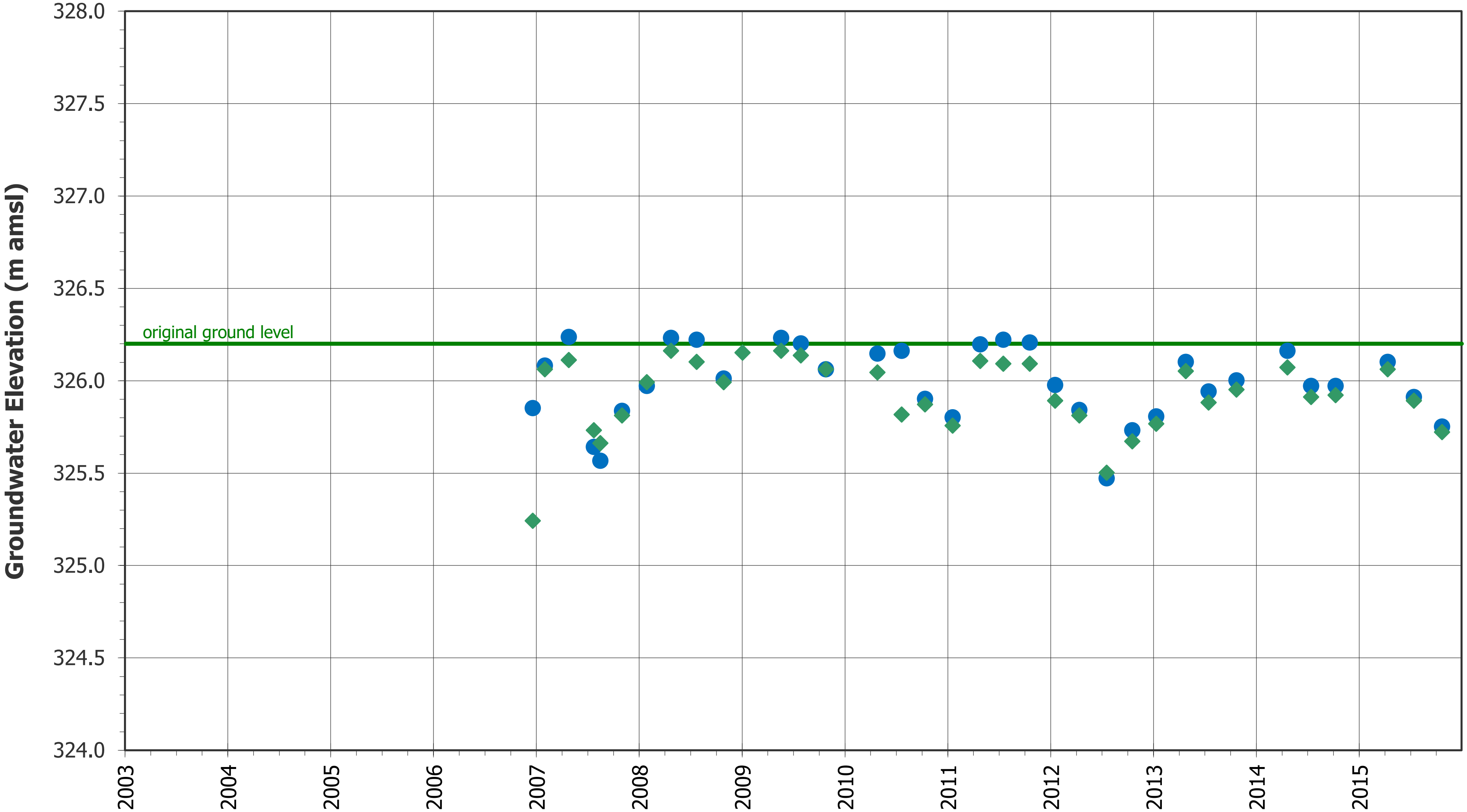
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3- Core PSW** **Graph C 51**

PZ-2S&D

Shallow Overburden Mini-Piezometers
Ground Elevation (est.): 326.2 m amsl



Banks Groundwater Engineering Limited

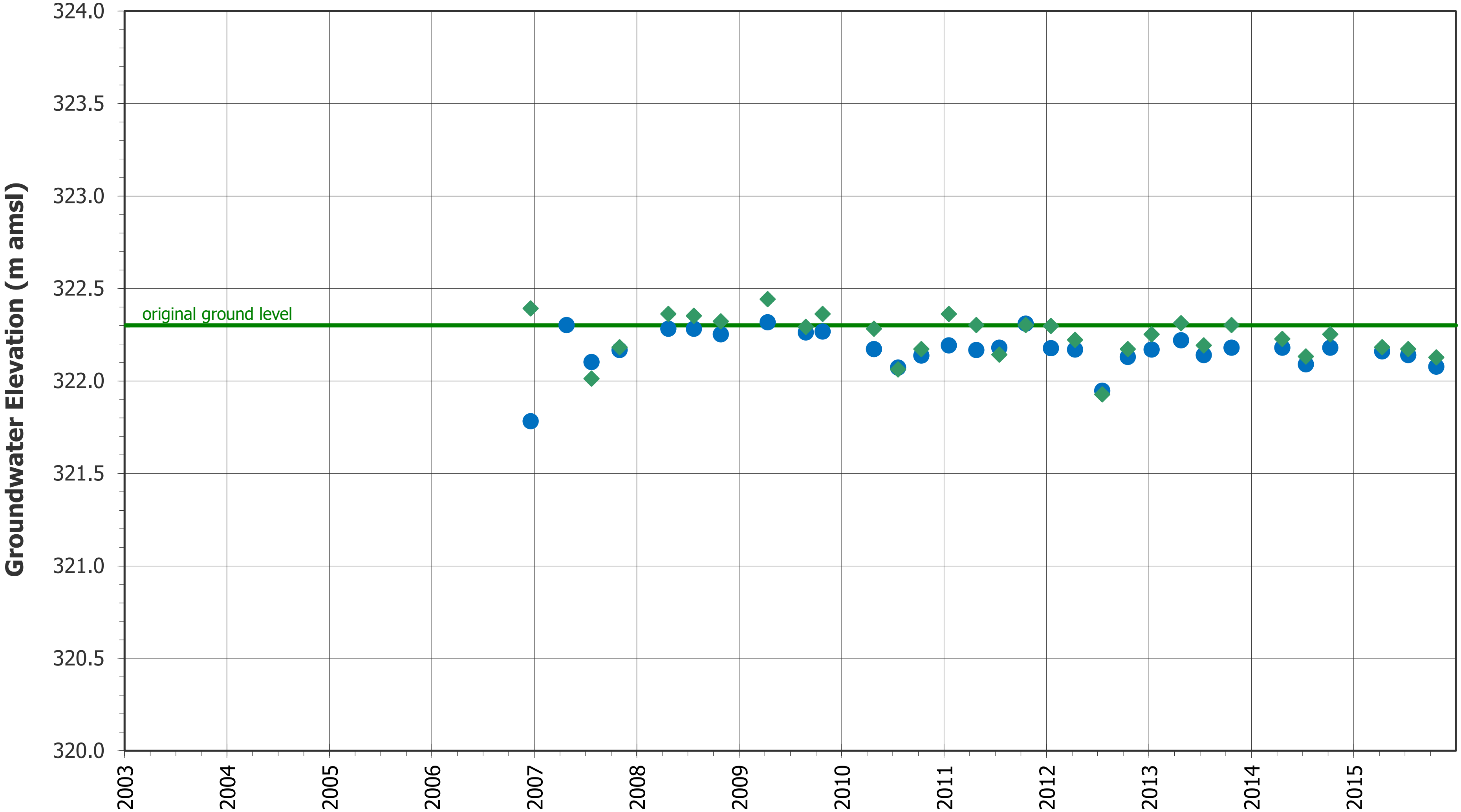
Hanlon Creek Business Park - Groundwater Monitoring Program

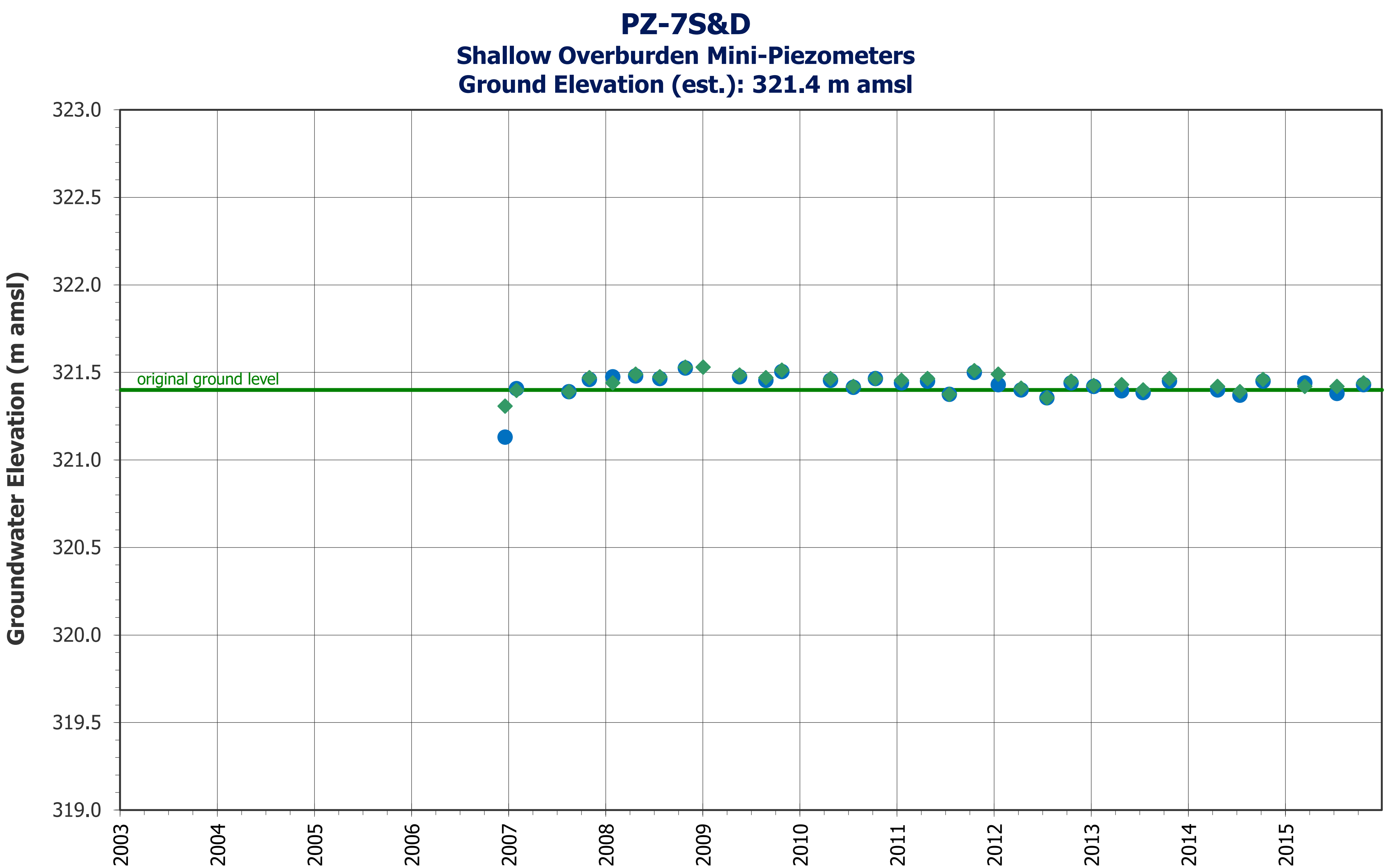
December 2015 **Phase 3 - Core PSW** **Graph C 52**

PZ-4S&D

Shallow Overburden Mini-Piezometers

Ground Elevation (est.): 322.3 m amsl

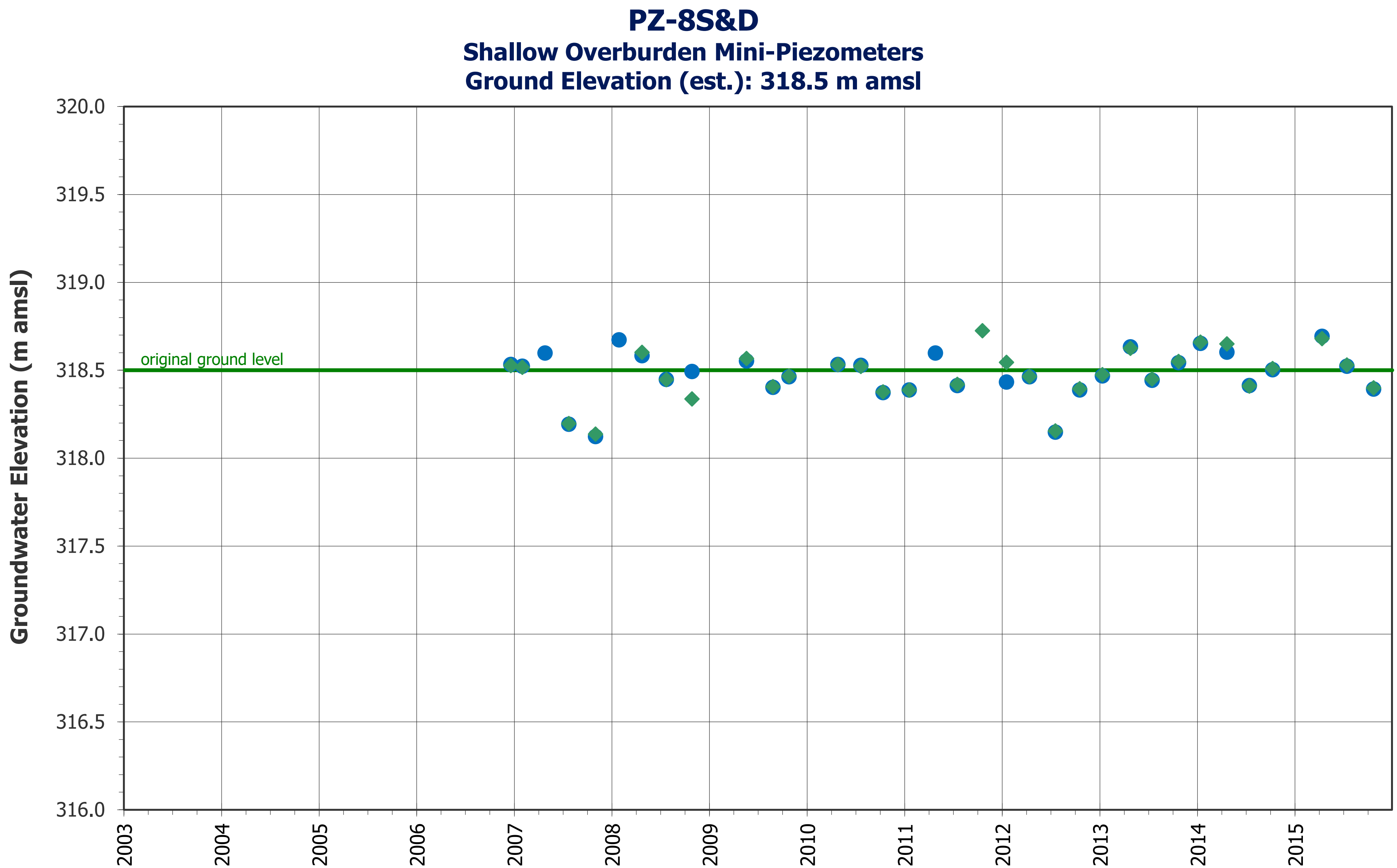




Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 54**

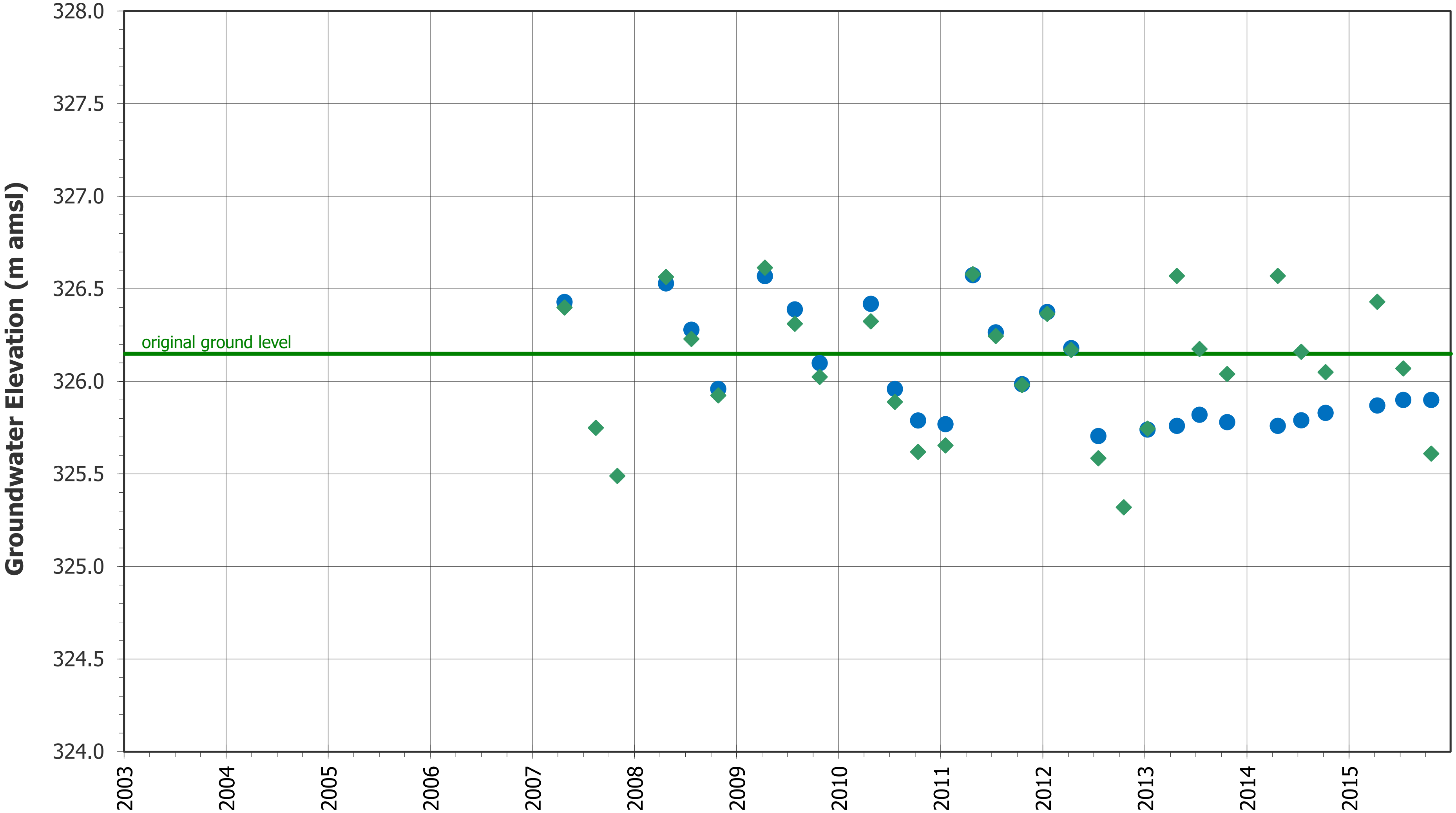


PZ-8S&D
Shallow Overburden Mini-Piezometers
Ground Elevation (est.): 318.5 m amsl
Groundwater Elevation (m amsl)
320.0
319.5
319.0
318.5
318.0
317.5
317.0
316.5
316.0
original ground level
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

PZ-9S&D

Shallow Overburden Mini-Piezometers

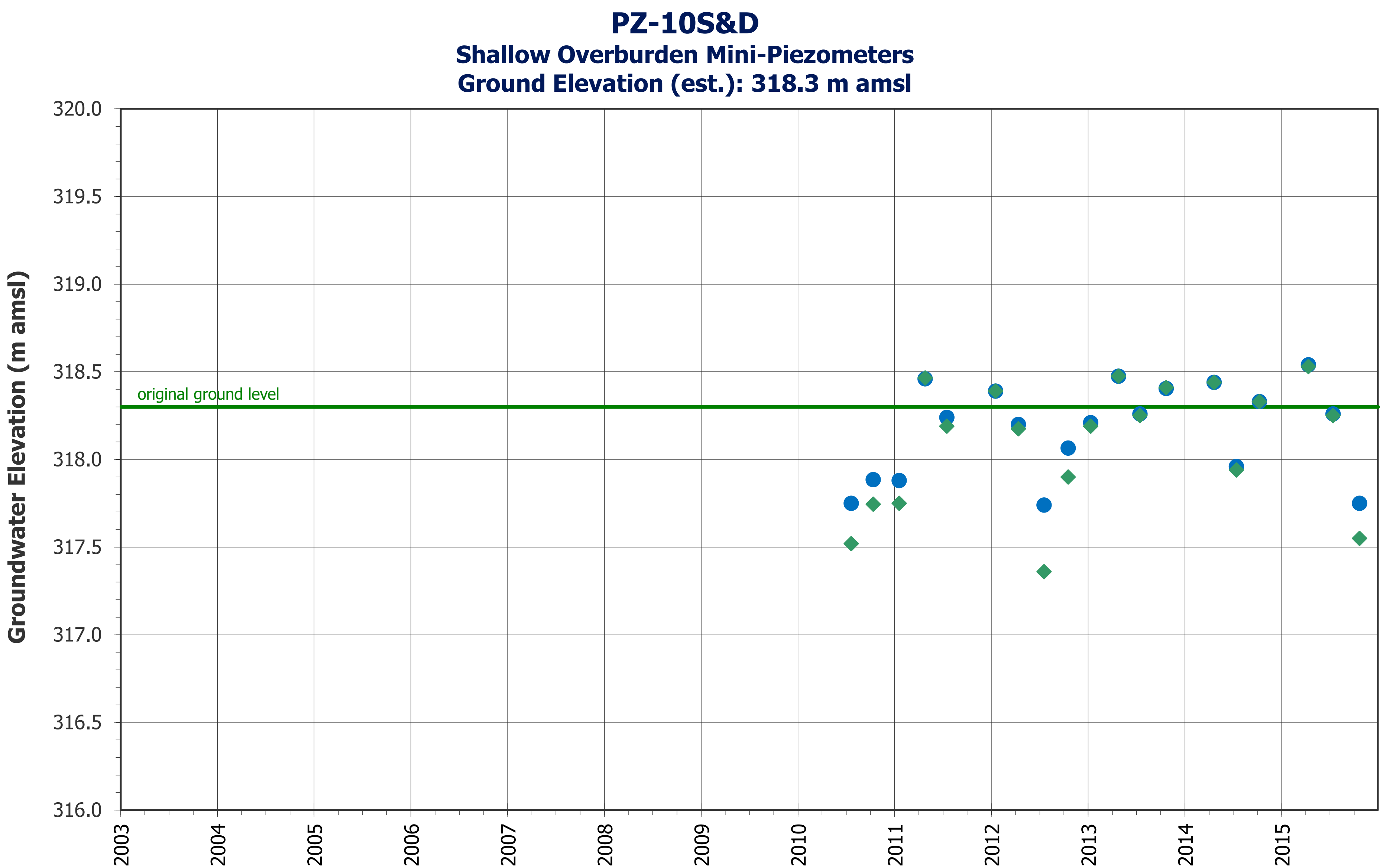
Ground Elevation: 326.2 m amsl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph C 56**



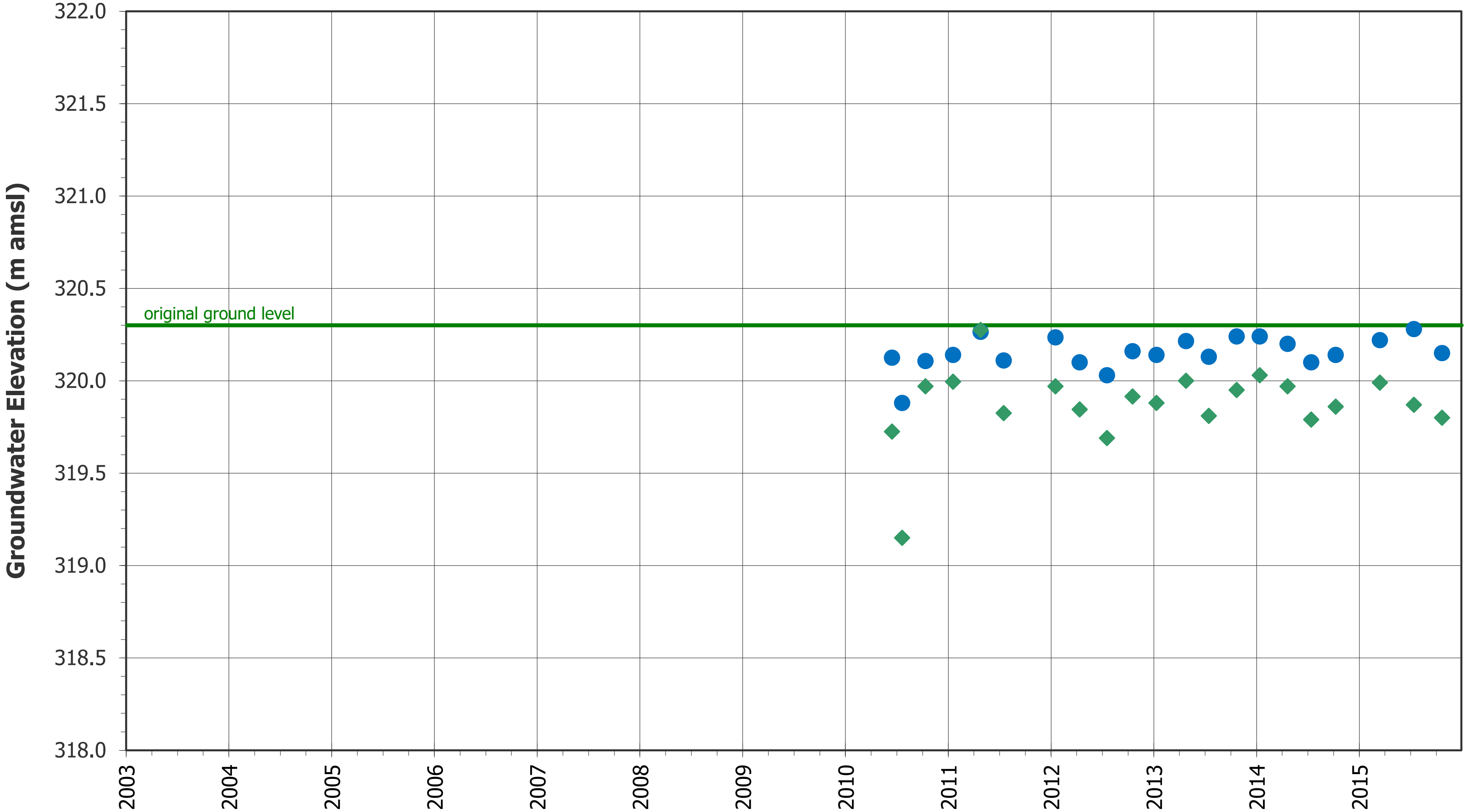
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 57**

PZ-11S&D

Shallow Overburden Mini-Piezometers
Ground Elevation (est.): 320.3 m amsl



Banks Groundwater Engineering Limited

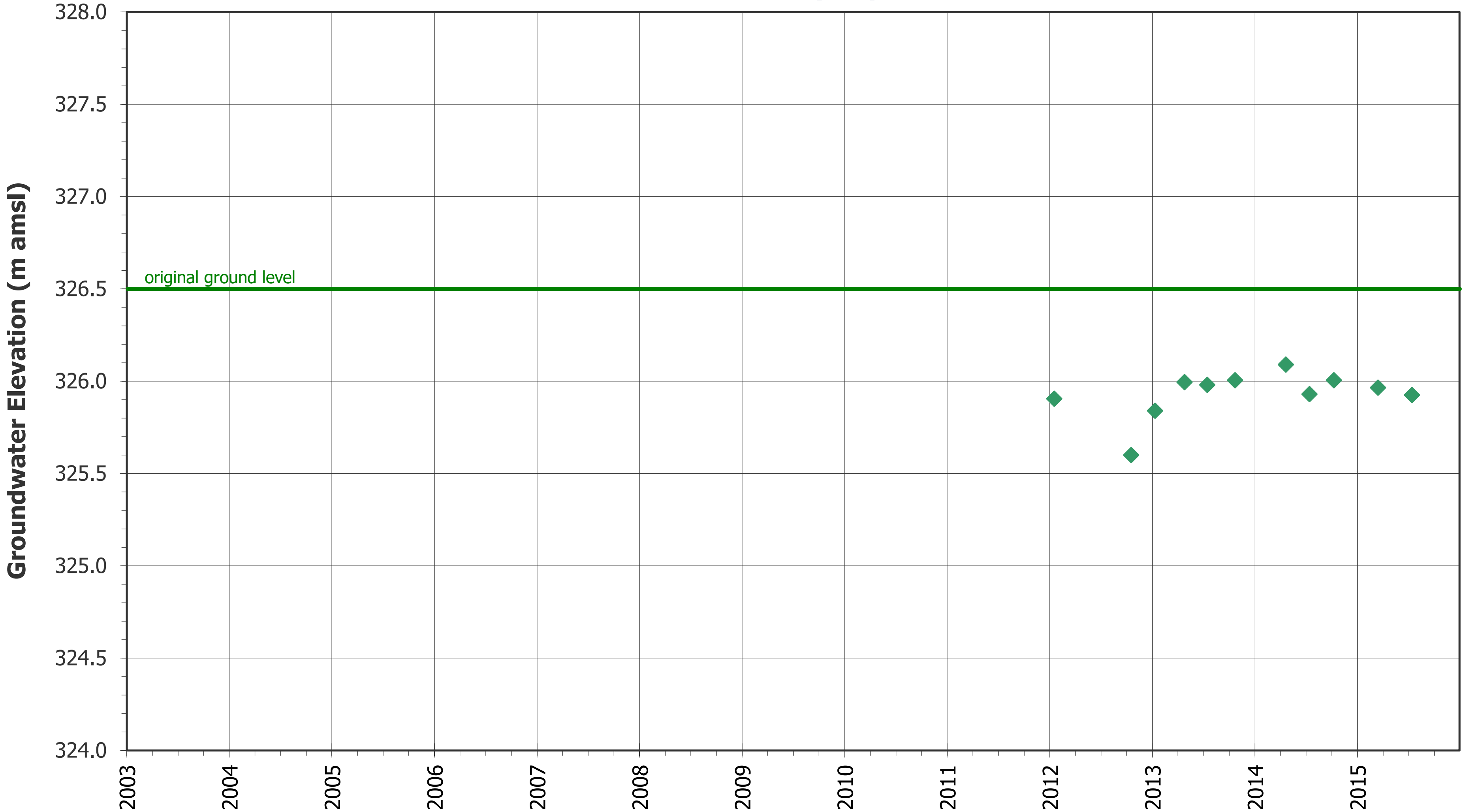
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph C 58**

PZ-12D

Shallow Overburden Mini-Piezometer (Installed 2011)

Ground Elevation (est.): 326.5 m amsl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 Phase 2 - Core PSW Graph C 59

Appendix D

Vertical Hydraulic Gradients
2003 – 2015

Hanlon Creek Business Park -Groundwater Monitoring Program

Vertical Hydraulic Gradient Data

Monitoring Well Number	Type	Groundwater Elevations (m amsl)															
		Sep-03	Apr-07	Jul-07	Nov-07	Jan-08	Apr-08	Jul-08	Oct-08	Jan-09	Apr-09	Jul-09	Oct-09	Jan-10	Apr-10	Jul-10	Oct-10
001	S	323.96	324.33	323.87	323.67	324.29	324.42	324.22	324.03	324.40	324.43	324.20	324.10	324.16	324.22	323.89	323.85
002	S	325.39	damaged	325.33	325.27	325.95	325.01	325.91	325.83								
003	S	325.61	326.57	325.89	325.48	326.17	326.58	326.22	325.92	326.56	326.64	326.30	326.01	326.10	326.35	325.91	325.64
004	S	325.72	327.03	326.19	325.52	326.22	327.53	326.49	326.03	326.87	327.29	326.54	326.08	326.10	326.67	326.14	325.70
005 (S)	S	329.78	n/a	moist/dry	dry	330.10	330.20	330.33	330.05	330.52	330.11	330.07			330.09		
005 (I)	I	326.92	n/a	327.88	327.16	327.29	328.62	328.13	327.70	327.82	328.82	328.38	327.85	327.50	327.89	327.63	
006	S	326.97	328.27	327.74	327.11	327.46	328.54	328.05	327.62	327.99	328.66	328.21	327.76	327.51	327.84	327.56	
101	S	317.58	318.01	317.54	317.35	318.09	318.49	317.79	317.77	318.65	318.52	317.62	317.88	317.92	318.07	317.72	317.66
102	S	318.91	319.74	318.72	318.30	319.74	319.89	320.18	319.15	320.13	320.13	319.17	319.34	319.98	319.72		
103	S	322.63	323.33	322.44	322.40	323.33	323.44	323.05	322.79	323.55	323.51	322.90	322.80	322.90	323.11	322.57	322.52
104	S	320.83	321.49	320.59	320.70	321.46	321.43	321.30	321.14	321.55	321.61	321.14	321.17	321.28	321.24	320.87	320.82
105	S	322.60	322.93	322.48	322.62	322.77	322.82	322.77	322.72	322.84	322.93	322.79	322.79	322.81	322.76	322.53	322.66
106	S	325.78	326.66	326.07	325.76	326.39	326.83	326.50	326.19	326.77	326.93	326.48	326.28	326.29	326.41	326.08	
107	S	326.31	n/a	326.71	326.29	326.78	327.52	327.15	326.75	327.25	327.76	327.14	326.85	326.78	326.96	326.61	326.56
109	S	326.29	327.56	326.88	326.29	326.71	327.91	327.10	326.74	327.31	327.87	327.21	326.83	326.74	327.18	326.76	326.42
110	I	326.53	327.90	327.30	326.63	326.89	328.20	327.53	327.14	327.43	328.23	327.70	327.25	327.04	327.47	327.15	
111	D	324.60	324.95	325.03	324.67	325.18	325.93	325.05	324.86	325.05		325.22	324.73	324.78	324.94	324.66	324.53
112	D	325.47	326.49	325.77	325.35	325.97	327.07	326.26	325.81	326.54	326.79	326.24	325.55	325.57	325.97	325.64	325.31
113	D	325.42	326.73	326.10	325.55	325.89	326.95	326.26	325.88	326.17	326.87	326.42	325.84	325.71	326.06	325.74	
114	D	325.82	327.04	326.65	326.04	326.29	327.43	326.87	326.45	326.68	327.43	327.07	326.49	326.28	326.64	326.29	
115	I	323.02	322.77	323.14	323.19	frozen	323.76	323.76	323.45		323.76	323.55	323.50	323.61	323.62	323.19	323.33
115A	S	322.44	323.05	321.97	322.34	322.81	322.82	323.10	322.74	322.92	323.09	322.73	322.91	322.95	322.94	322.40	322.72
116	I	314.86	315.71	314.63	314.41	315.35	316.00	314.63	314.84		315.95	314.26	315.05	315.17	315.32	314.80	314.73
116A	S	317.92	318.50	317.58	317.56	318.47	318.49	318.27	318.21	318.57	318.53	318.27	318.18	318.27	318.28	317.74	317.89
117	I	318.09	318.19	318.05	318.04	318.55	318.84	318.06	318.25	318.85	318.79	317.82	318.33	318.38	318.40	317.82	318.28
117A	S	319.97	320.45	319.83	319.93	320.13	320.25	320.04	320.10	320.37	320.36	320.00	320.09	320.13	320.10	319.32	320.26
118	I	323.18	323.43	323.33	323.34	323.66	323.75	323.49	323.43	323.69	323.74	323.54	323.48	323.52	323.50	323.44	323.46
118A	S	323.16	323.45	322.99	323.04	323.31	323.33	323.26	323.20	323.48	323.50	323.30	323.25	323.29	323.26	323.05	323.10
119	I	324.76	325.37	324.72	324.85	325.15	325.22	325.35	325.18	325.27	325.42	325.25	325.24	325.26	325.19	325.23	325.04
119A	S	324.77	325.19	324.73	324.87	325.17	325.24	325.35	325.20	325.29	325.42	325.27	325.26	325.27	325.20	325.26	325.06
121	I	325.72	326.38	326.35	325.81	326.15	326.71	326.50	326.29	326.53	326.74	326.57	325.26	326.26	326.49	326.22	326.03
121A	S	326.44	damaged	326.99	326.84	326.58	327.30	327.13	326.94	327.15	327.34	327.19	326.38	326.90	327.11	326.86	326.66
122	I	325.93	326.30	326.07	325.96	326.14	326.30	326.30	326.13	326.28	326.38	326.26	327.01	326.14	326.20	326.29	326.03
122A	S	325.81	326.10	325.93	325.84	325.98	326.12	326.12	325.99	326.11	326.17	326.08	326.19	325.98	326.03	326.12	325.90
123	VD	n/a	305.83	305.14	304.55	310.53	311.64	308.11	306.97		307.22		326.03	305.50	305.68	304.96	304.80

S=Shallow; I=Intermediate; D=Deep (Bedrock)

Hanlon Creek Business Park -Groundwater Monitoring Program

Vertical Hydraulic Gradient Data

Monitoring Well Number	MW for Gradient Calc.	Mid-Point of Screen Elevation (m)	Vertical Hydraulic Gradient I (-ve = up)																
			Sep-03	Apr-07	Jul-07	Nov-07	Jan-08	Apr-08	Jul-08	Oct-08	Jan-09	Apr-09	Jul-09	Oct-09	Jan-10	Apr-10	Jul-10	Oct-10	average I
001	118	319.75	0.20	0.23	0.14	0.08	0.16	0.17	0.18	0.15	0.18	0.18	0.17	0.16	0.16	0.18	0.11	0.10	0.16
002	119	324.16	0.12	n/a	0.11	0.08	0.15	-0.04	0.11	0.12									0.09
003	122	323.56	-0.09	0.08	-0.05	-0.14	0.01	0.08	-0.02	-0.06	0.08	0.08	0.01	-0.29	-0.01	0.04	-0.11	-0.11	-0.03
004	112	324.38	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.02
005 (S)	005(I)	331.23	0.47	n/a	n/a	n/a	0.46	0.26	0.36	0.39	n/a	0.21	0.28			0.36			0.35
005 (I)	114	325.13	0.05	n/a	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05	0.05	0.06		0.05
006	121	326.45	0.14	0.22	0.16	0.15	0.15	0.21	0.18	0.15	0.17	0.22	0.19	0.29	0.14	0.16	0.15		0.18
101	116	316.70	0.32	0.27	0.34	0.34	0.32	0.29	0.37	0.34		0.30	0.39	0.33	0.32	0.32	0.34	0.34	0.33
102	117	316.91	0.22	0.41	0.18	0.07	0.31	0.28	0.56	0.24	0.34	0.35	0.36	0.27	0.42	0.35			0.31
103	117	320.75	0.59	0.67	0.57	0.57	0.63	0.60	0.65	0.59	0.62	0.62	0.66	0.59	0.59	0.62	0.62	0.55	0.61
104	118	318.84	-0.76	-0.63	-0.89	-0.86	-0.72	-0.76	-0.71	-0.75	-0.70	-0.69		-0.75	-0.73	-0.74	-0.84	-0.86	-0.76
105	111	320.52	-0.11	-0.11	-0.14	-0.11	-0.13	-0.17	-0.12	-0.12	-0.12		-0.13	-0.11	-0.11	-0.12	-0.12	-0.10	-0.12
106	119	323.60	0.22	0.27	0.29	0.19	0.26	0.34	0.24	0.21	0.32	0.32	0.26	0.22	0.22	0.26	0.18		0.25
107	119	324.49	0.28	n/a	0.35	0.26	0.29	0.41	0.32	0.28	0.35	0.42	0.34	0.29	0.27	0.32	0.25	0.27	0.31
109	113	323.50	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04		0.03
110	113	323.79	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		0.05
111	105	302.10	-0.11	-0.11	-0.14	-0.11	-0.13	-0.17	-0.12	-0.12	-0.12		-0.13	-0.11	-0.11	-0.12	-0.12	-0.10	-0.12
112	004	300.29	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.02
113	110	296.30	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		0.05
114	005(I)	302.13	0.05	n/a	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05	0.05	0.06		0.05
115	115A	315.07	-0.10	0.05	-0.20	-0.14	n/a	-0.16	-0.11	-0.12		-0.11	-0.14	-0.10	-0.11	-0.11	-0.13	-0.10	-0.11
115A	115	321.00	-0.10	0.05	-0.20	-0.14	n/a	-0.16	-0.11	-0.12		-0.11	-0.14	-0.10	-0.11	-0.11	-0.13	-0.10	-0.11
116	116A	308.15	0.38	0.35	0.37	0.39	0.39	0.31	0.45	0.42		0.32	0.50	0.39	0.39	0.37	0.37	0.39	0.39
116A	116	316.17	0.38	0.35	0.37	0.39	0.39	0.31	0.45	0.42		0.32	0.50	0.39	0.39	0.37	0.37	0.39	0.39
117	117A	313.11	0.33	0.40	0.32	0.34	0.28	0.25	0.35	0.33	0.27	0.28	0.39	0.31	0.31	0.30	0.27	0.35	0.32
117A	117	318.75	0.33	0.40	0.32	0.34	0.28	0.25	0.35	0.33	0.27	0.28	0.39	0.31	0.31	0.30	0.27	0.35	0.32
118	118A	315.77	-0.003	0.004	-0.07	-0.06	-0.07	-0.08	-0.04	-0.04	-0.04	-0.05	-0.05	-0.04	-0.04	-0.05	-0.07	-0.07	-0.05
118A	118	320.92	-0.003	0.004	-0.07	-0.06	-0.07	-0.08	-0.04	-0.04	-0.04	-0.05	-0.05	-0.04	-0.04	-0.05	-0.07	-0.07	-0.05
119	119A	318.88	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
119A	119	322.53	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
121	121A	317.79	0.11	n/a	0.09	0.15	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.17	0.09	0.09	0.09	0.09	0.10
121A	121	324.59	0.11	n/a	0.09	0.15	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.17	0.09	0.09	0.09	0.09	0.10
122	122A	320.09	-0.03	-0.06	-0.04	-0.04	-0.05	-0.05	-0.05	-0.04	-0.05	-0.06	-0.05	-0.24	-0.05	-0.05	-0.05	-0.04	-0.06
122A	122	323.51	-0.03	-0.06	-0.04	-0.04	-0.05	-0.05	-0.05	-0.04	-0.05	-0.06	-0.05	-0.24	-0.05	-0.05	-0.05	-0.04	-0.06
123	111	272.78	n/a	0.65	0.68	0.69	0.50	0.49	0.58	0.61				-0.04	0.66	0.66	0.67	0.67	0.57

S=Shallow; I=Intermediate; D=Deep (Bedrock)

Hanlon Creek Business Park -Groundwater Monitoring Program

Vertical Hydraulic Gradient Data

Monitoring Well Number	Type	Groundwater Elevations (m amsl)															
		Jan-11	Apr-11	Jul-11	Oct-11	Jan-12	Apr-12	Jul-12	Oct-12	Jan-13	Apr-13	Jul-13	Oct-13	Jan-14	Apr-14	Jul-14	Oct-14
003	S	325.68	326.61	326.24	325.97	326.35	326.15	325.57	325.30	325.73	326.56	326.15	326.02	326.40	326.56	326.14	326.03
004	S	325.67	326.80	326.78	325.88	326.44	326.40	325.76	325.32	325.69	327.16	326.50	325.96	326.26	327.13	326.49	326.11
103	S	322.50	323.27	322.41	322.62	322.91	322.59	322.10	322.42	322.67	323.21	322.77	322.89	322.90	323.19	322.50	322.87
104	S	320.92	321.42	321.10	321.28	321.30	321.06	320.62	320.87	321.31	321.50	321.18	321.33	321.47	321.39	320.97	321.25
105	S	322.64	322.90	322.62	323.04	322.78	322.69	322.33	322.67	322.75	322.85	322.62	322.82	322.86	322.81	322.58	322.77
107	S	326.14	327.00	326.67	326.22	326.42	326.32	326.06	325.98	326.07	326.66	326.59	326.45	326.43	326.68	326.54	326.49
111	D	324.47	325.15	325.01	324.70	324.90	324.90	324.42	324.40	324.66	325.39	324.92	325.02	0.00	325.27	325.03	324.95
112	D	325.29	326.35	326.18	325.56	326.11	325.96	325.23	325.12	325.48	326.77	326.18	325.76	326.07	326.79	326.13	325.88
115	I	323.48	323.75	323.28	323.57	323.61	323.58	322.83	323.21	323.46	323.76	323.51	323.62	323.71	323.76	323.47	323.65
115A	S	322.80	323.07	322.28	323.10	322.95	322.92	321.94	322.65	322.95	322.99	322.62	322.97	323.03	323.00	322.55	322.93
116	I	314.77	315.79	315.24	315.23	315.56	315.10	314.55	314.77	315.14	315.87	315.48	315.95	315.53	315.96	315.23	315.57
116A	S	317.92	318.39	318.10	318.47	318.34	318.14	317.51	317.97	318.22	318.39	318.15	318.30	318.43	318.36	317.96	318.22
117	I	318.29	318.81	318.31	318.59	318.54	318.27	317.99	318.27	318.39	318.67	318.43	318.70	318.63	318.69	318.29	318.53
117A	S	320.29	320.58	320.08	320.70	320.23	320.11	319.97	320.18	320.18	320.25	320.08	320.22	320.29	320.22	320.06	320.14
118	I	323.41	323.73	323.21	323.47	323.56	323.43	323.02	323.40	323.46	323.67	323.52	323.60	323.64	323.64	323.28	323.44
118A	S	323.04	323.34	322.81	323.21	323.19	323.05	322.69	323.04	323.11	323.25	323.09	323.21	323.24	323.21	323.00	323.18
119	I	325.30	325.68	323.76	325.12	324.99	324.91	324.84	324.88	324.88	324.97	324.90	324.96	325.08	324.98	324.87	324.92
119A	S	325.30	325.68	323.77	325.15	325.02	324.94	324.86	324.90	324.91	324.99	324.92	324.99	325.10	325.01	324.89	324.94
121	I	325.81	326.49	326.61	326.24	326.22	326.24	325.82	325.57	325.72	326.49	326.41	326.20	326.26	326.52	326.41	326.26
121A	S	326.44	327.12	327.20	326.87	326.87	326.89	326.46	326.20	326.36	327.11	327.04	326.84	326.89	327.14	327.05	326.91
122	I	325.99	326.31	326.00	326.17	326.17	326.13	325.91	325.83	326.01	326.29	326.15	326.15	326.25	326.29	326.15	326.14
122A	S	325.86	326.11	326.04	326.02	326.01	325.97	325.79	325.72	325.88	326.10	325.98	325.99	326.06	326.08	325.98	325.98
123	D+	304.76	306.54	306.81	308.29	308.32	312.91	305.61	307.36	307.84	308.63	306.68	306.82	306.98	307.82	307.03	307.00
124	S					320.29	319.83	319.20	319.28	320.20	319.91	319.96	320.34	320.43	320.39	319.56	320.23
125	S					314.83	314.40	314.03	314.22	314.44	315.18	314.69	315.08	314.76	315.28	314.53	314.72
126	S					317.35	316.82	315.62	316.02	316.85	317.64	317.89	318.10	317.98	318.16	317.51	318.04
127	S					318.55	318.39	318.20	318.40	318.49	318.66	318.50	318.61	318.64	318.68	318.46	318.58
128	S					320.29	320.20	319.94	320.10	320.21	320.43	320.32	320.36	320.40	320.40	320.23	320.35
129	S					325.07	324.87	324.62	324.91	324.97	325.24	325.04	325.16	325.23	325.25	324.96	325.11
130A	S					322.65		322.14	322.56	322.58	322.75	322.53	322.67	322.73	322.69	322.45	322.65
131	S					325.39	325.33	325.53	325.68	325.74	326.06	325.93	325.97	326.10	326.06	325.91	325.92
132	S					327.73	327.68	327.38	327.16	327.16	327.93	328.02	327.72	327.62	327.97	328.01	327.89
133	I					328.03	328.11	327.73	327.40	327.33	328.22	328.50	328.12	327.96	328.32	328.54	328.28
134	I					327.06	327.16	326.63	326.27	326.43	327.57	327.31	326.91	326.96	327.61	327.35	327.03
135	I					327.20	327.24	326.85	326.55	326.60	327.49	327.53	327.17	327.11	327.54	327.54	327.30

S=Shallow; I=Intermediate; D=Deep (Bedrock)

Hanlon Creek Business Park -Groundwater Monitoring Program

Vertical Hydraulic Gradient Data

Monitoring Well Number	MW for Gradient Calc.	Mid-Point of Screen Elevation (m)	Vertical Hydraulic Gradient I (-ve = up)																
			Jan-11	Apr-11	Jul-11	Oct-11	Jan-12	Apr-12	Jul-12	Oct-12	Jan-13	Apr-13	Jul-13	Oct-13	Jan-14	Apr-14	Jul-14	Oct-14	average I
003	122	323.56	-0.09	0.09	0.07	-0.06	0.05	0.01	-0.10	-0.15	-0.08	0.08	0.00	-0.04	0.04	0.08	-0.00	-0.03	-0.01
004	112	324.38	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
103	117	320.75	0.55	0.58	0.54	0.53	0.57	0.57	0.54	0.54	0.56	0.59	0.57	0.55	0.56	0.59	0.55	0.57	0.56
104	118	318.84	-0.81	-0.75	-0.69	-0.71	-0.74	-0.77	-0.78	-0.82	-0.70	-0.71	-0.76	-0.74	-0.71	-0.73	-0.75	-0.71	-0.74
105	111	320.52	-0.10	-0.12	-0.13	-0.09	-0.12	-0.12	-0.11	-0.09	-0.10	-0.14	-0.12	-0.12	17.53	-0.13	-0.13	-0.12	0.99
107	119	324.49	0.15	0.24	0.52	0.20	0.25	0.25	0.22	0.20	0.21	0.30	0.30	0.26	0.24	0.30	0.30	0.28	0.26
111	105	302.10	-0.10	-0.12	-0.13	-0.09	-0.12	-0.12	-0.11	-0.09	-0.10	-0.14	-0.12	-0.12	17.53	-0.13	-0.13	-0.12	0.99
112	004	300.29	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
115	115A	315.07	-0.11	-0.11	-0.17	-0.08	-0.11	-0.11	-0.15	-0.09	-0.09	-0.13	-0.15	-0.11	-0.11	-0.13	-0.16	-0.12	-0.12
115A	115	321.00	-0.11	-0.11	-0.17	-0.08	-0.11	-0.11	-0.15	-0.09	-0.09	-0.13	-0.15	-0.11	-0.11	-0.13	-0.16	-0.12	-0.12
116	116A	308.15	0.39	0.32	0.36	0.40	0.35	0.38	0.37	0.40	0.38	0.31	0.33	0.29	0.36	0.30	0.34	0.33	0.35
116A	116	316.17	0.39	0.32	0.36	0.40	0.35	0.38	0.37	0.40	0.38	0.31	0.33	0.29	0.36	0.30	0.34	0.33	0.35
117	117A	313.11	0.35	0.31	0.31	0.37	0.30	0.33	0.35	0.34	0.32	0.28	0.29	0.27	0.29	0.27	0.31	0.29	0.31
117A	117	318.75	0.35	0.31	0.31	0.37	0.30	0.33	0.35	0.34	0.32	0.28	0.29	0.27	0.29	0.27	0.31	0.29	0.31
118	118A	315.77	-0.07	-0.08	-0.08	-0.05	-0.07	-0.07	-0.07	-0.07	-0.07	-0.08	-0.08	-0.07	-0.08	-0.08	-0.05	-0.05	-0.07
118A	118	320.92	-0.07	-0.08	-0.08	-0.05	-0.07	-0.07	-0.07	-0.07	-0.07	-0.08	-0.08	-0.07	-0.08	-0.08	-0.05	-0.05	-0.07
119	119A	318.88	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01
119A	119	322.53	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01
121	121A	317.79	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
121A	121	324.59	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
122	122A	320.09	-0.04	-0.06	0.01	-0.05	-0.05	-0.05	-0.04	-0.03	-0.04	-0.06	-0.05	-0.05	-0.06	-0.06	-0.05	-0.05	-0.04
122A	122	323.51	-0.04	-0.06	0.01	-0.05	-0.05	-0.05	-0.04	-0.03	-0.04	-0.06	-0.05	-0.05	-0.06	-0.06	-0.05	-0.05	-0.04
123	111	272.78	0.67	0.63	0.62	0.56	0.57	0.41	0.64	0.58	0.57	0.57	0.62	0.62	-10.47	0.60	0.61	0.61	-0.10
124	117	315.47					0.74	0.66	0.51	0.43	0.77	0.53	0.65	0.69	0.76	0.72	0.54	0.72	0.64
125	116	313.57					-0.13	-0.13	-0.10	-0.10	-0.13	-0.13	-0.15	-0.16	-0.14	-0.13	-0.13	-0.16	-0.13
126	116	314.51					0.28	0.27	0.17	0.20	0.27	0.28	0.38	0.34	0.38	0.35	0.36	0.39	0.30
127	116	316.07					0.38	0.42	0.46	0.46	0.42	0.35	0.38	0.34	0.39	0.34	0.41	0.38	0.39
128	116	316.10					0.60	0.64	0.68	0.67	0.64	0.57	0.61	0.55	0.61	0.56	0.63	0.60	0.61
129	119	320.04					0.06	-0.04	-0.19	0.03	0.08	0.23	0.12	0.17	0.13	0.23	0.08	0.16	0.09
130A	118	322.19					-0.14		-0.14	-0.13	-0.14	-0.14	-0.15	-0.14	-0.14	-0.15	-0.13	-0.12	-0.14
131	119	322.90					0.10	0.10	0.17	0.20	0.21	0.27	0.26	0.25	0.25	0.27	0.26	0.25	0.22
132	121	326.12					0.18	0.17	0.19	0.19	0.17	0.17	0.19	0.18	0.16	0.17	0.19	0.20	0.18
133	135	326.04					0.26	0.27	0.28	0.27	0.23	0.23	0.31	0.30	0.27	0.24	0.31	0.31	0.27
134	121	325.13					0.11	0.13	0.11	0.10	0.10	0.15	0.12	0.10	0.10	0.15	0.13	0.10	0.12
135	121	322.85					0.19	0.20	0.20	0.19	0.17	0.20	0.22	0.19	0.17	0.20	0.22	0.21	0.20

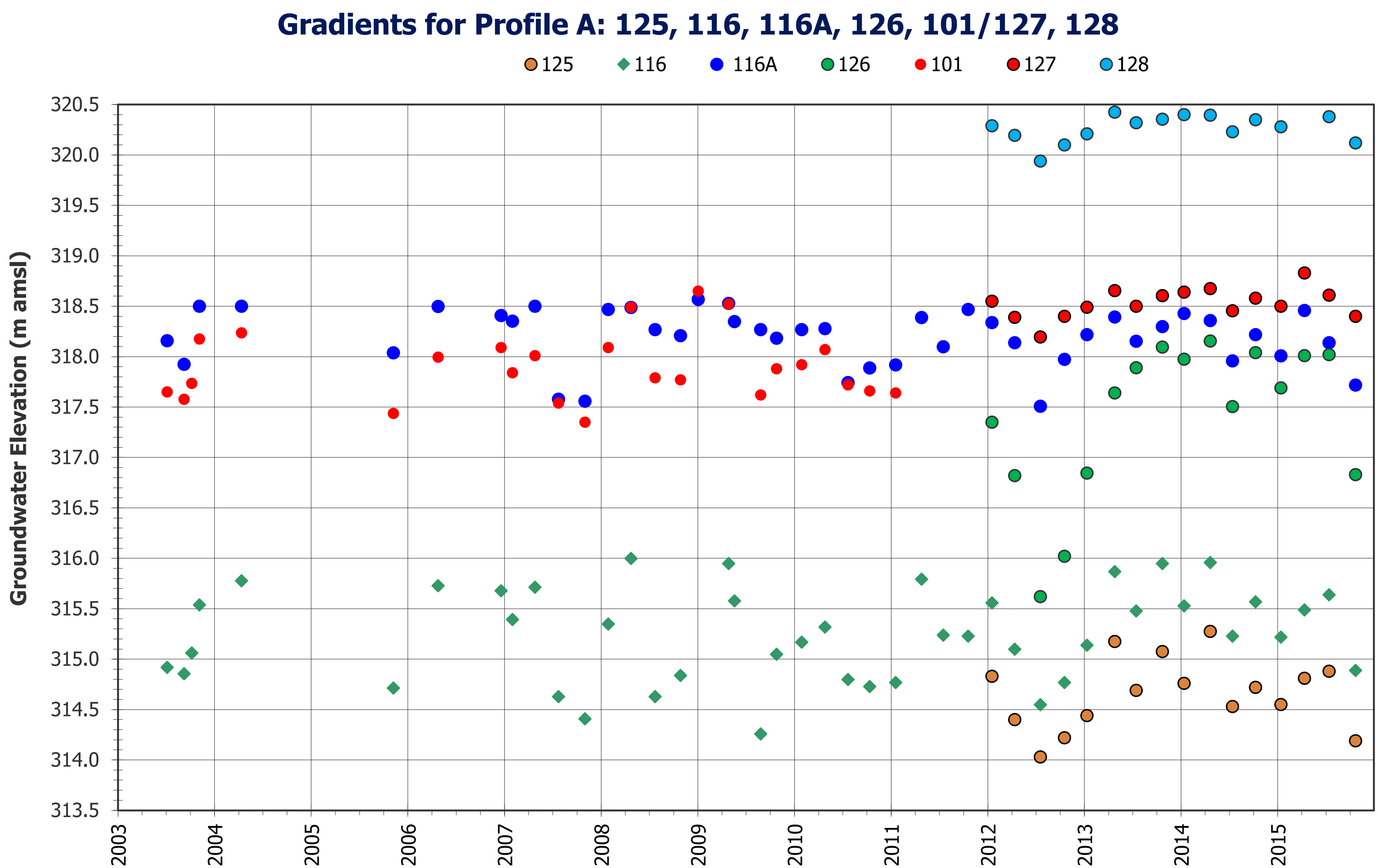
S=Shallow; I=Intermediate; D=Deep (Bedrock)

Hanlon Creek Business Park -Groundwater Monitoring Program

Vertical Hydraulic Gradient Data

Monitoring Well Number	Type	Groundwater Elevations (m amsl)				MW for Gradient Calc.	Mid-Point of Screen Elevation (m)	Vertical Hydraulic Gradient I (-ve = up)				
		Jan-15	Apr-15	Jul-15	Oct-15			Jan-15	Apr-15	Jul-15	Oct-15	average I
003	S	326.08	326.45	326.09	325.62	122	323.56	-0.02	0.07	-0.01	-0.10	-0.01
004	S	326.17	326.33	326.32	325.71	112	324.38	0.01	0.01	0.01	0.01	0.01
103	S	322.66	323.08	322.78	322.39	117	320.75	0.56	0.59	0.56	0.55	0.57
104	S	321.05	321.57	321.20	320.87	118	318.84	-0.75	-0.68	-0.72	-0.77	-0.73
105	S	322.68	323.00	322.73	322.61	111	320.52		-0.10	-0.12	-0.10	-0.11
107	S	326.31	326.40	326.40	326.10	119	324.49	0.25	0.26	0.26	0.23	0.25
111	D		324.89	324.91	324.50	105	302.10		-0.10	-0.12	-0.10	-0.11
112	D	325.96	326.19	326.06	325.50	004	300.29	0.01	0.01	0.01	0.01	0.01
115	I	323.67	323.70	323.63	323.28	115A	315.07	-0.13	-0.10	-0.12	-0.10	-0.11
115A	S	322.91	323.11	322.91	322.66	115	321.00	-0.13	-0.10	-0.12	-0.10	-0.11
116	I	315.22	315.49	315.64	314.89	116A	308.15	0.35	0.37	0.31	0.35	0.35
116A	S	318.01	318.46	318.14	317.72	116	316.17	0.35	0.37	0.31	0.35	0.35
117	I	318.37	318.55	318.49	318.22	117A	313.11	0.30	0.33	0.29	0.33	0.31
117A	S	320.09	320.40	320.13	320.09	117	318.75	0.30	0.33	0.29	0.33	0.31
118	I	323.34	323.65	323.41	323.24	118A	315.77	-0.05	-0.05	-0.05	-0.05	-0.05
118A	S	323.08	323.38	323.13	322.97	118	320.92	-0.05	-0.05	-0.05	-0.05	-0.05
119	I	324.89	324.96	324.93	324.83	119A	318.88	0.01	0.01	0.01	0.01	0.01
119A	S	324.92	324.99	324.96	324.86	119	322.53	0.01	0.01	0.01	0.01	0.01
121	I	326.12	326.24	326.24	325.83	121A	317.79	0.09	0.09	0.09	0.09	0.09
121A	S	326.77	326.88	326.88	326.47	121	324.59	0.09	0.09	0.09	0.09	0.09
122	I	326.14	326.22	326.11	325.97	122A	320.09	-0.05	-0.06	-0.05	-0.04	-0.05
122A	S	325.98	326.03	325.95	325.84	122	323.51	-0.05	-0.06	-0.05	-0.04	-0.05
123	D+	306.63	306.30	310.91	305.38	111	272.78	-10.46	0.63	0.48	0.65	-2.17
124	S	320.04	320.37	320.15	319.46	117	315.47	0.71	0.77	0.70	0.53	0.68
125	S	314.55	314.81	314.88	314.19	116	313.57	-0.12	-0.13	-0.14	-0.13	-0.13
126	S	317.69	318.01	318.02	316.83	116	314.51	0.39	0.40	0.37	0.31	0.37
127	S	318.50	318.83	318.61	318.40	116	316.07	0.41	0.42	0.38	0.44	0.41
128	S	320.28	320.53	320.38	320.12	116	316.10	0.64	0.63	0.60	0.66	0.63
129	S	325.03	325.42	325.08	324.87	119	320.04	0.12	0.39	0.13	0.03	0.17
130A	S	322.55	322.94	322.60	322.45	118	322.19	-0.12	-0.11	-0.13	-0.12	-0.12
131	S	325.85	326.04	325.88	325.71	119	322.90	0.24	0.27	0.24	0.22	0.24
132	S	327.53	327.43	327.76	327.35	121	326.12	0.17	0.14	0.18	0.18	0.17
133	I	327.85	327.75	328.05	327.66	135	326.04	0.25	0.25	0.27	0.27	0.26
134	I	326.89	326.93	327.03	326.59	121	325.13	0.10	0.09	0.11	0.10	0.10
135	I	327.04	326.95	327.19	326.80	121	322.85	0.18	0.14	0.19	0.19	0.18

S=Shallow; I=Intermediate; D=Deep (Bedrock)



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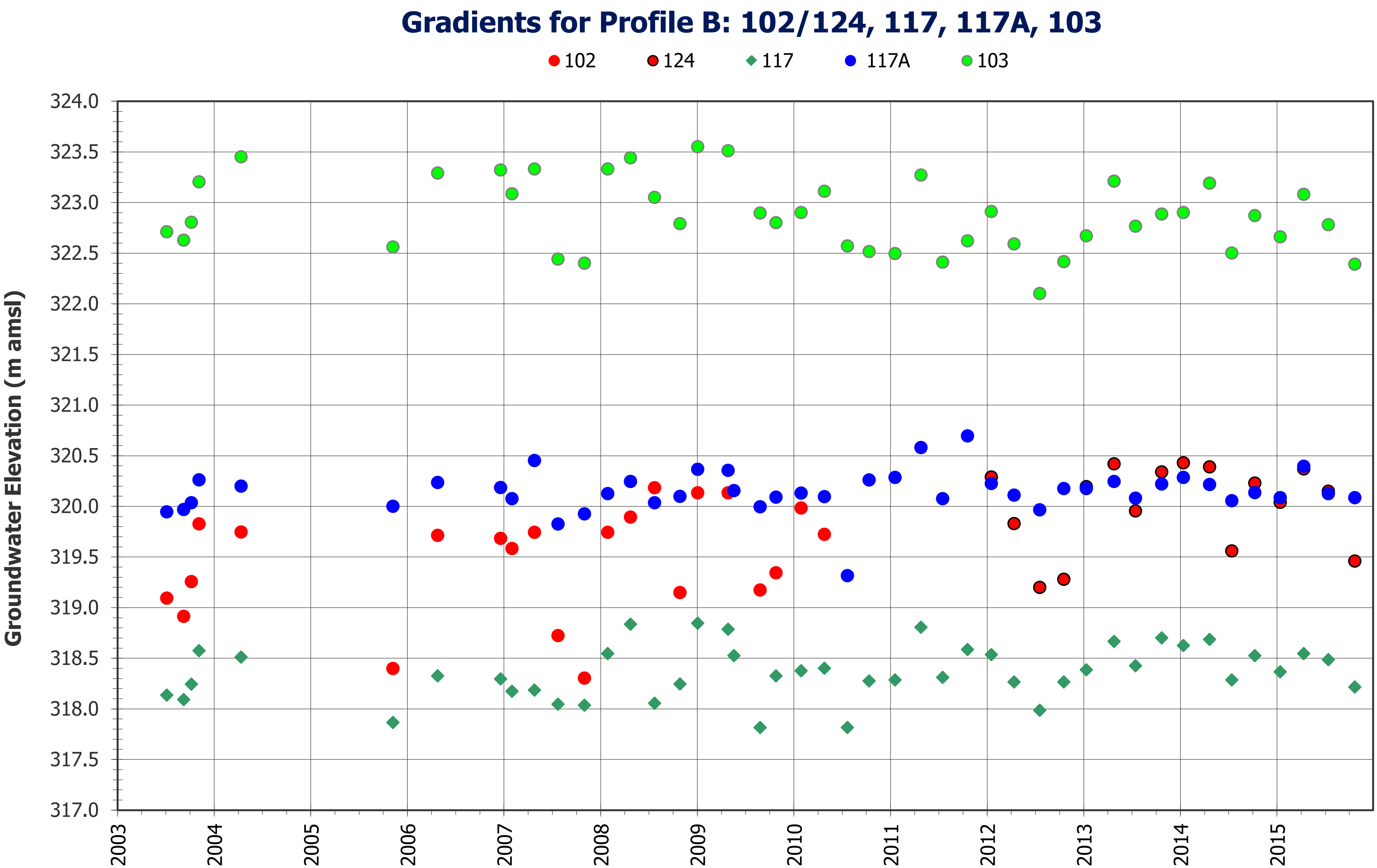
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph D 1**



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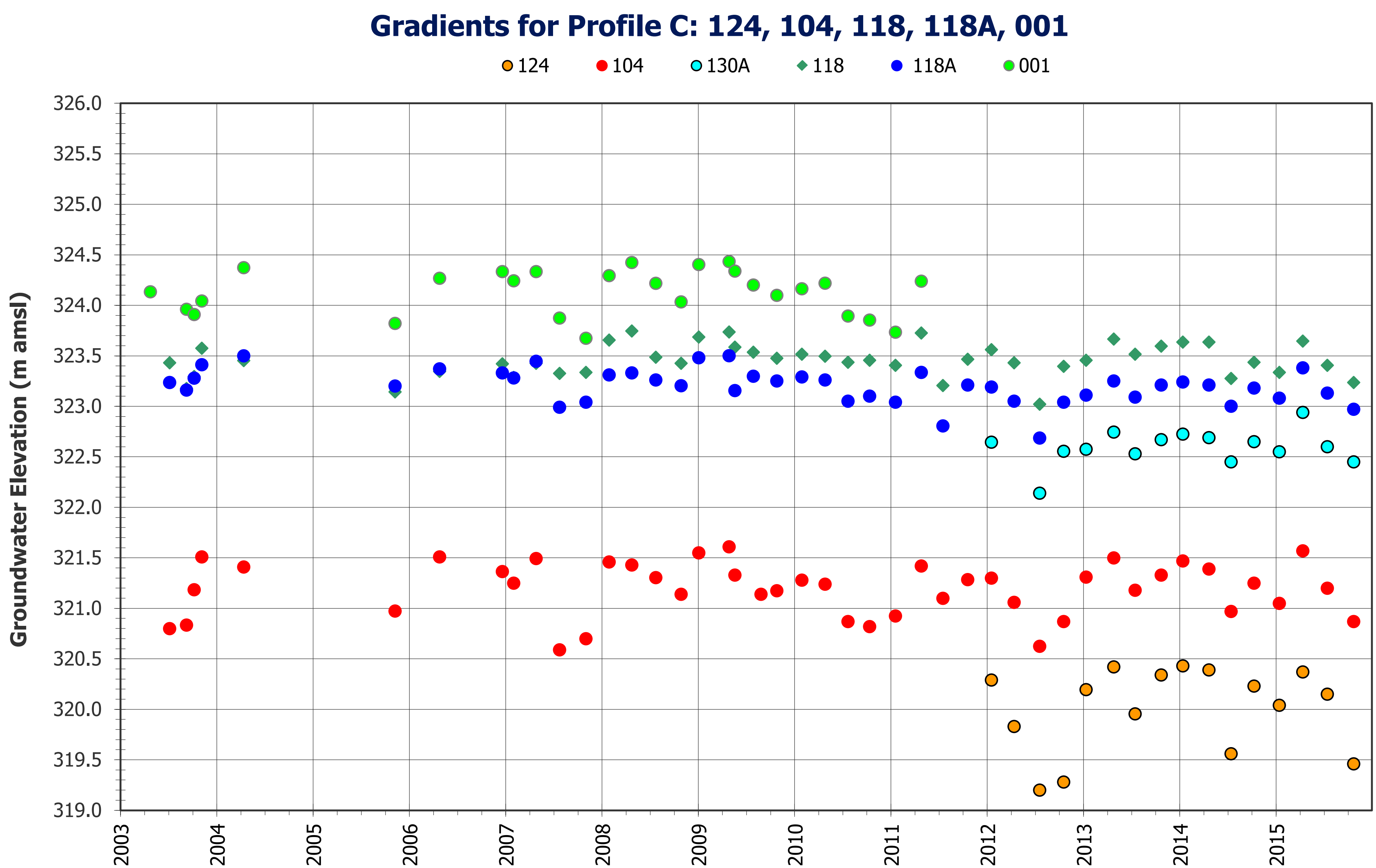
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW/Perimeter** **Graph D 2**



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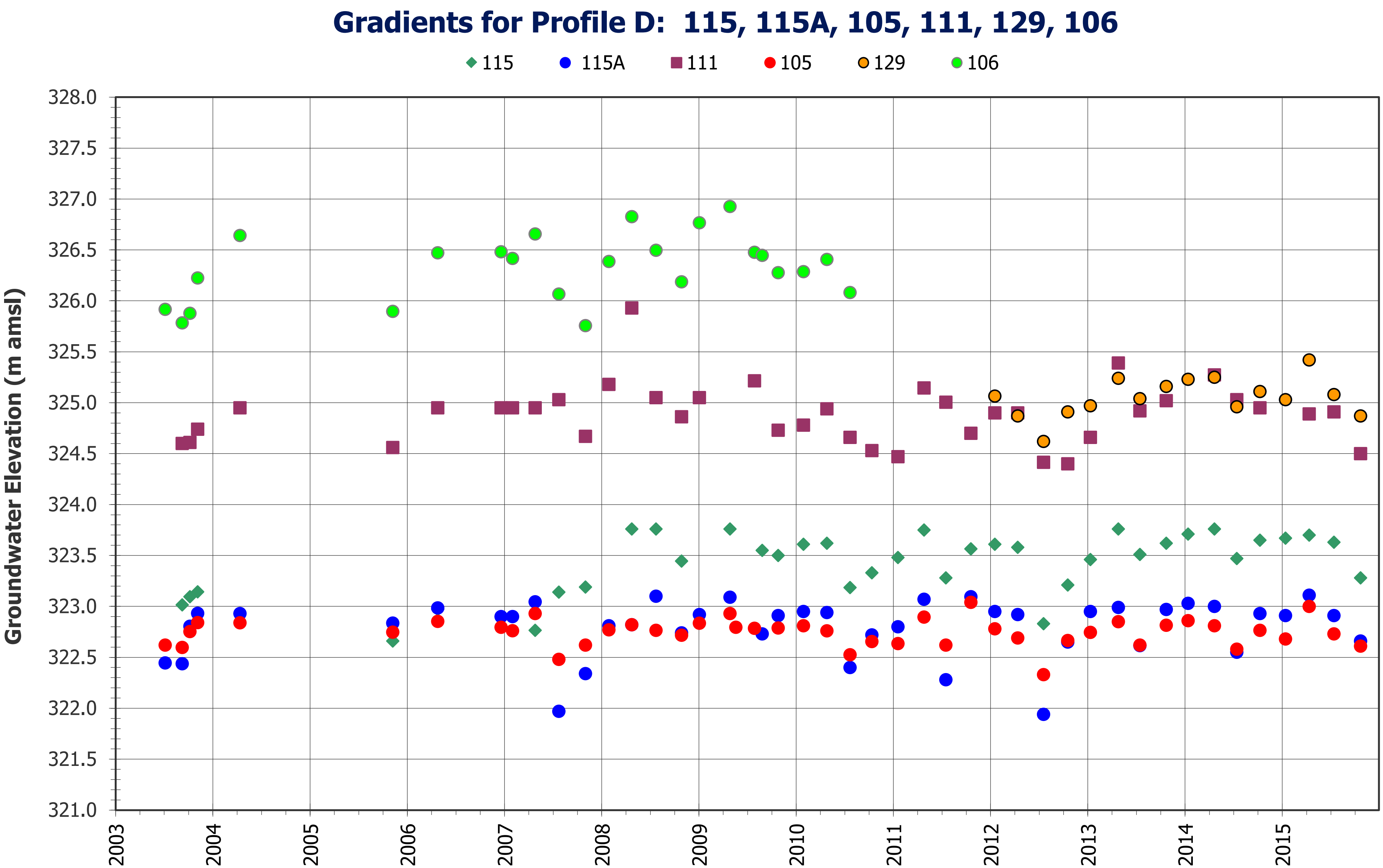
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph D 3**



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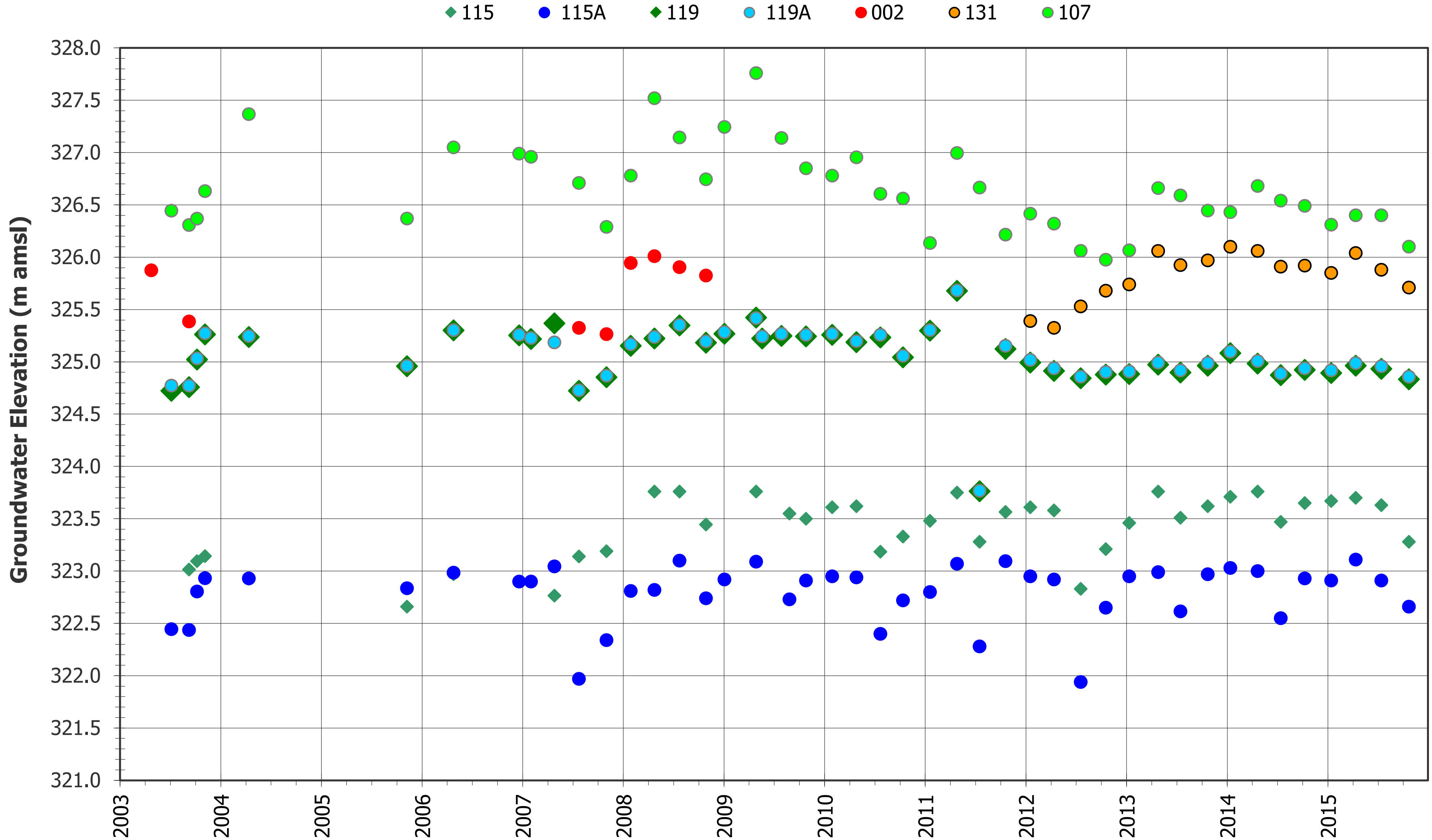
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phases 1/2 - Core PSW** **Graph D 4**

Gradients for Profile E: 115, 115A, 119, 119A, 002, 131, 107



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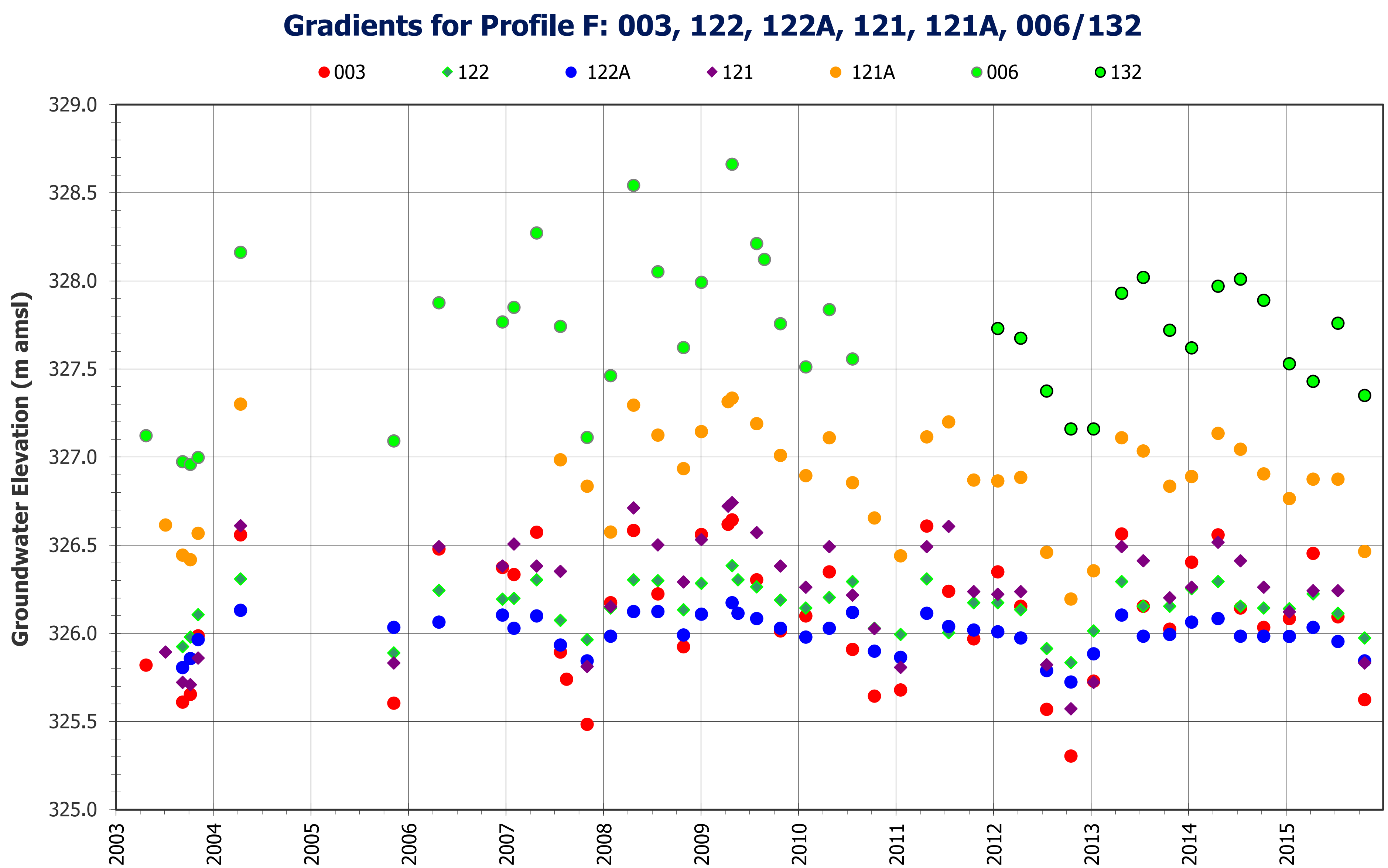
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phases 1/2 - Core PSW/Perimeter** **Graph D 5**



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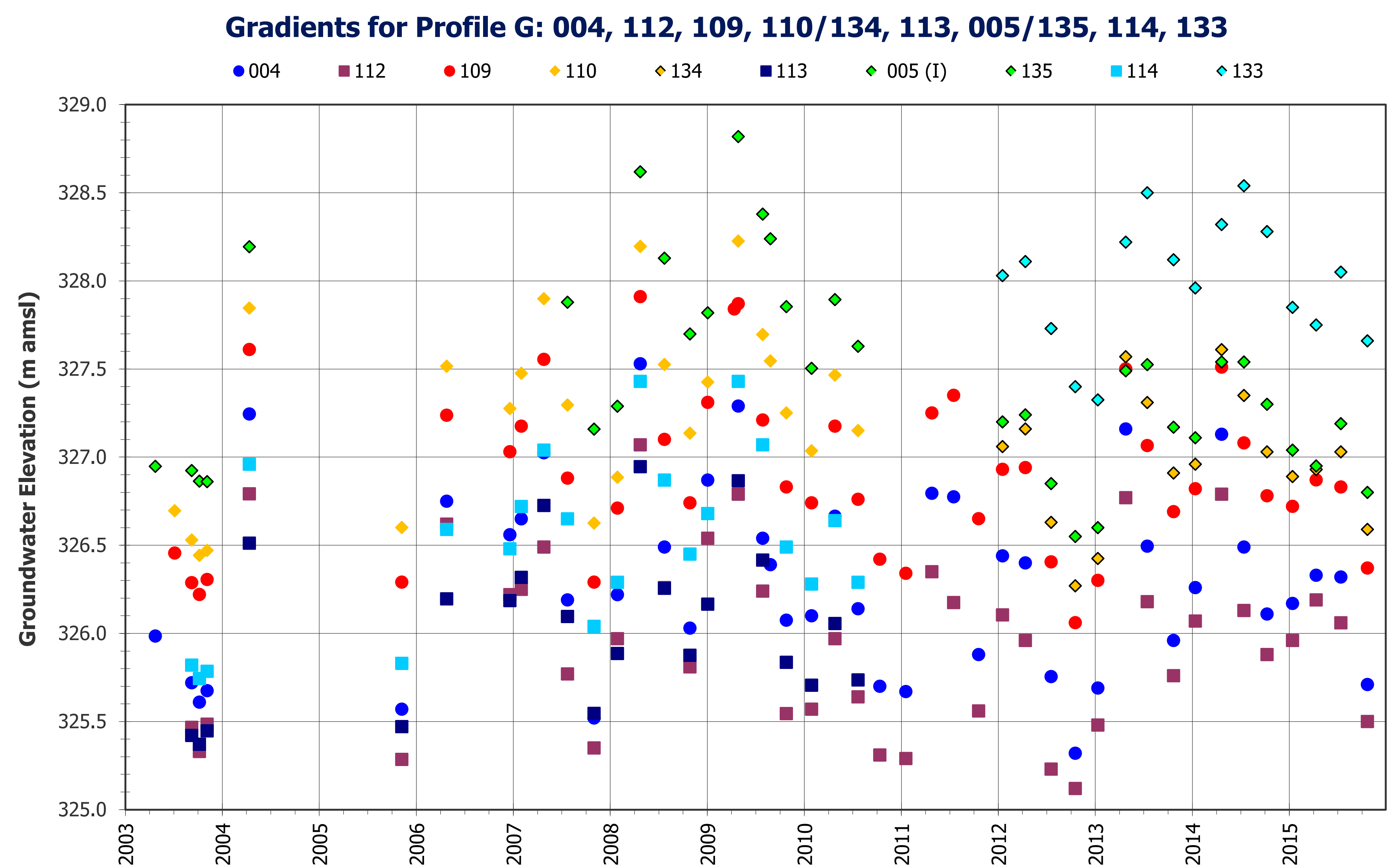
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phases 2/3 - Core PSW/Perimeter** **Graph D 6**



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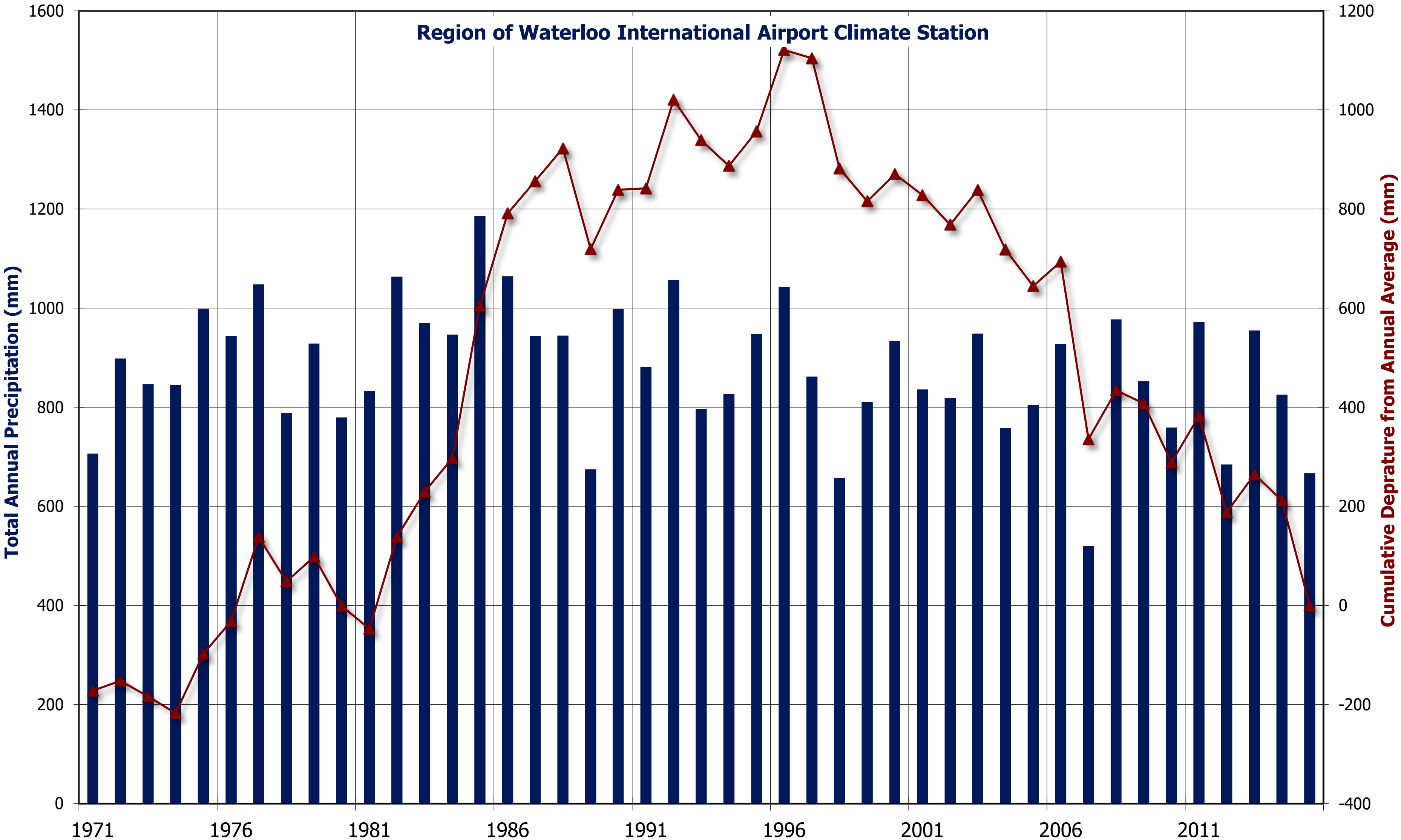
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phases 2/3 - Perimeter** **Graph D 7**

Appendix E

Climate Monitoring
1971 – 2015

Annual Precipitation & Cumulative Departure from Annual Average - 1971 to 2015



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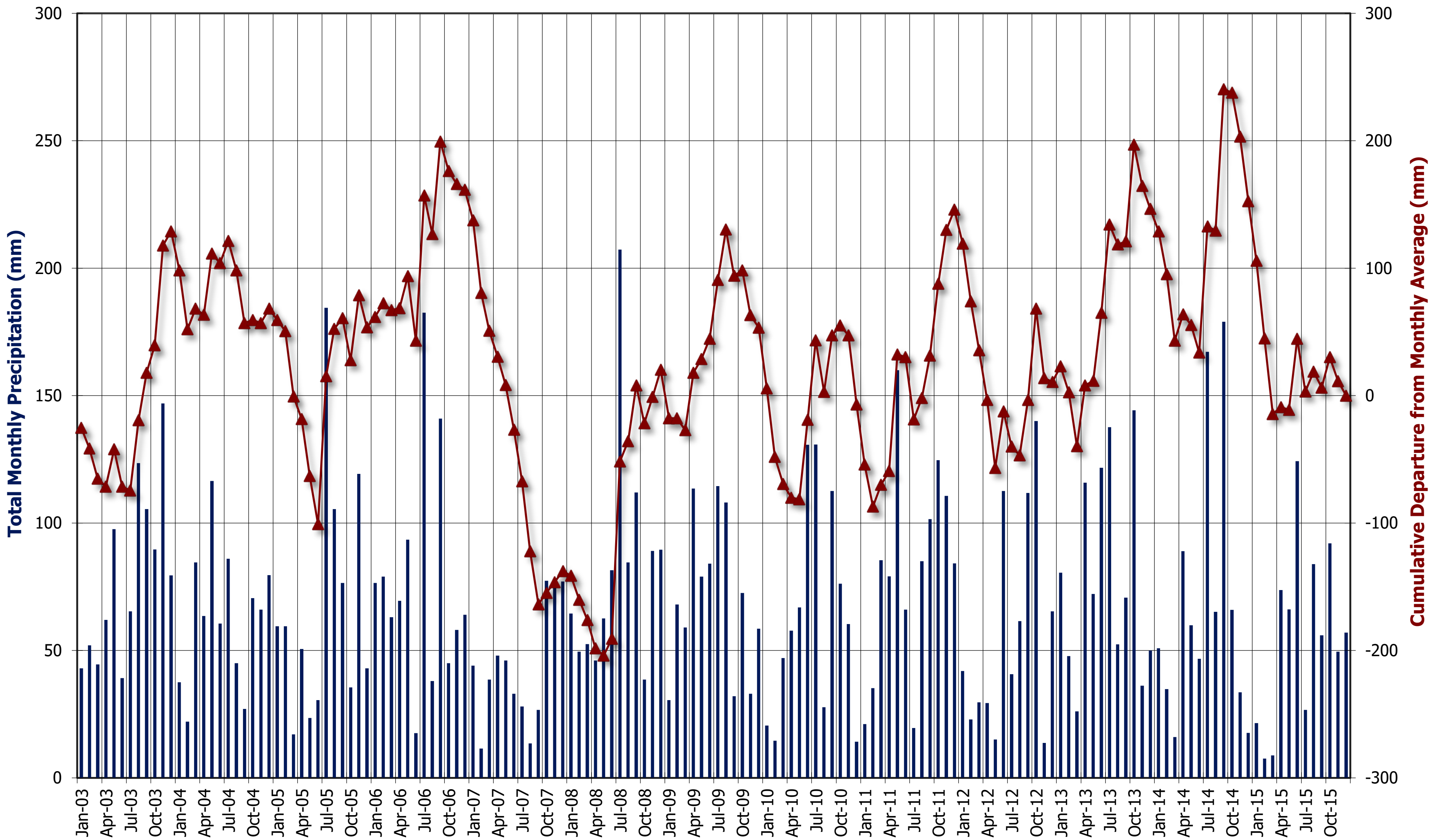
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Graph E 1**

Monthly Precipitation & Cumulative Departure from Monthly Average - 2003 to 2015



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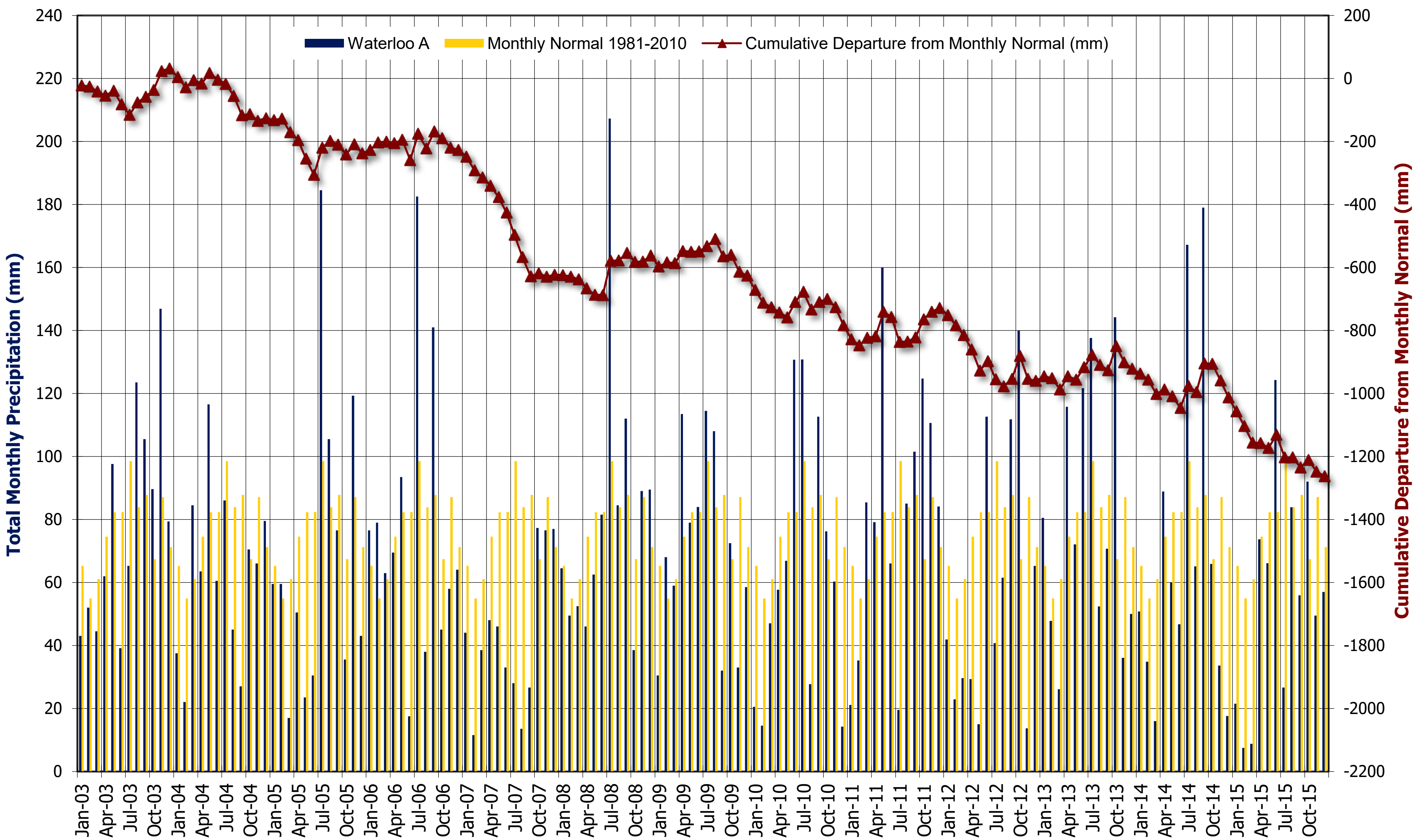
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Graph E 2**

Monthly Precipitation & Cumulative Departure from Monthly Normal - 2003 to 2015



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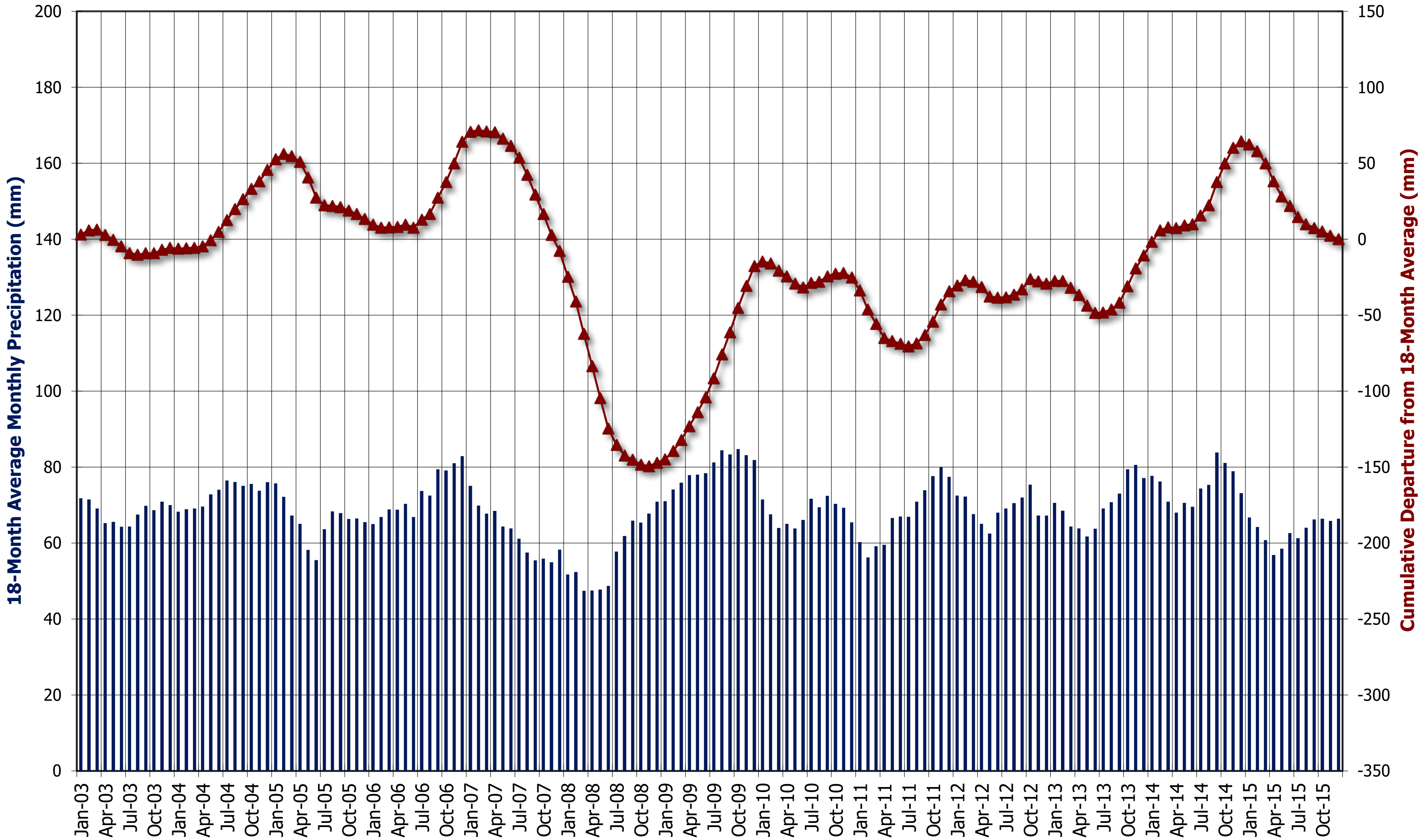
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph E 3

18-Month Average Monthly Precipitation & Cumulative Departure from 18-Month Average - 2003 to 2015



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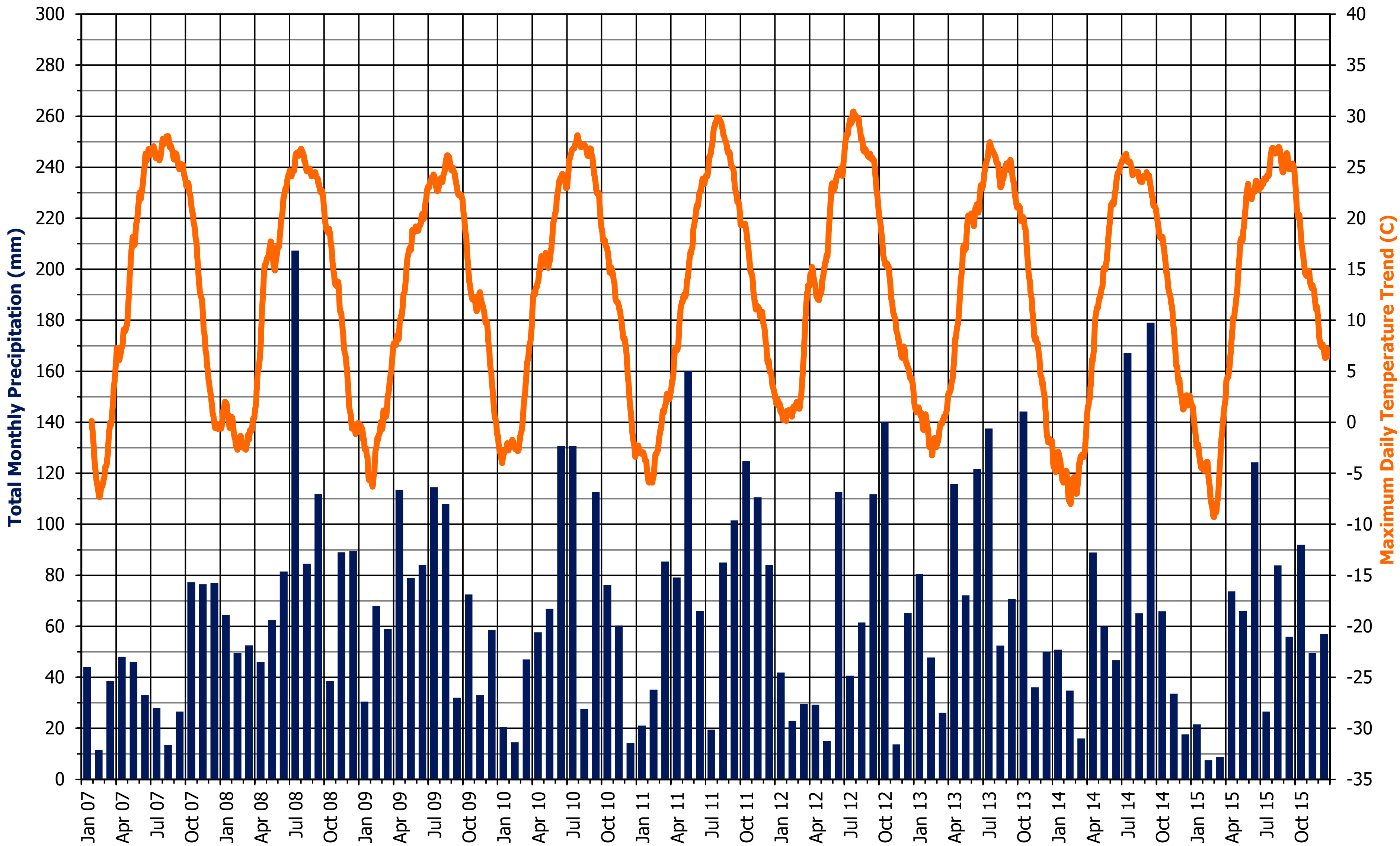
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Graph E 4**

Monthly Precipitation & Maximum Daily Temperature Trend: Waterloo Airport (January 2007 to December 2015)



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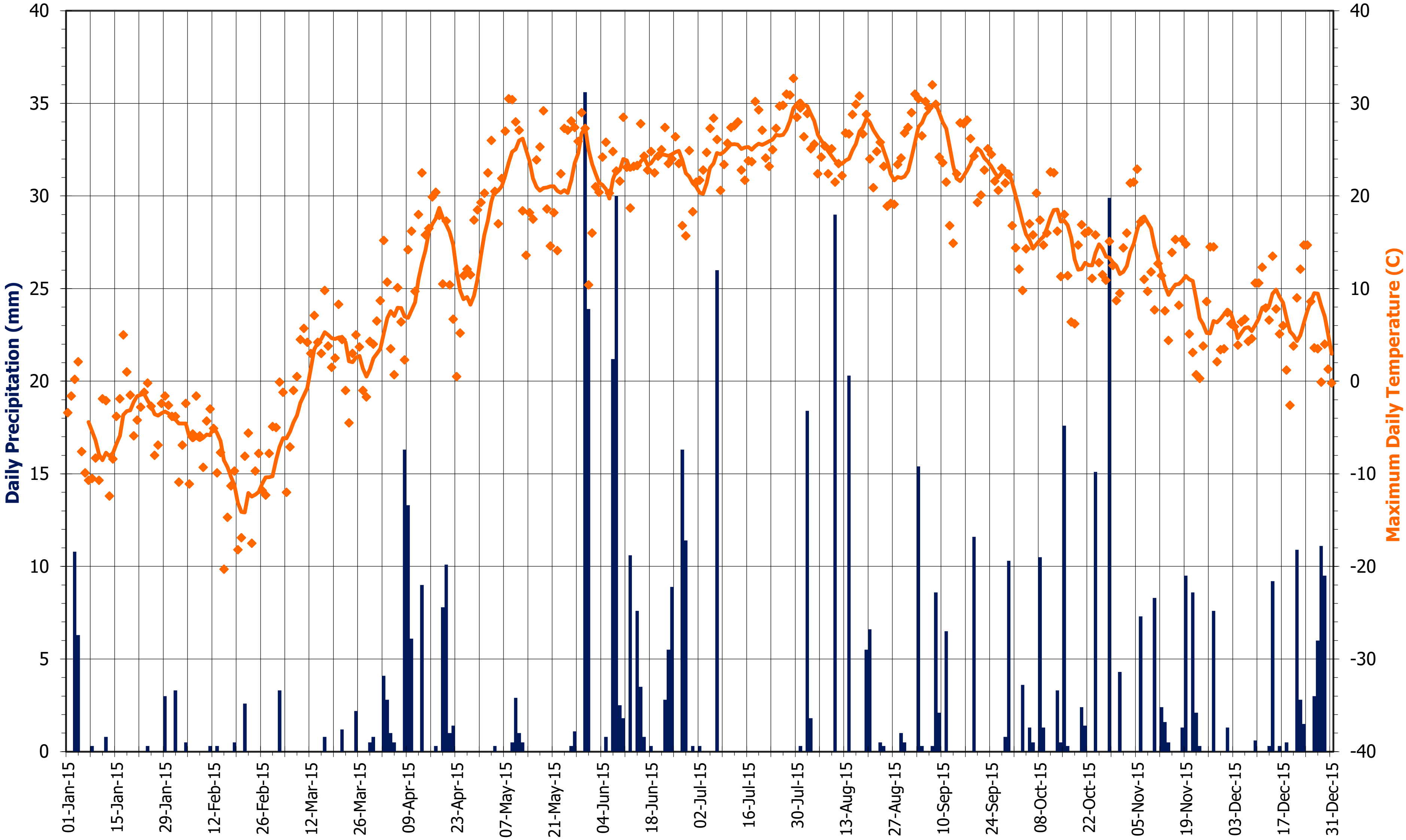
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph E 5

Daily Precipitation & Maximum Daily Temperature: Waterloo Airport (January to December 2015)



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Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph E 6

Appendix F

Downey Road PSW Groundwater Monitoring 2007 – 2015

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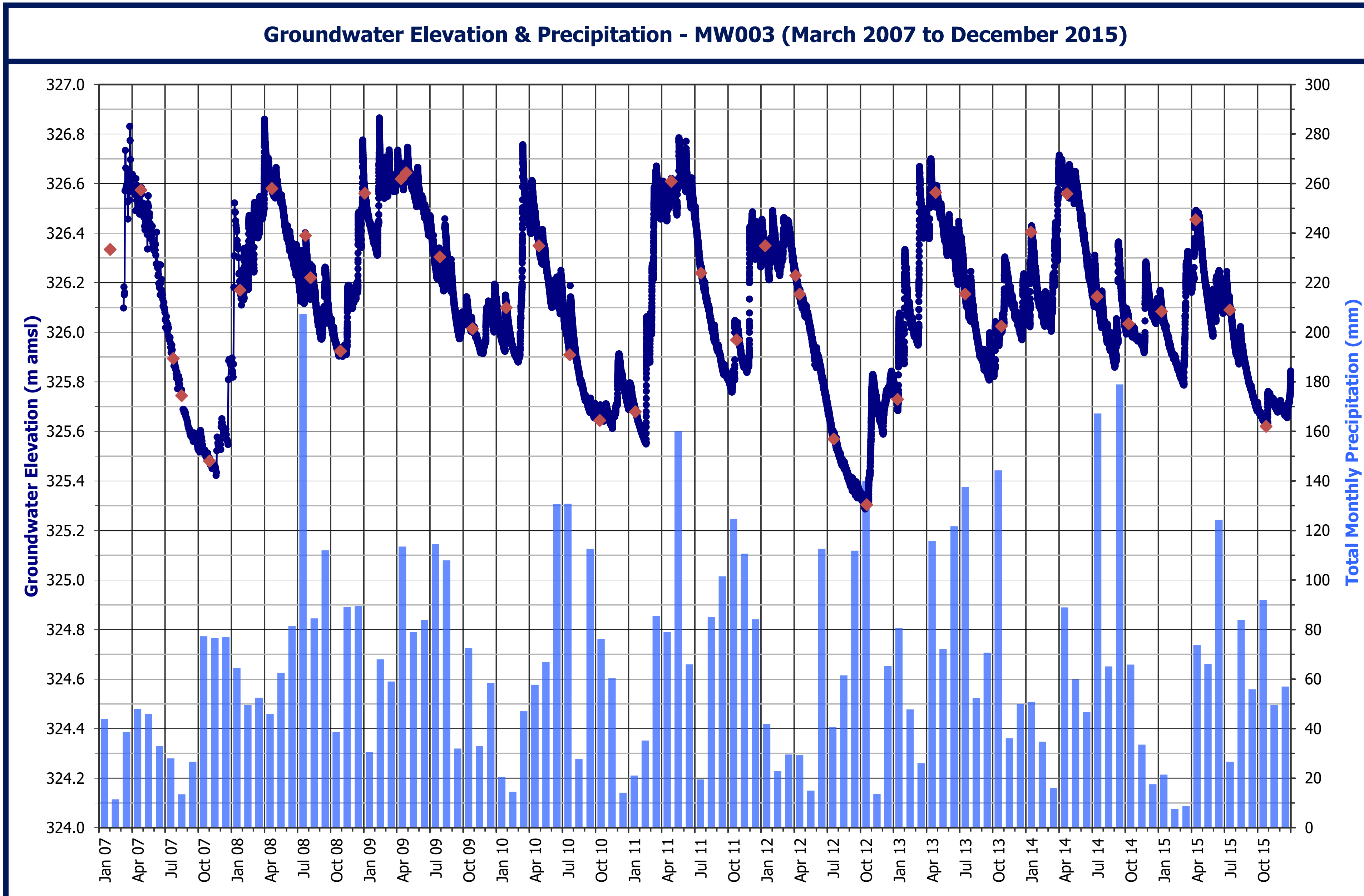

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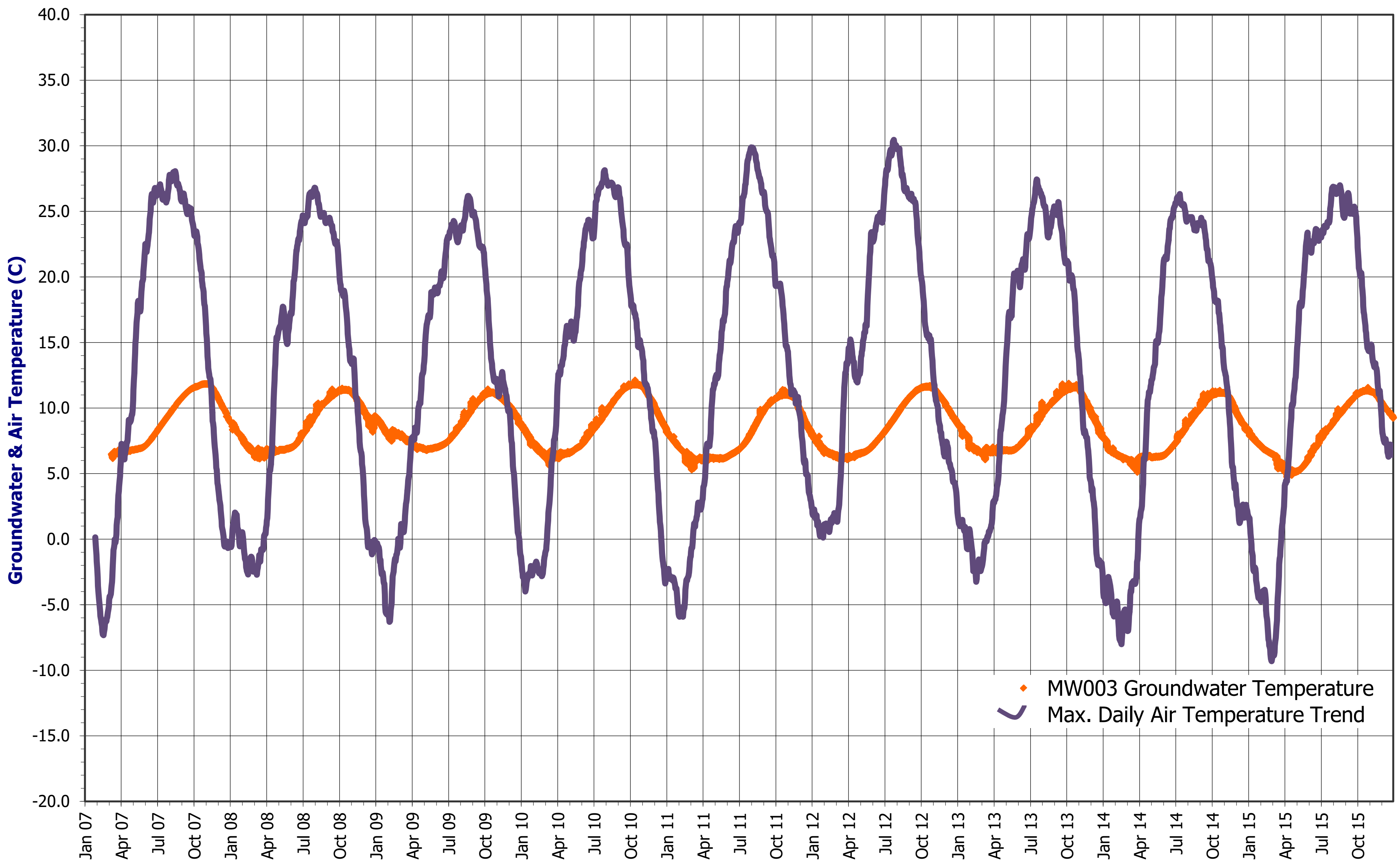
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph F 1**

Groundwater & Maximum Daily Air Temperature - MW003 (March 2007 to December 2015)



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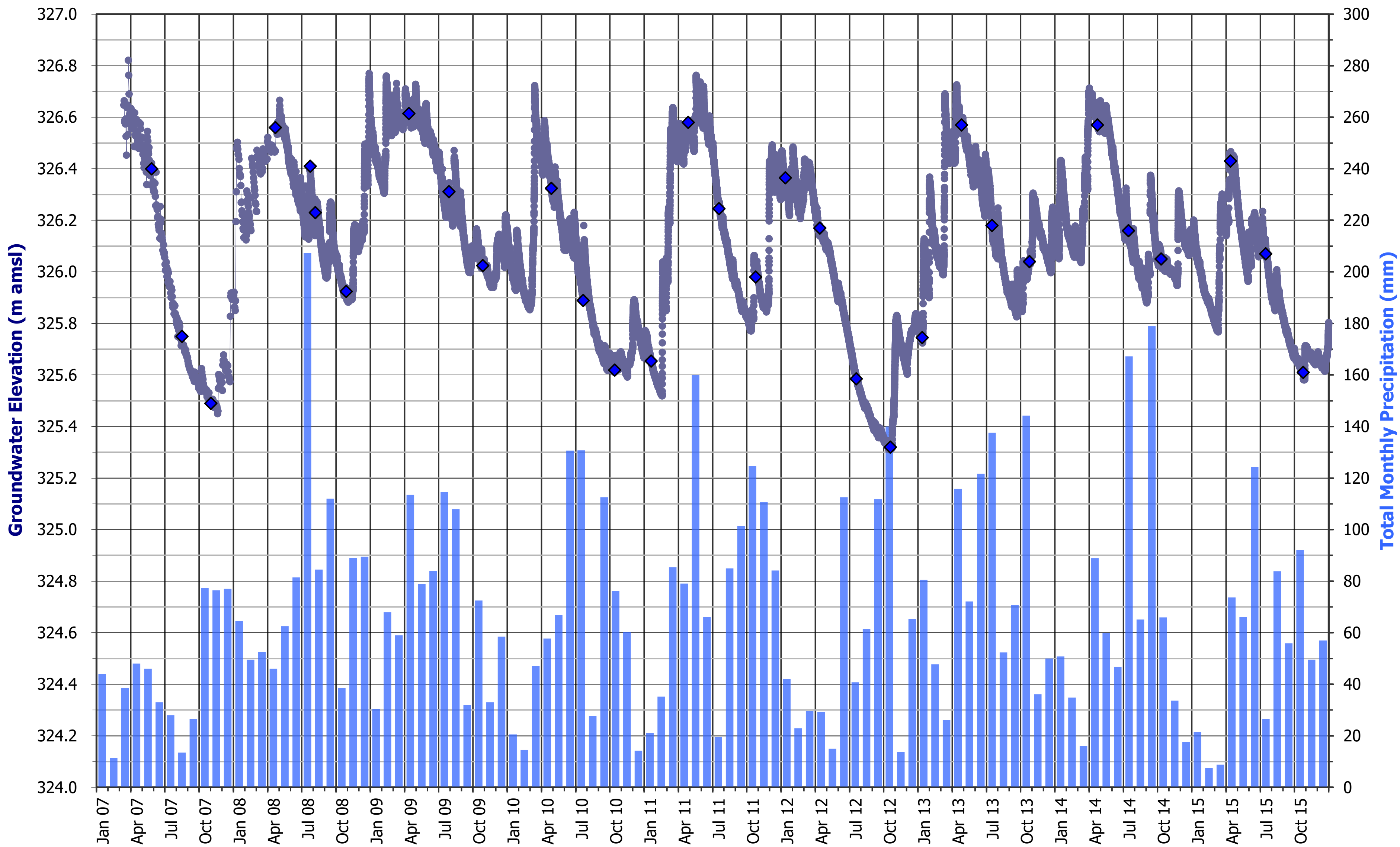
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph F 1a**

Groundwater Elevation & Precipitation - PZ-9D (March 2007 to December 2015)



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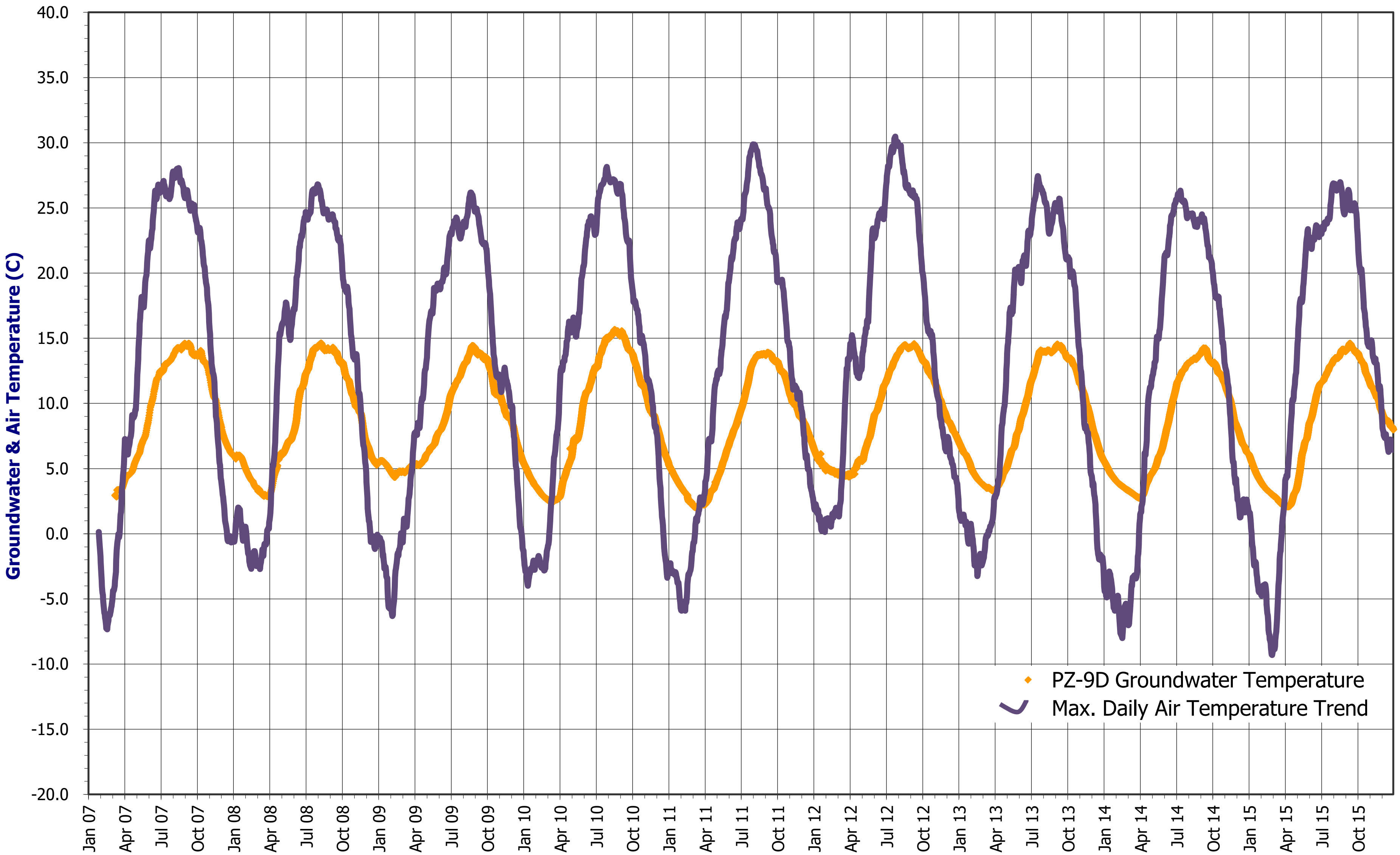
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph F 2**

Groundwater & Maximum Daily Air Temperature - PZ-9D (March 07 to December 15)



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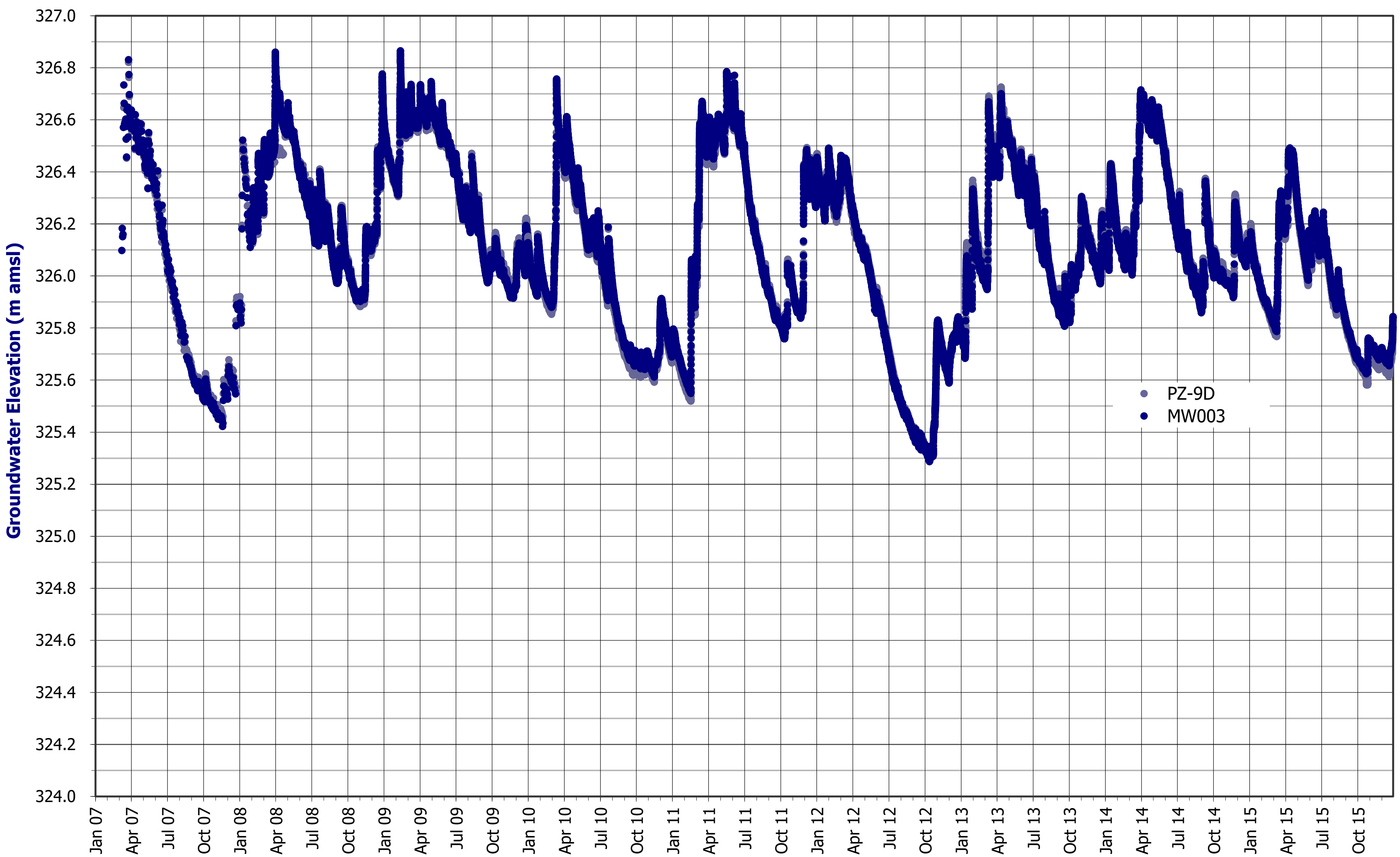
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph F 2a**

Groundwater Elevation: MW003 & PZ-9D (March 2007 to December 2015)



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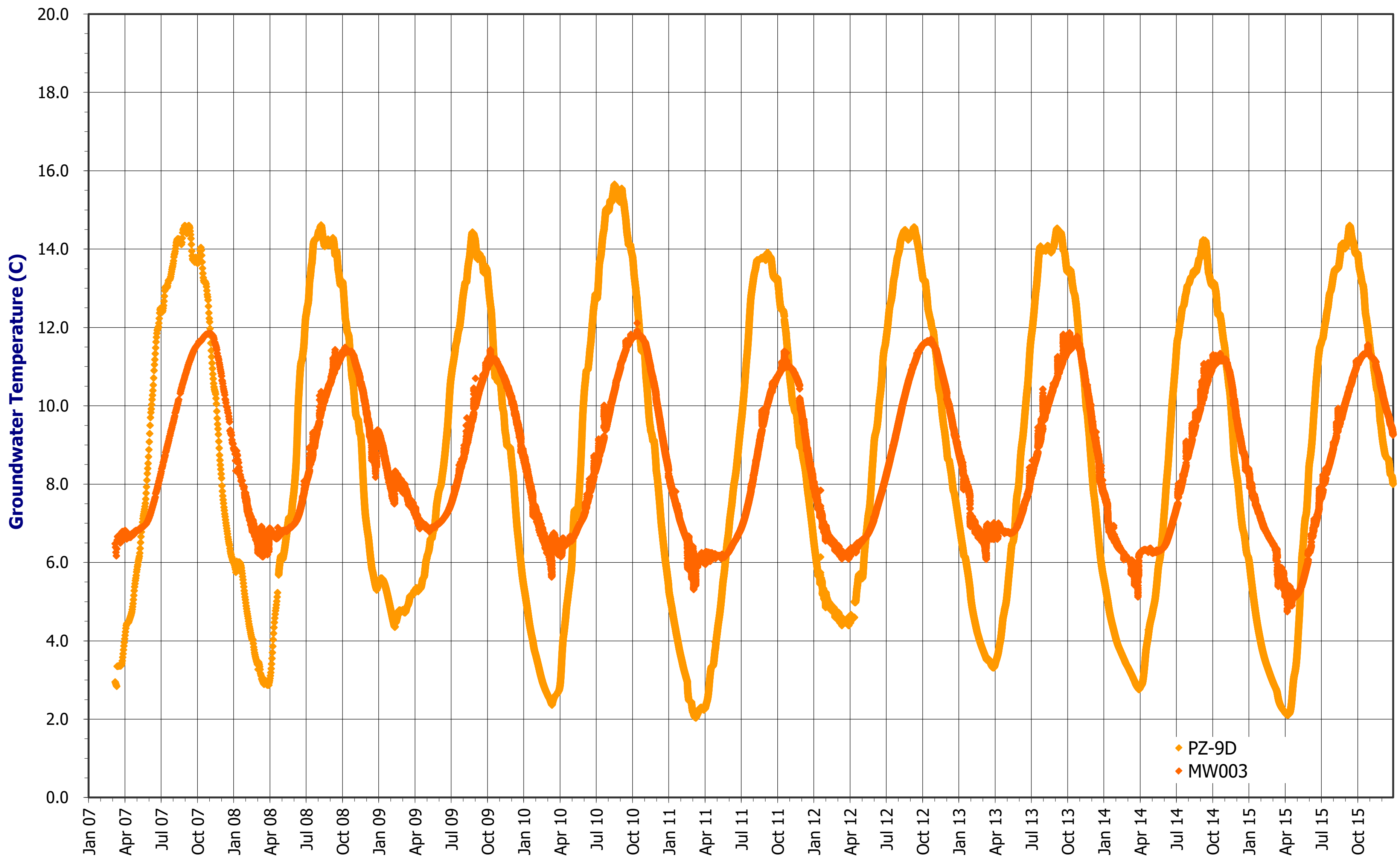
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph F 3**

Groundwater Temperature - MW003 & PZ-9D (March 07 to December 15)



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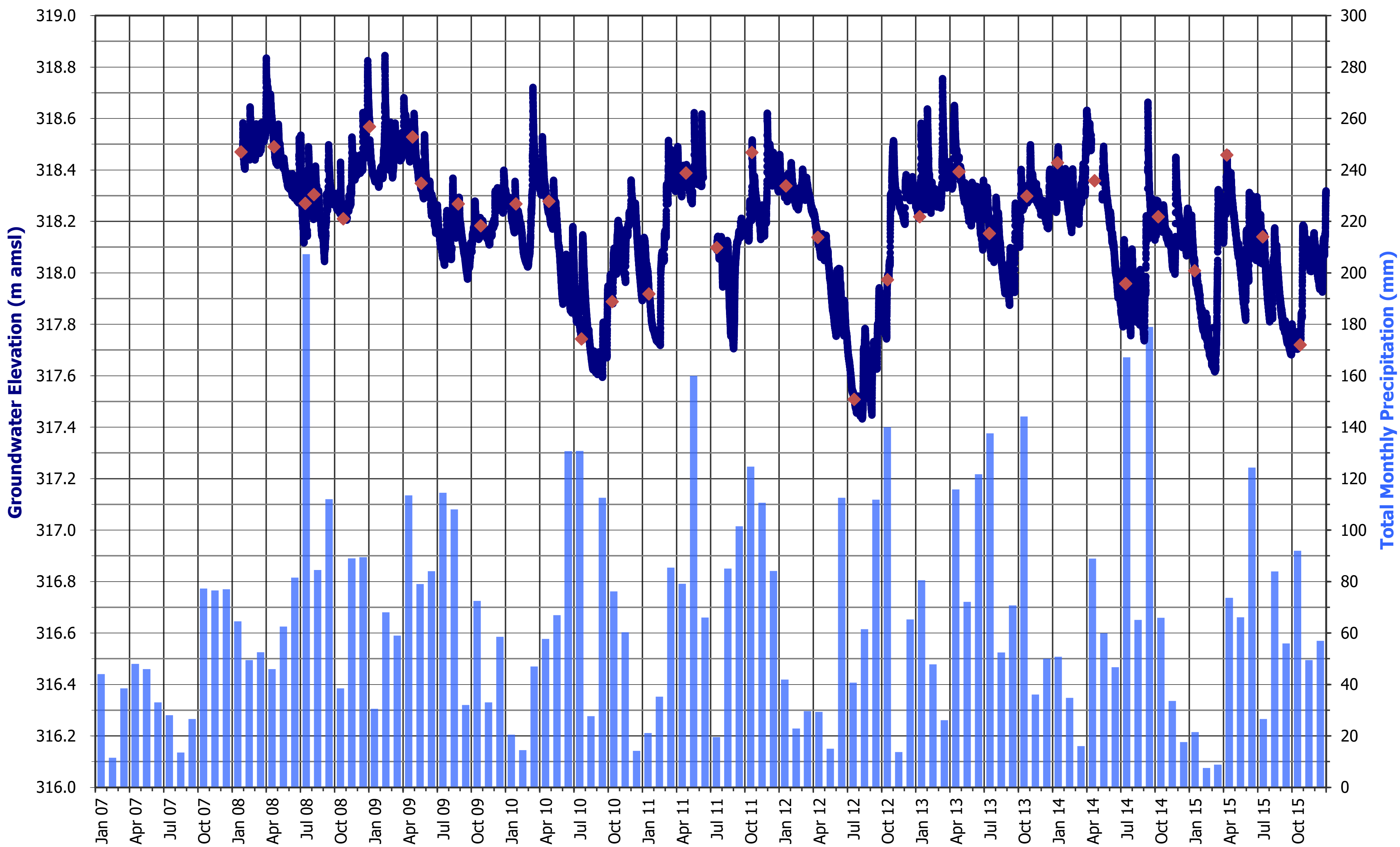
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Downey Rd. PSW** **Graph F 3a**

Appendix G

HCBP Core PSW Groundwater Monitoring
2007 – 2015

Groundwater Elevation & Precipitation - MW116A (January 2008 to December 2015)



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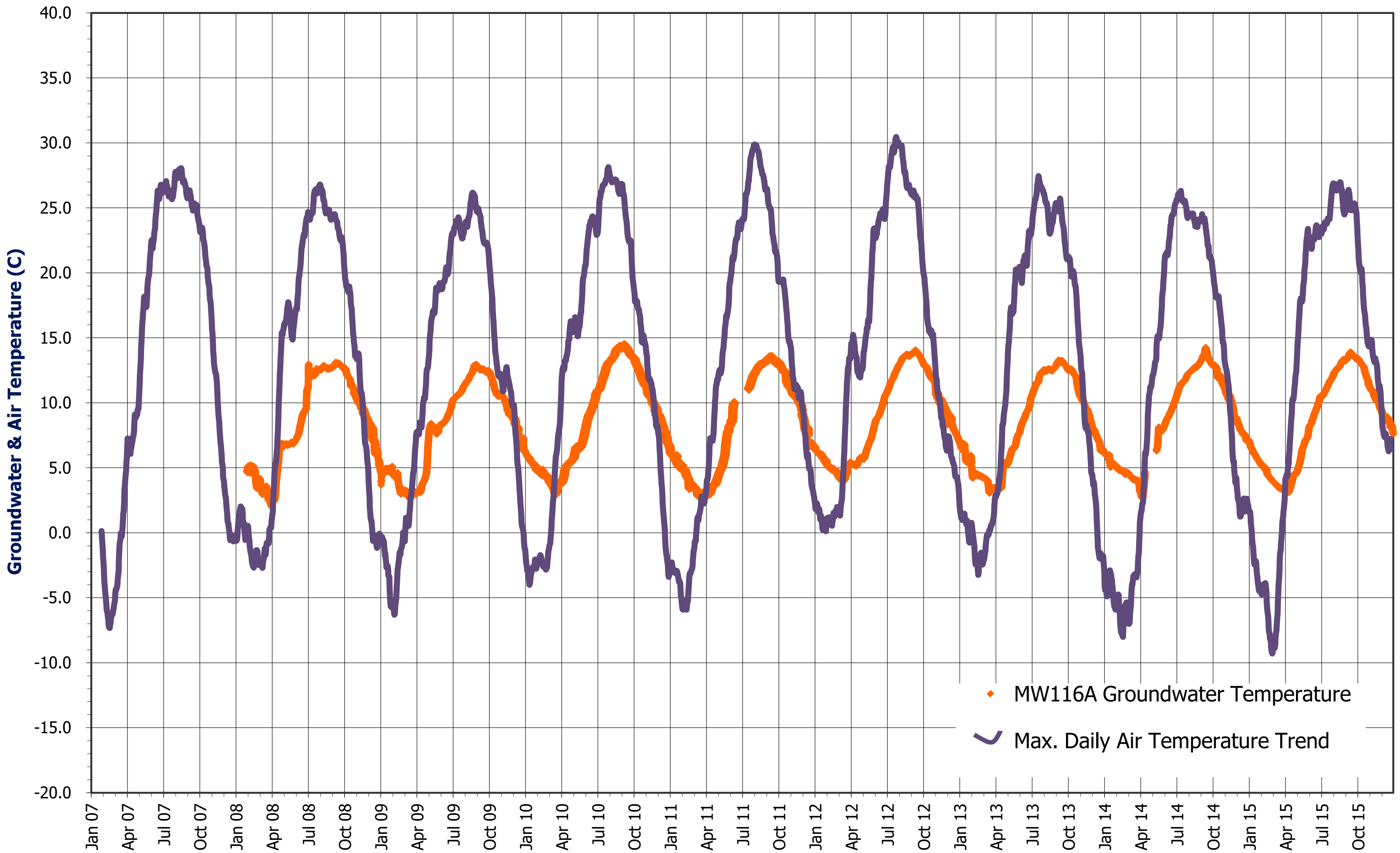
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 1**

Groundwater & Maximum Daily Air Temperature - MW116A (January 2008 to December 2015)



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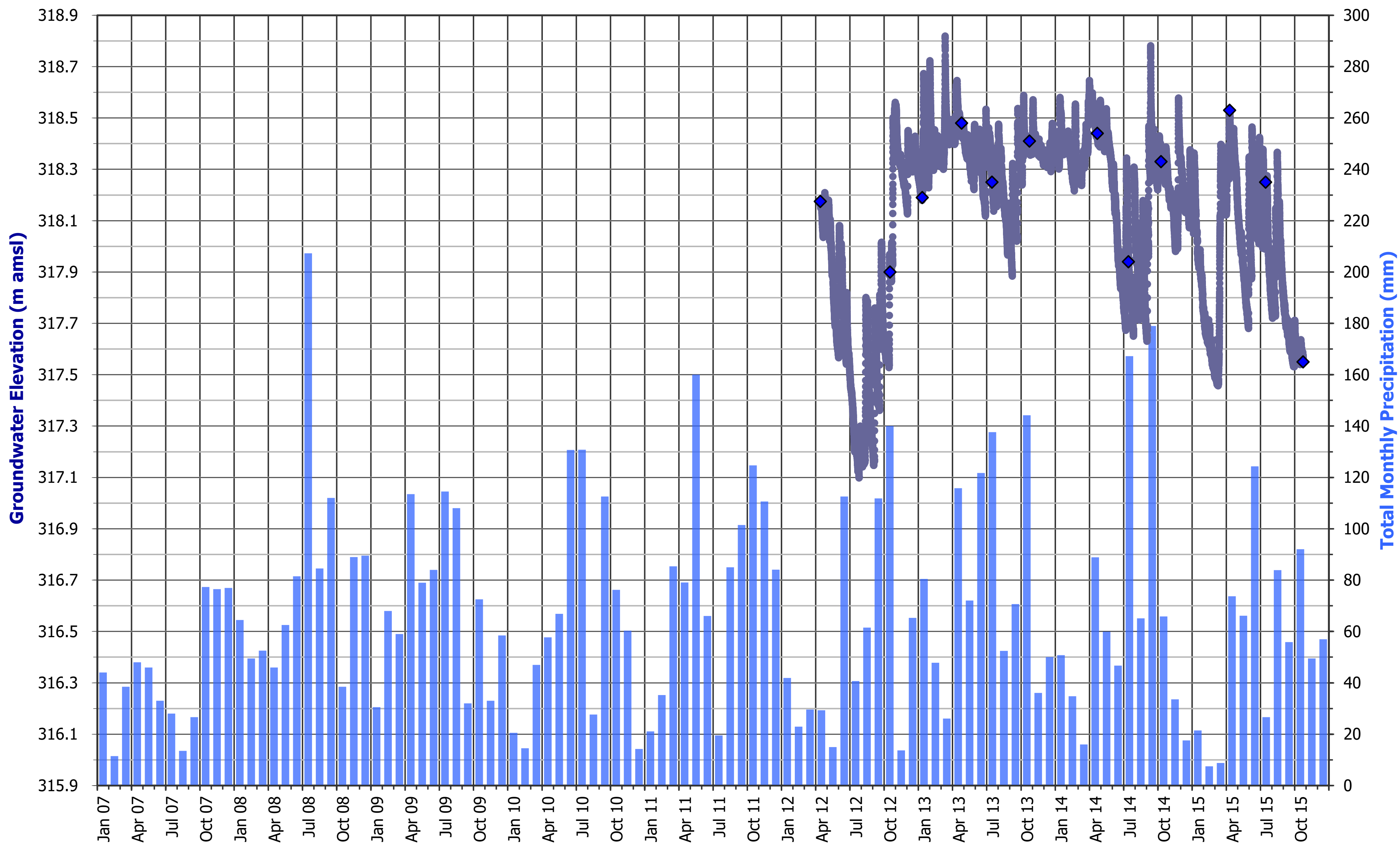
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Phase 1 - Core PSW Graph G 1a

Groundwater Elevation & Precipitation - PZ-10D (April 2012 to December 2015)



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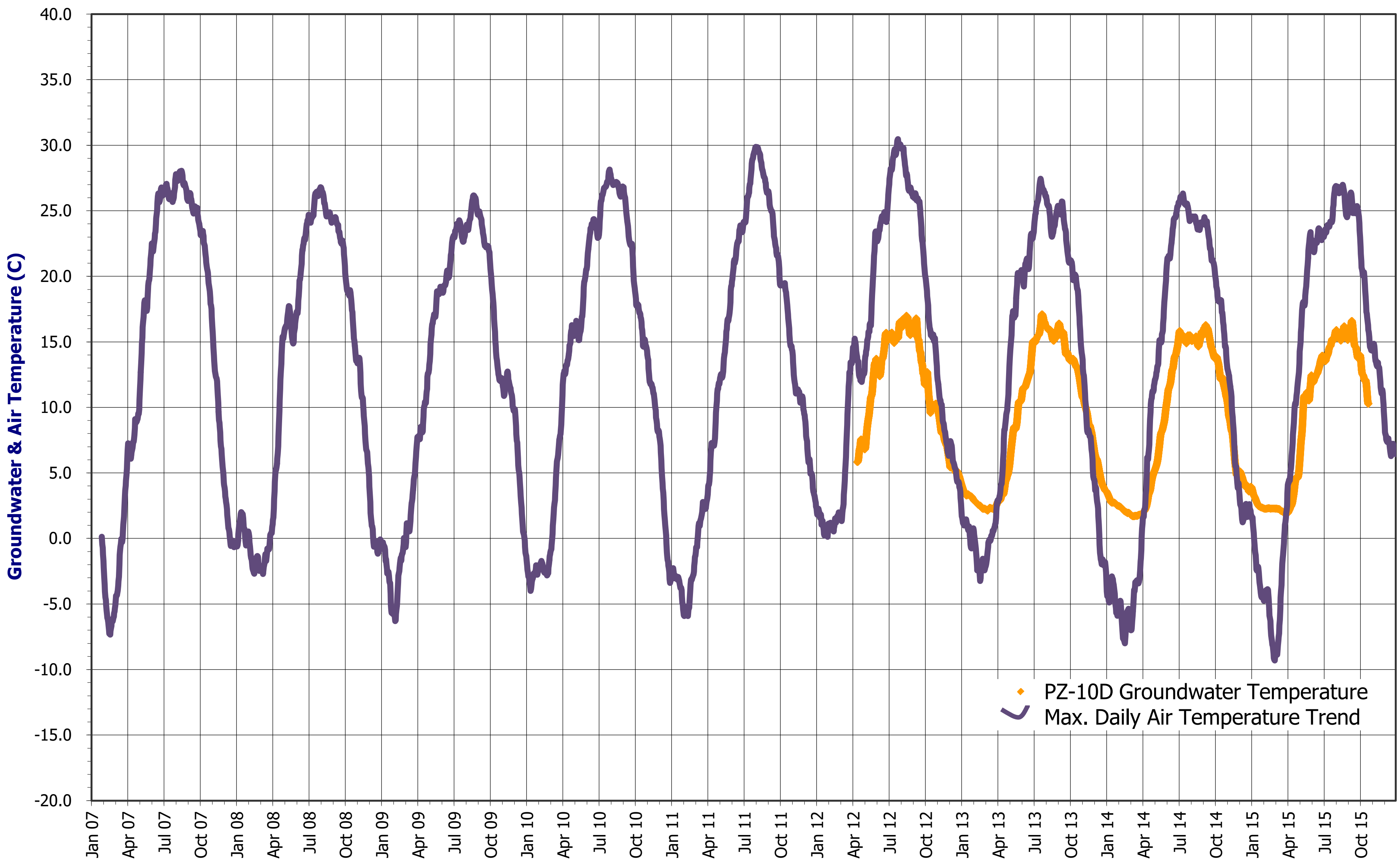
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Phase 1 - Core PSW Graph G 2

Groundwater & Maximum Daily Air Temperature - PZ-10D (April 2012 to December 2015)



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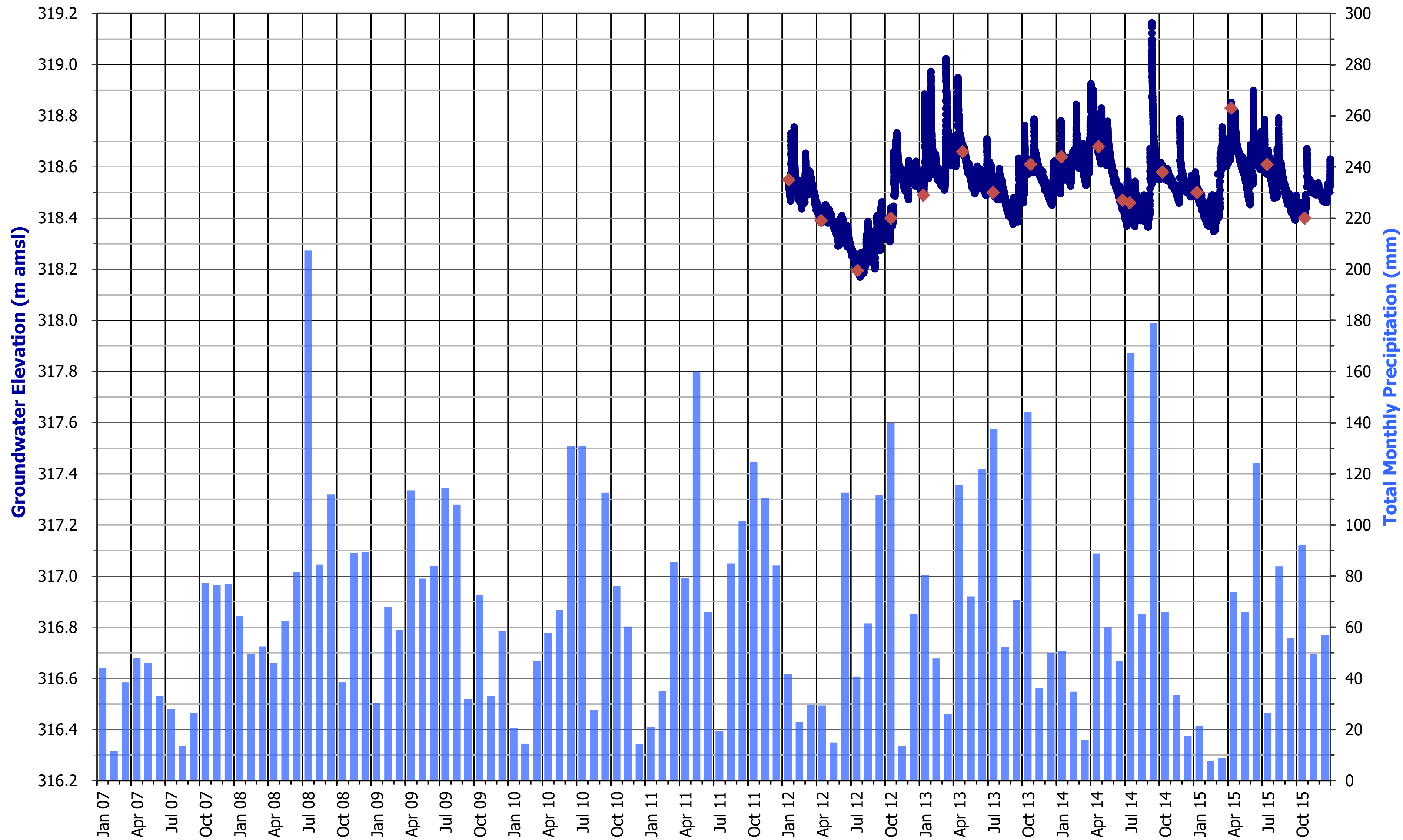
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 2a**

Groundwater Elevation & Precipitation - MW127 (January 2012 to December 2015)



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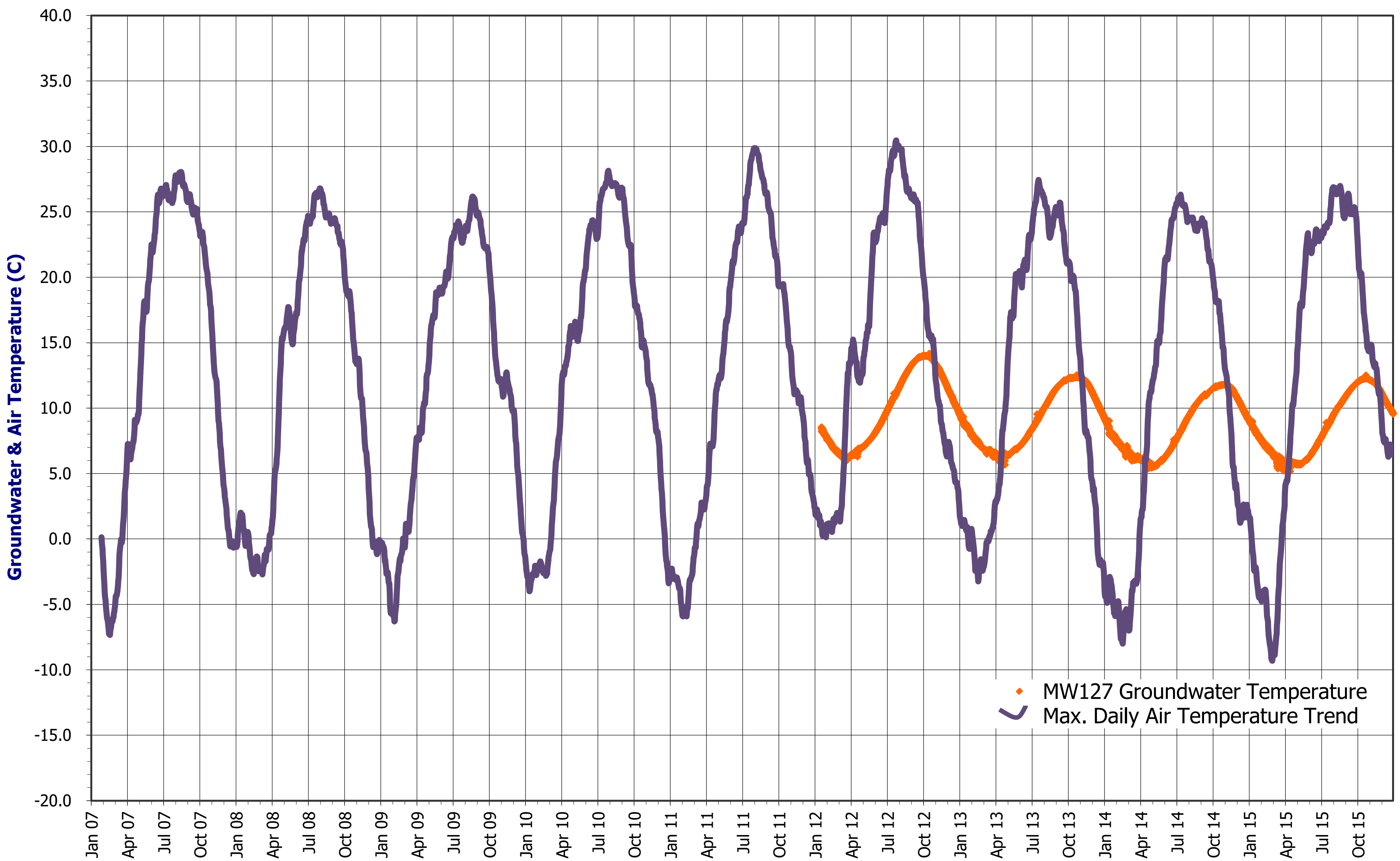
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 3**

Groundwater & Maximum Daily Air Temperature - MW127 (January 2012 to December 2015)



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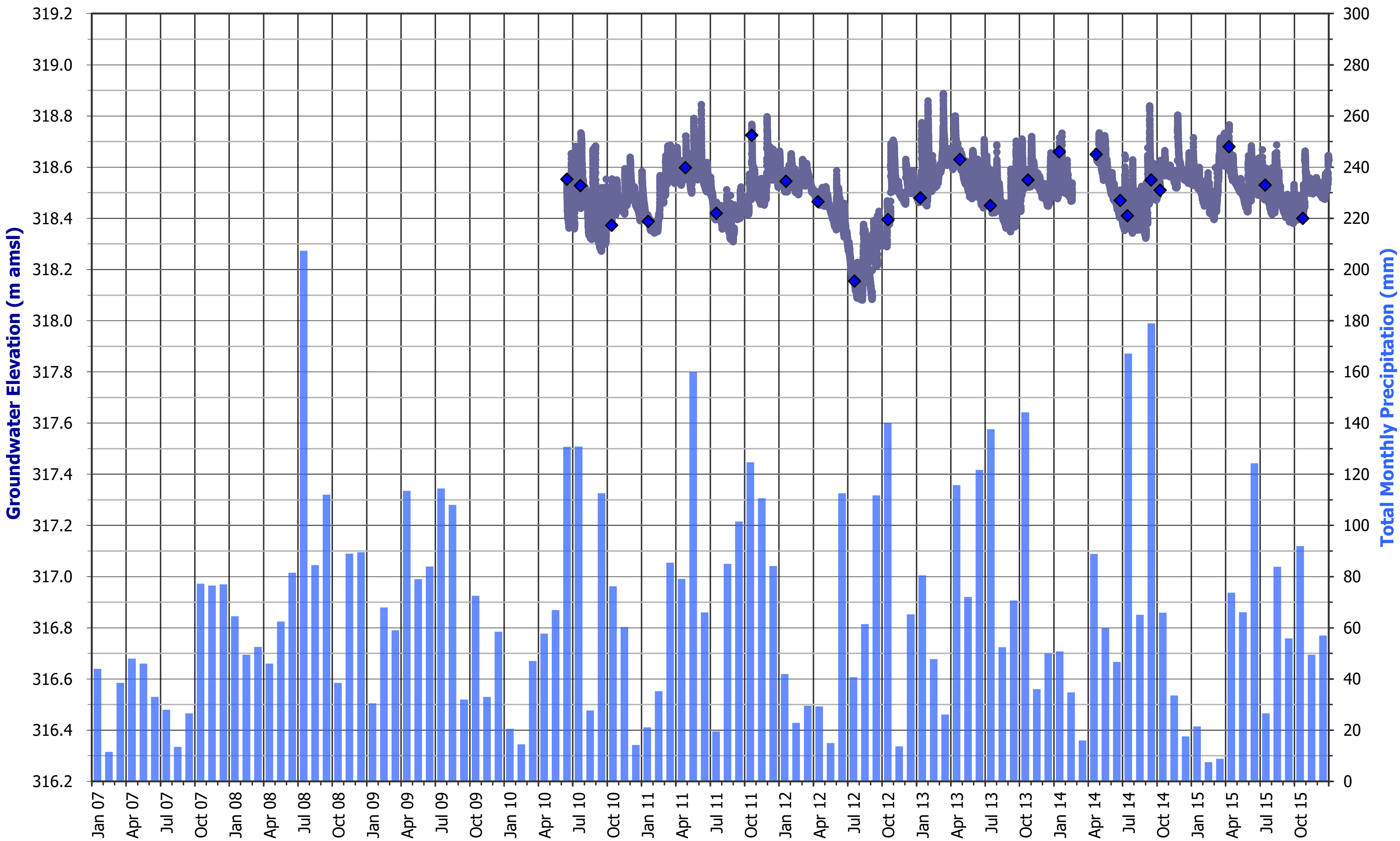
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 3a**

Groundwater Elevation & Precipitation - PZ-8D (June 2010 to December 2015)



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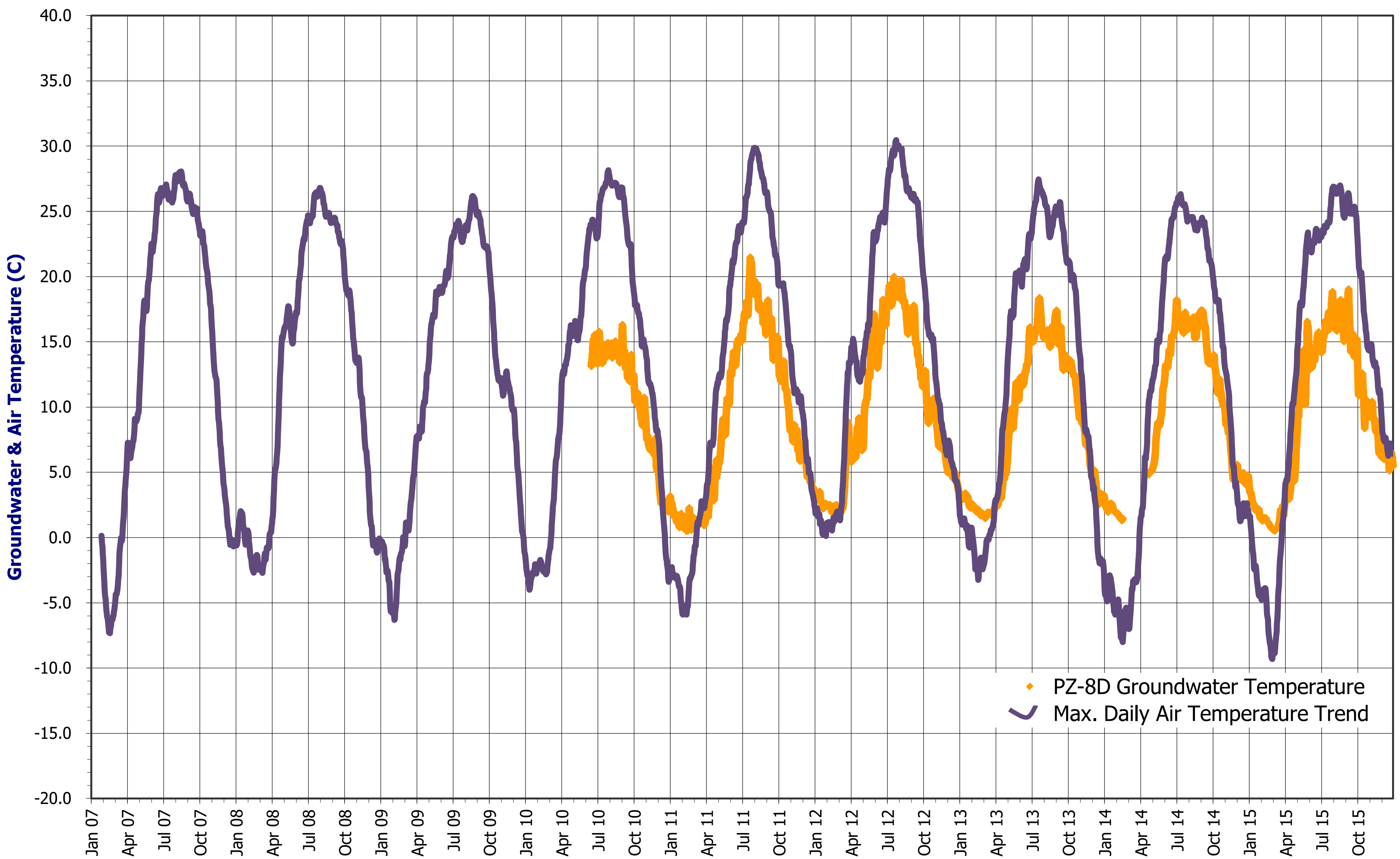
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 4**

Groundwater & Maximum Daily Air Temperature - PZ-8D (June 2010 to December 2015)



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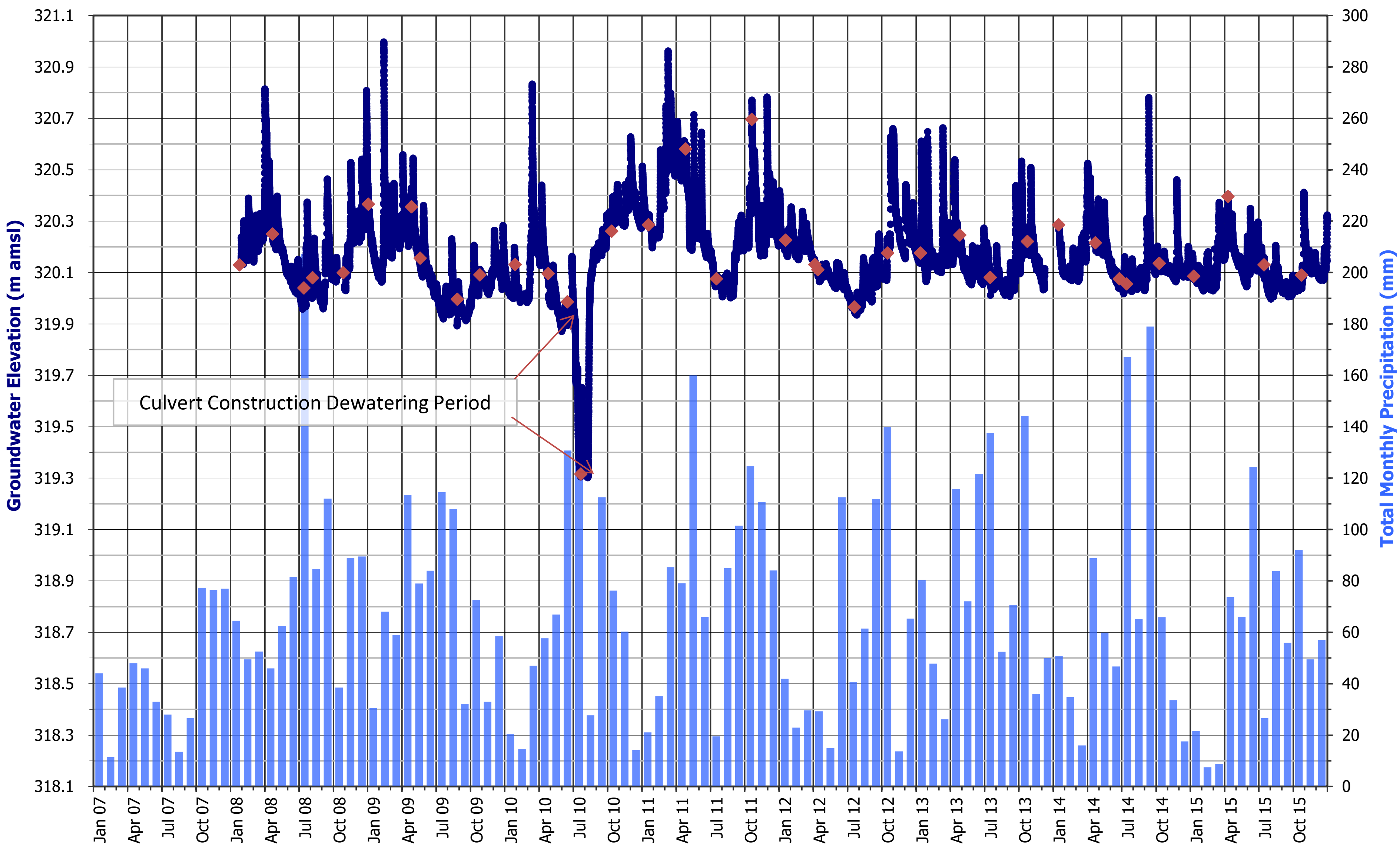
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 4a**

Groundwater Elevation & Precipitation - MW117A (January 2008 to December 2015)



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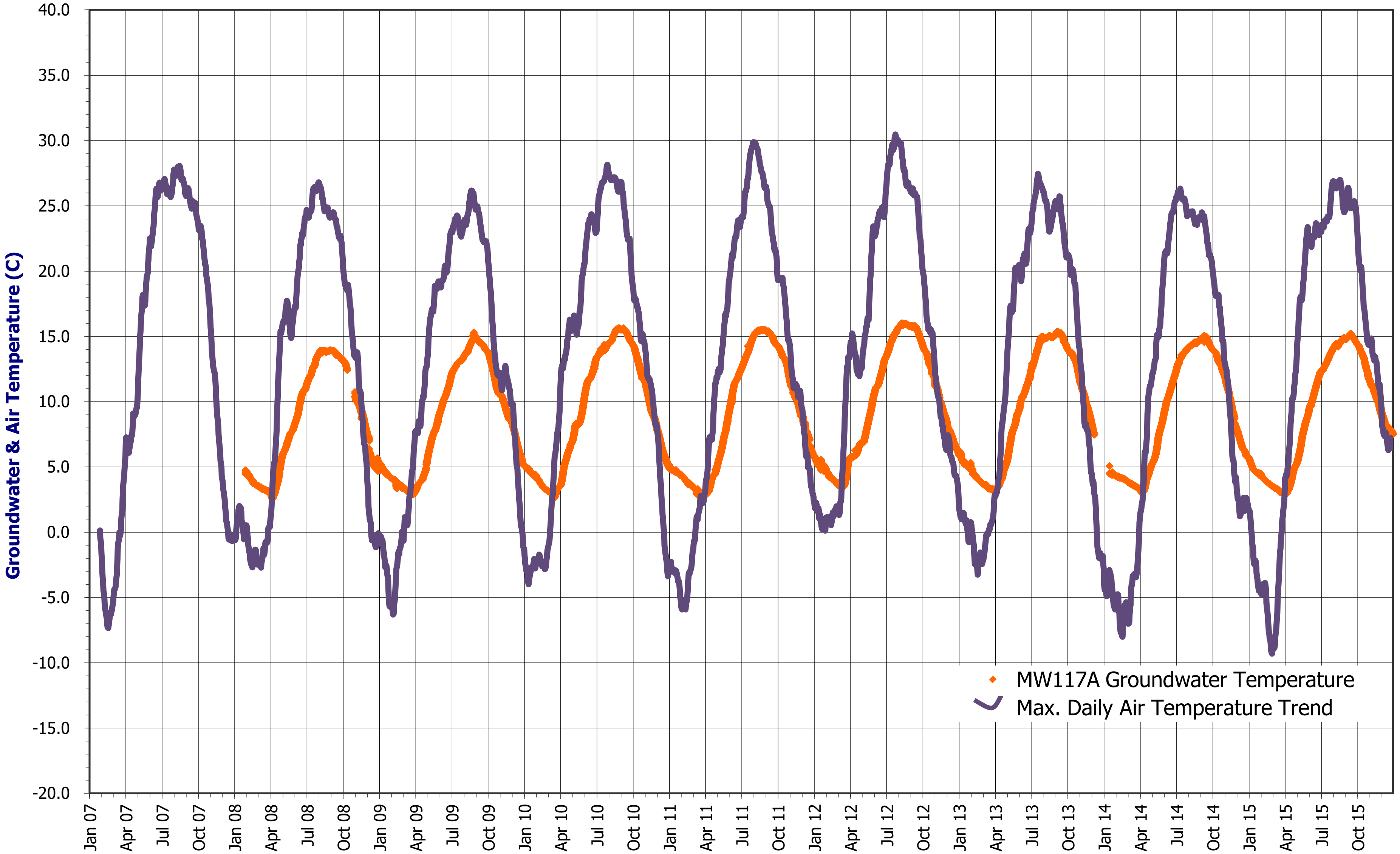
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 5**

Groundwater & Maximum Daily Air Temperature - MW117A (January 2008 to December 2015)



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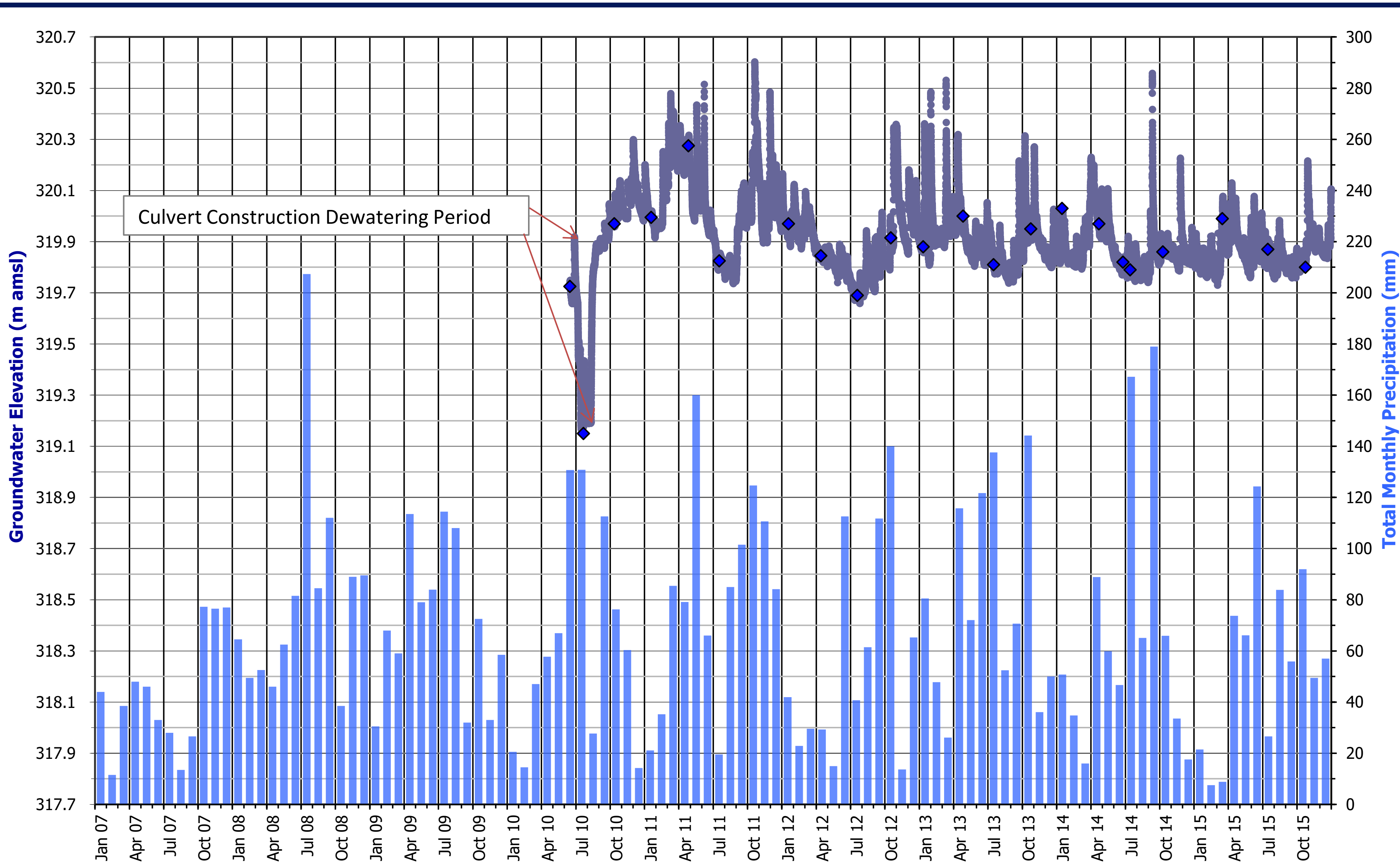
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 5a**

Groundwater Elevation & Precipitation - PZ-11D (June 2010 to December 2015)



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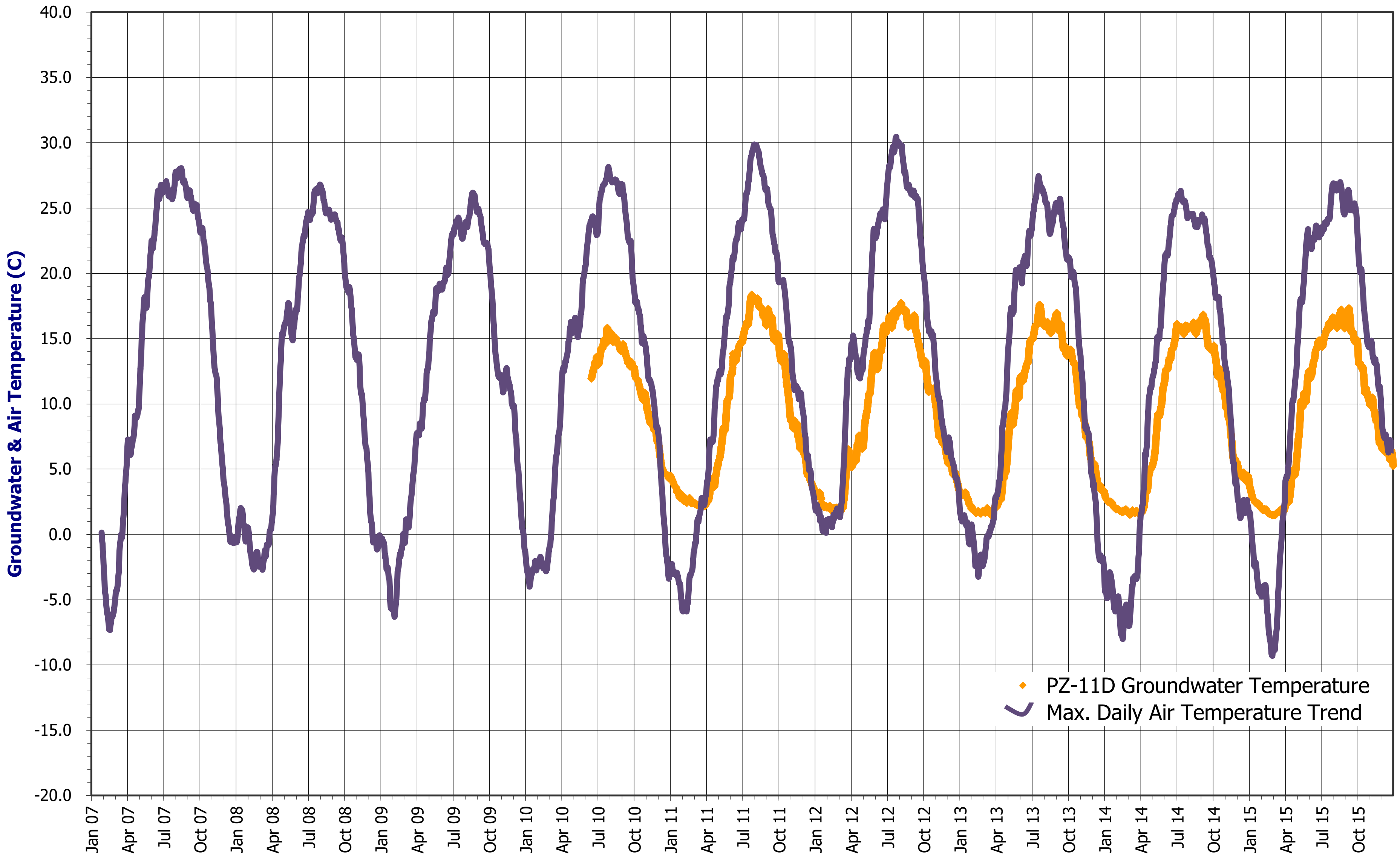
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 6**

Groundwater & Maximum Daily Air Temperature - PZ-11D (June 2010 to December 2015)



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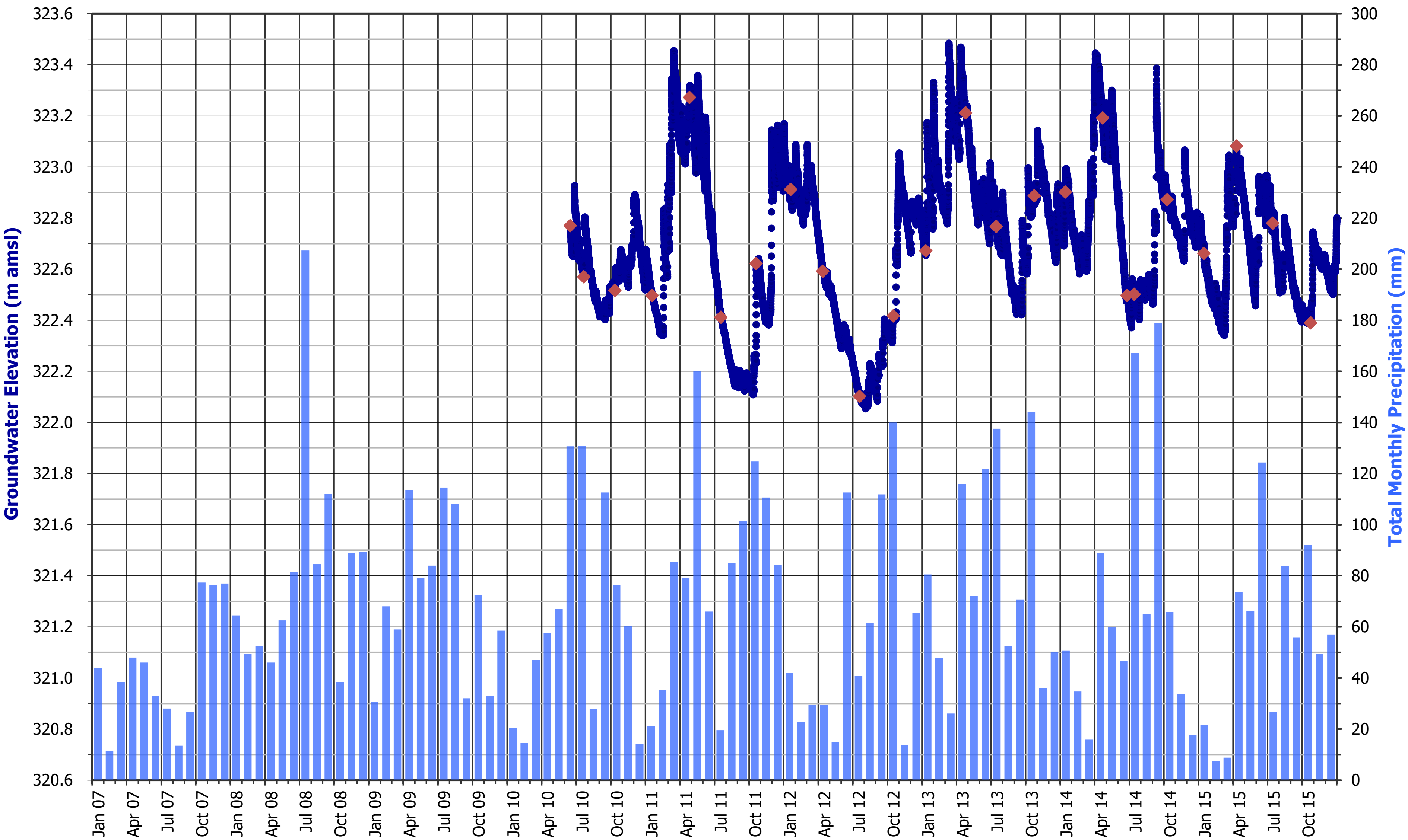
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 6a**

Groundwater Elevation & Precipitation - MW103 (June 2010 to December 2015)



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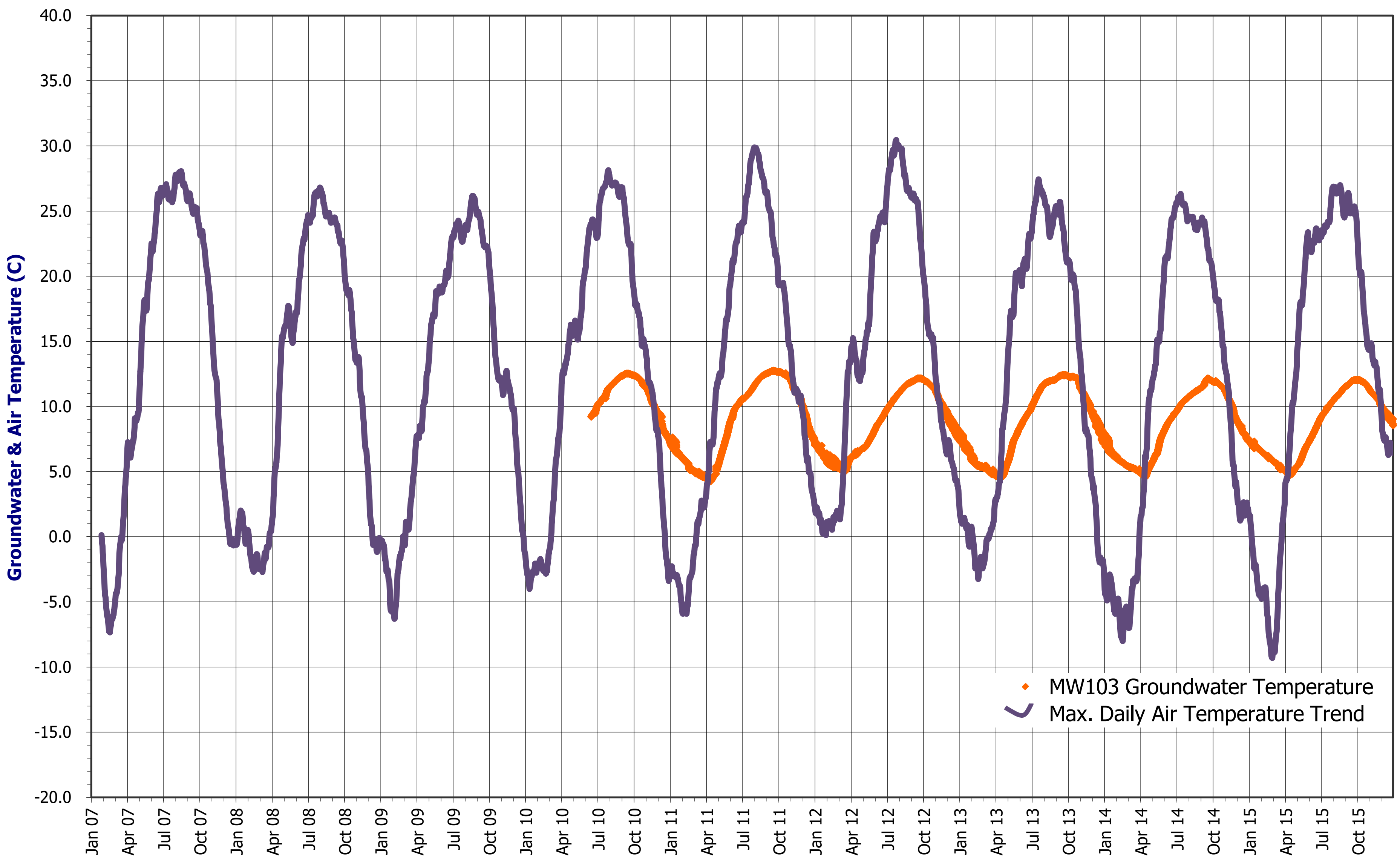
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 7**

Groundwater & Maximum Daily Air Temperature - MW103 (June 2010 to December 2015)



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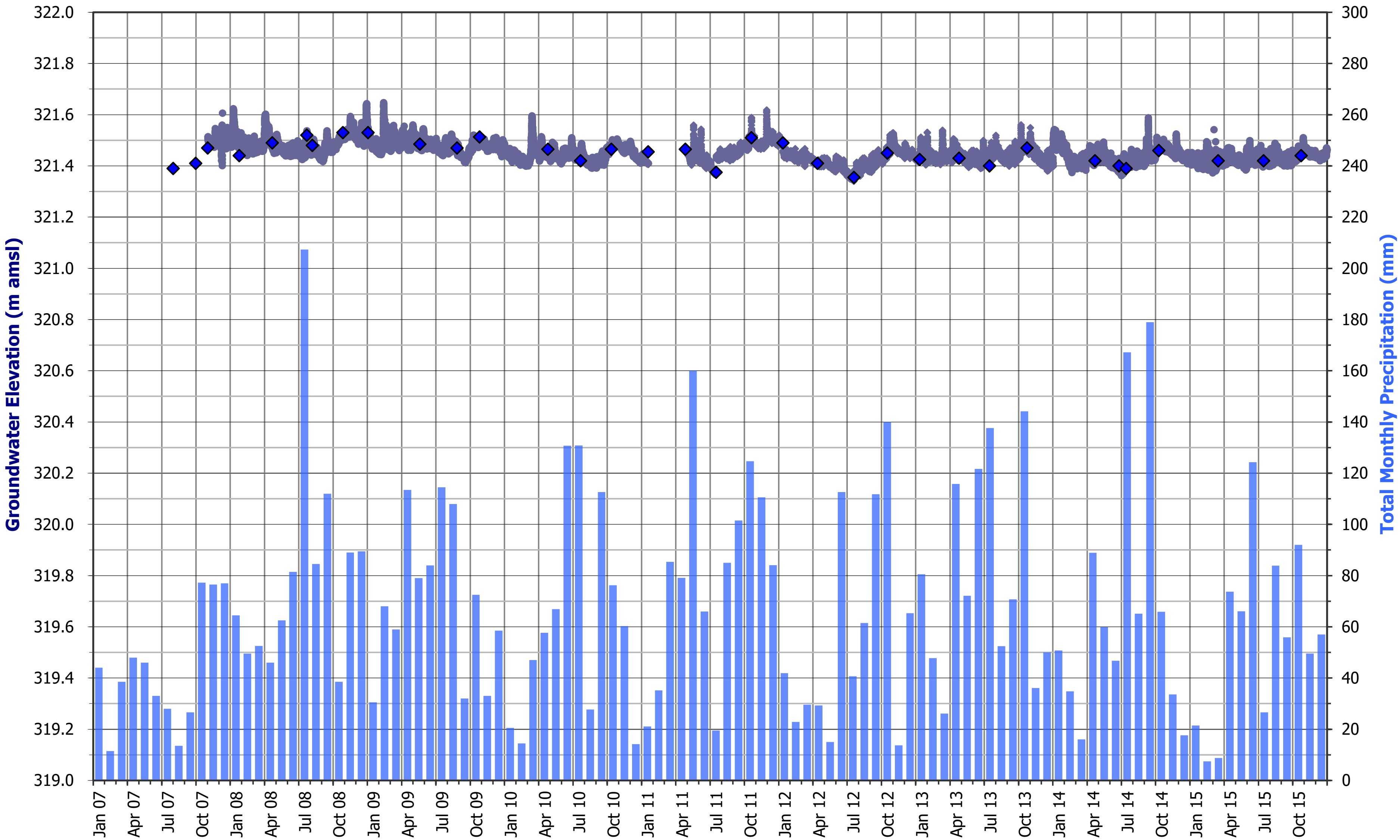
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 7a**

Groundwater Elevation & Precipitation - PZ-7D (August 2007 to December 2015)



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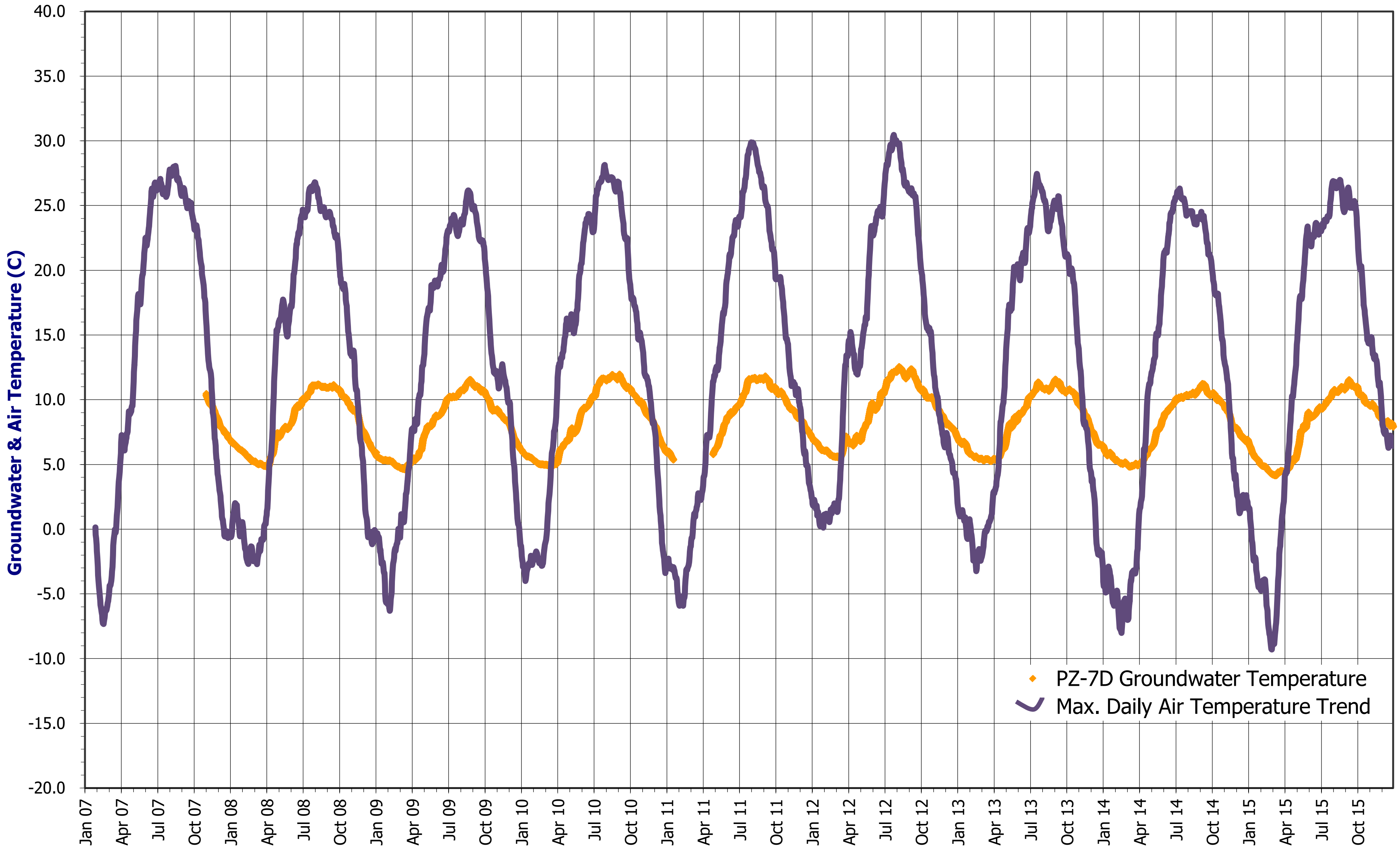
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 8**

Groundwater & Maximum Daily Air Temperature - PZ-7D (August 2007 to December 2015)



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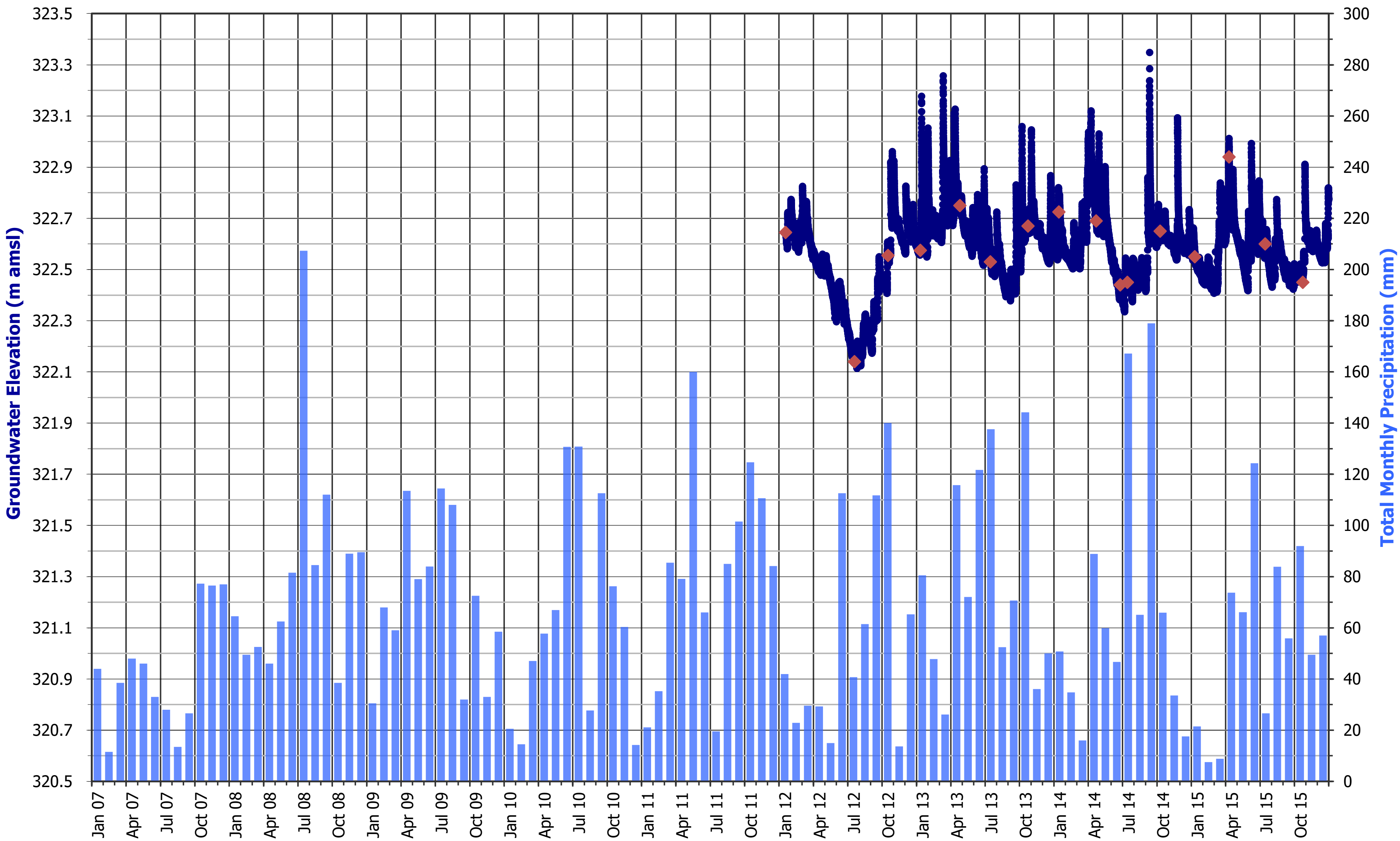
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 8a**

Groundwater Elevation & Precipitation - MW130A (January 2012 to December 2015)



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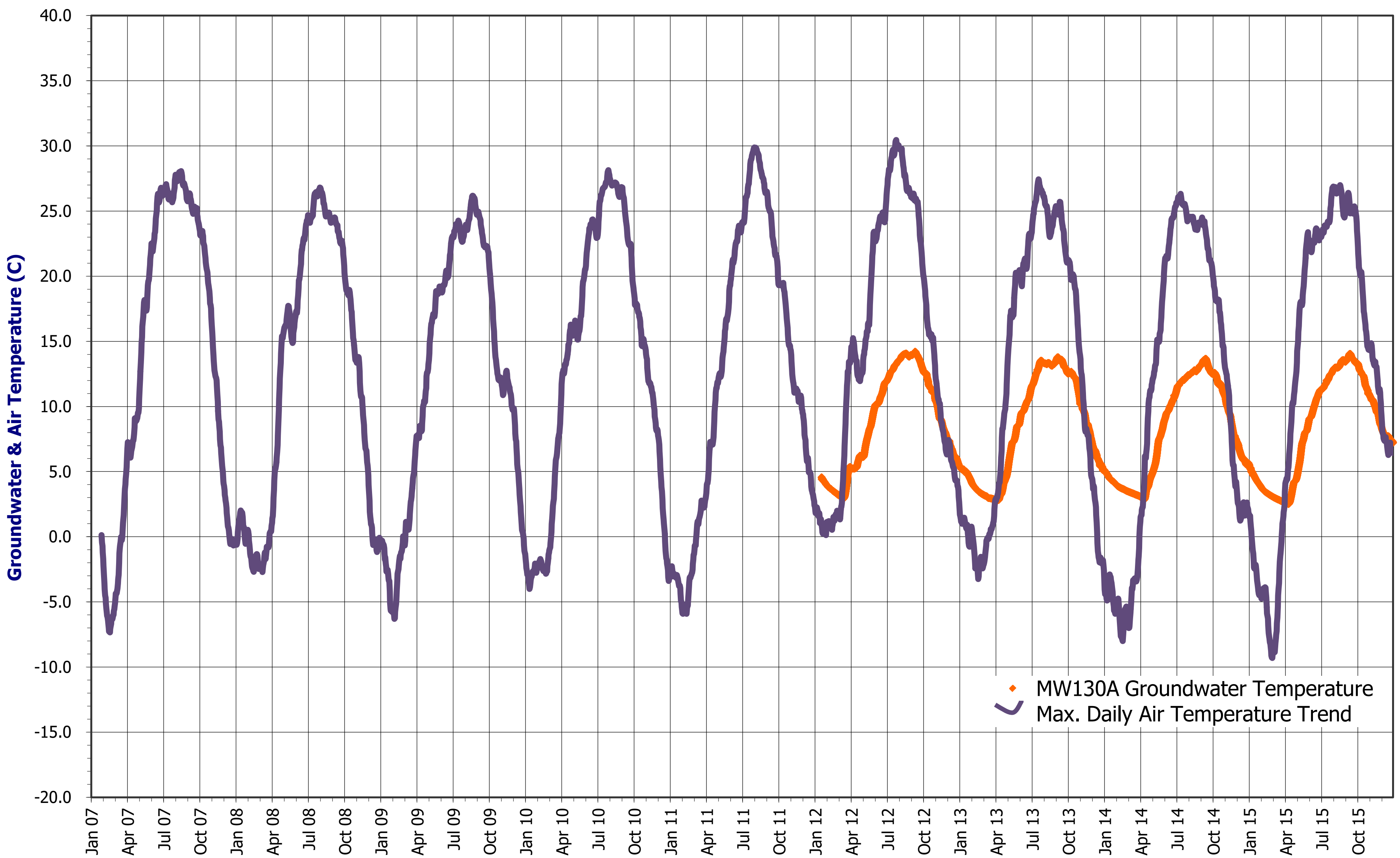
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 9**

Groundwater & Maximum Daily Air Temperature - MW130A (January 2012 to December 2015)



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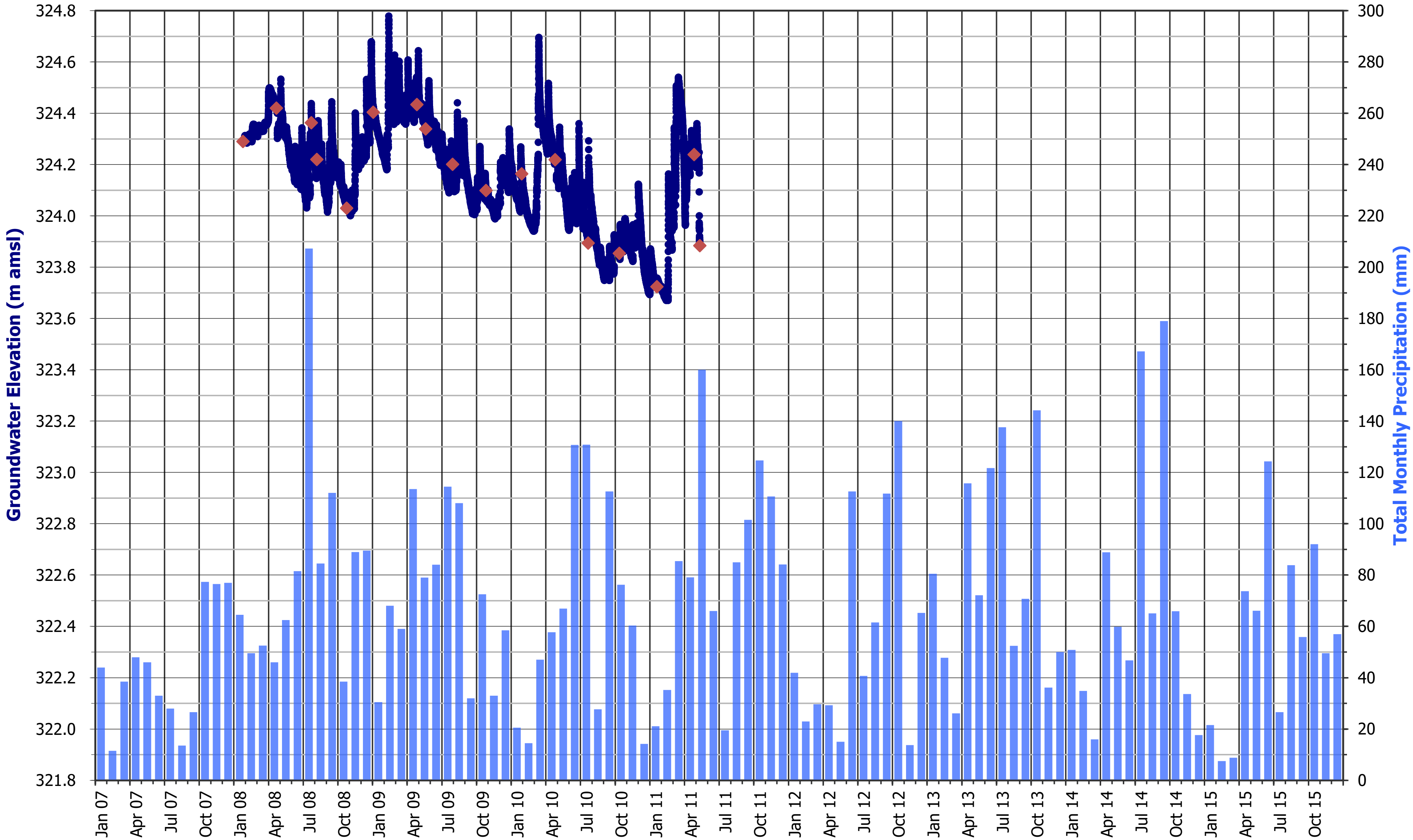
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 9a**

Groundwater Elevation & Precipitation - MW001 (January 08 to May 11) Abandoned 2011



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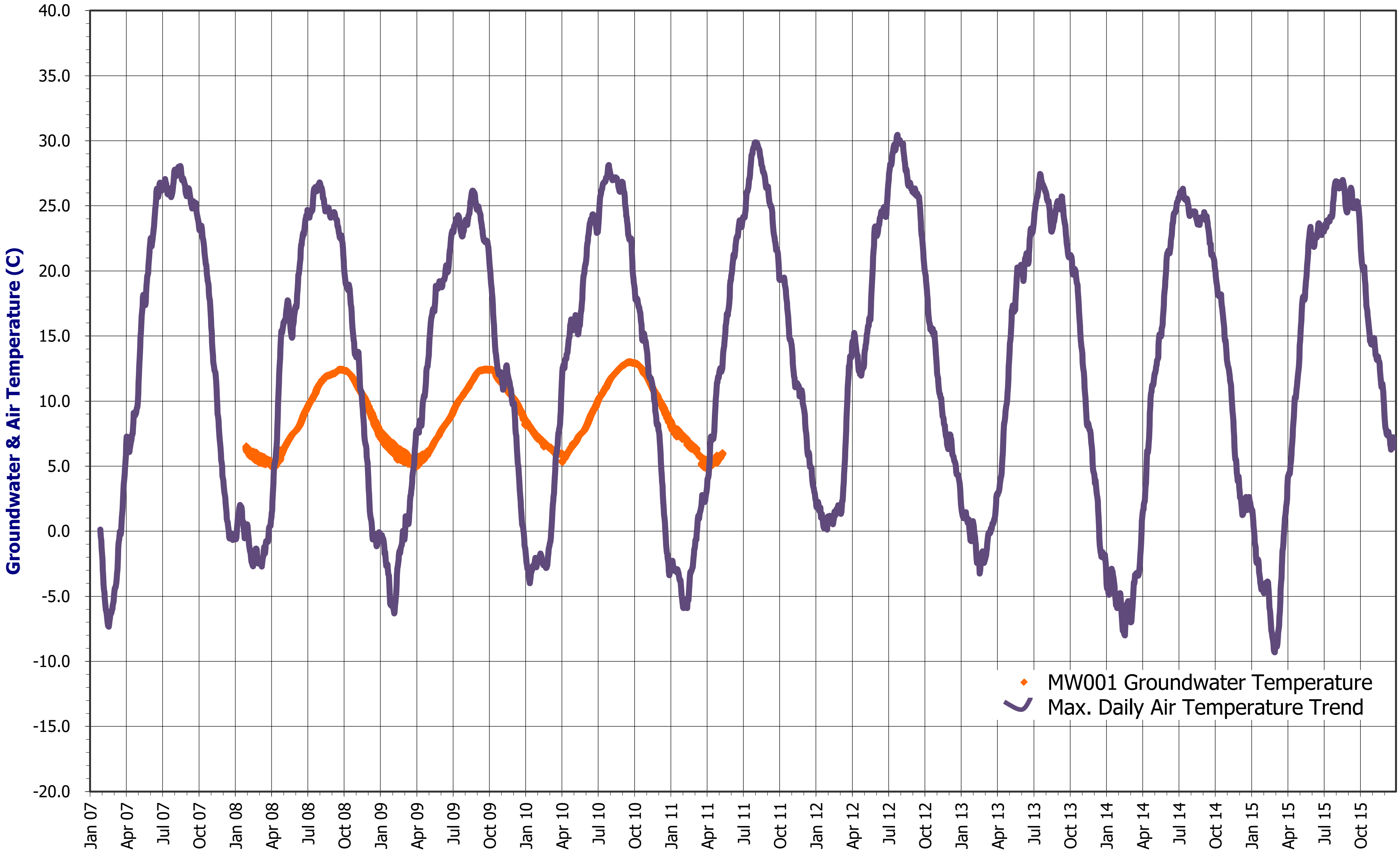
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 10**

Groundwater & Maximum Daily Air Temperature - MW001 (January 08 to May 11) Abandoned 2011



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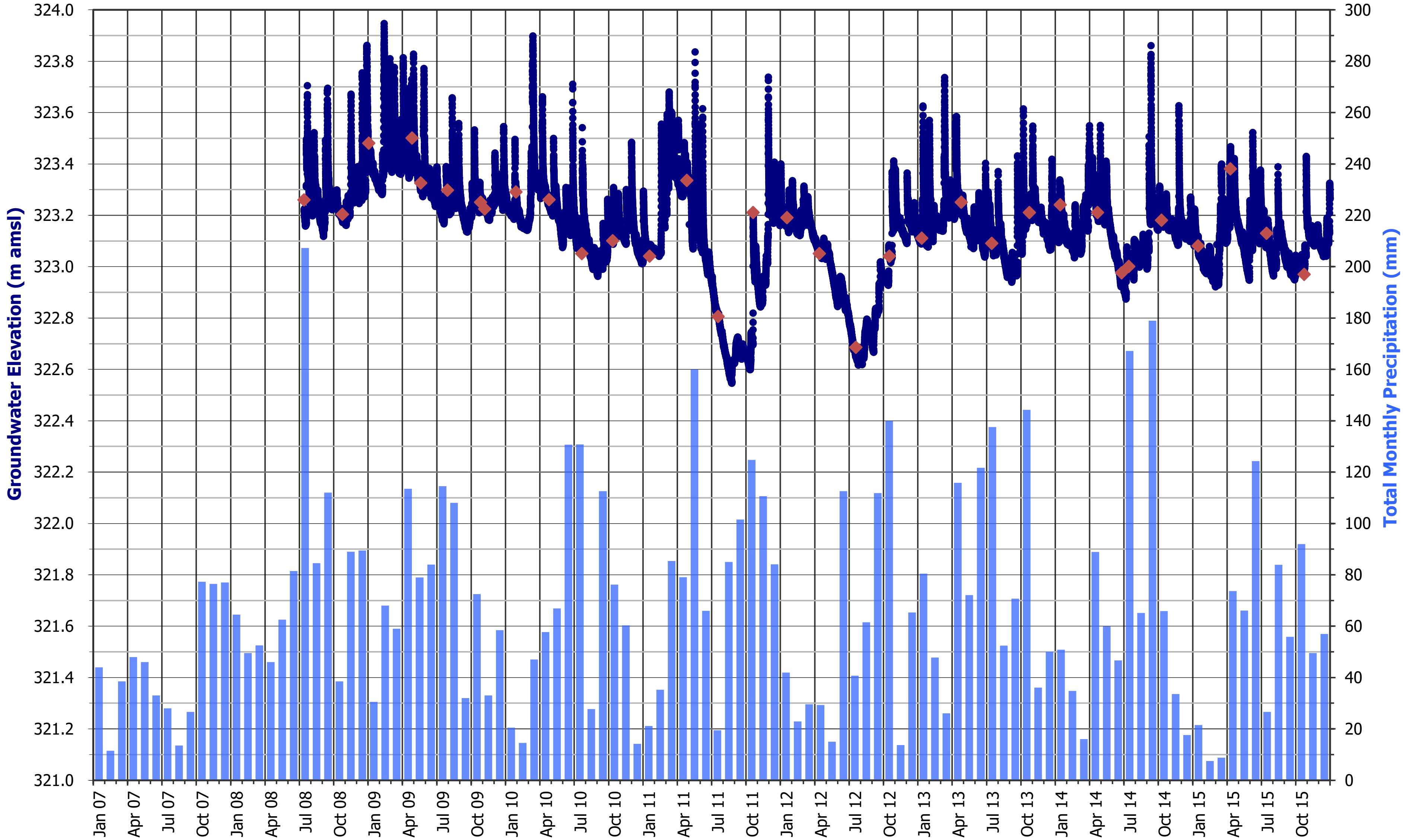
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Phase 1 - Core PSW Graph G 10a

Groundwater Elevation & Precipitation - MW118A (July 2008 to December 2015)



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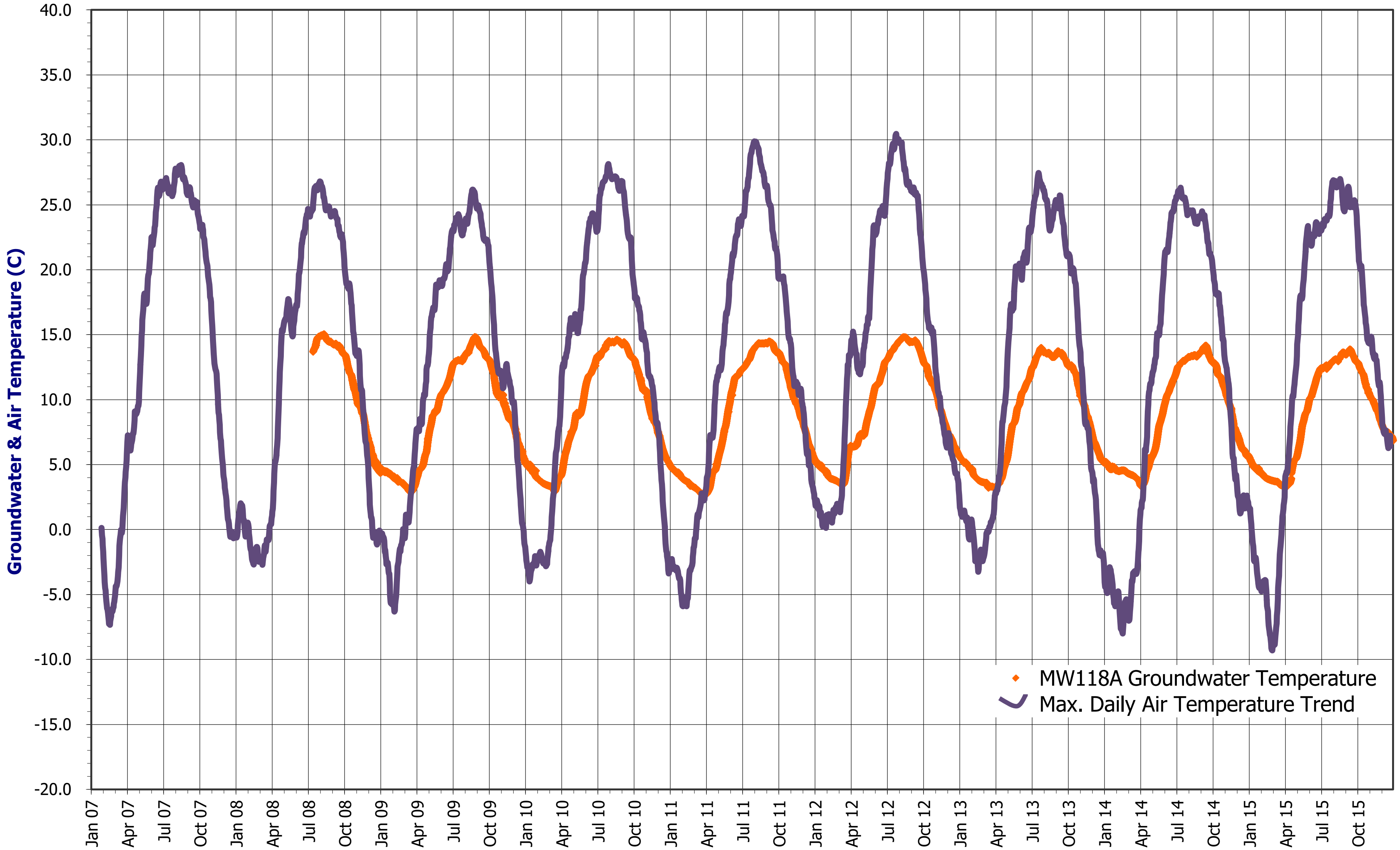
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 11**

Groundwater & Maximum Daily Air Temperature - MW118A (July 2008 to December 2015)



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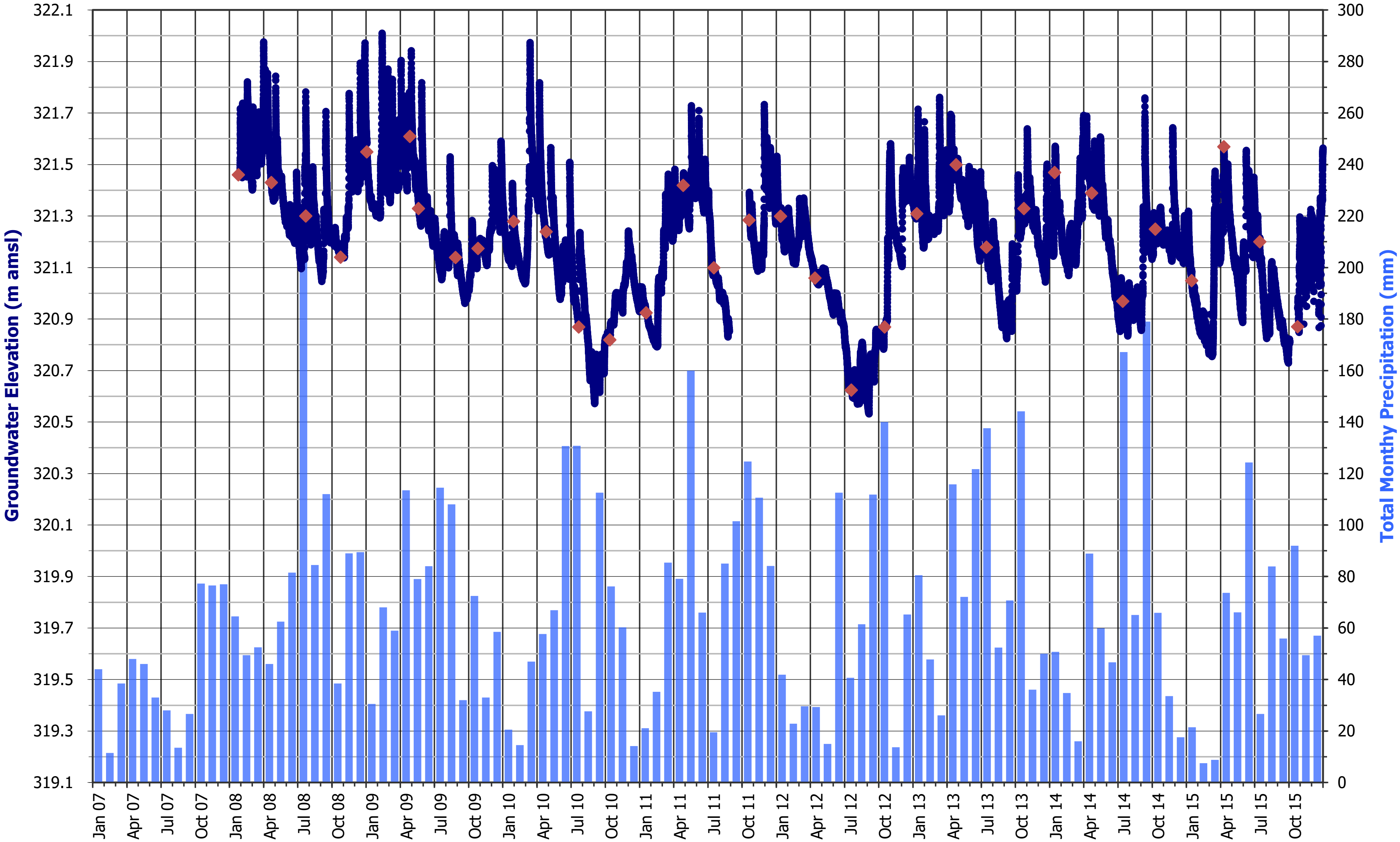
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 11a**

Groundwater Elevation & Precipitation - MW104 (January 2008 to December 2015)



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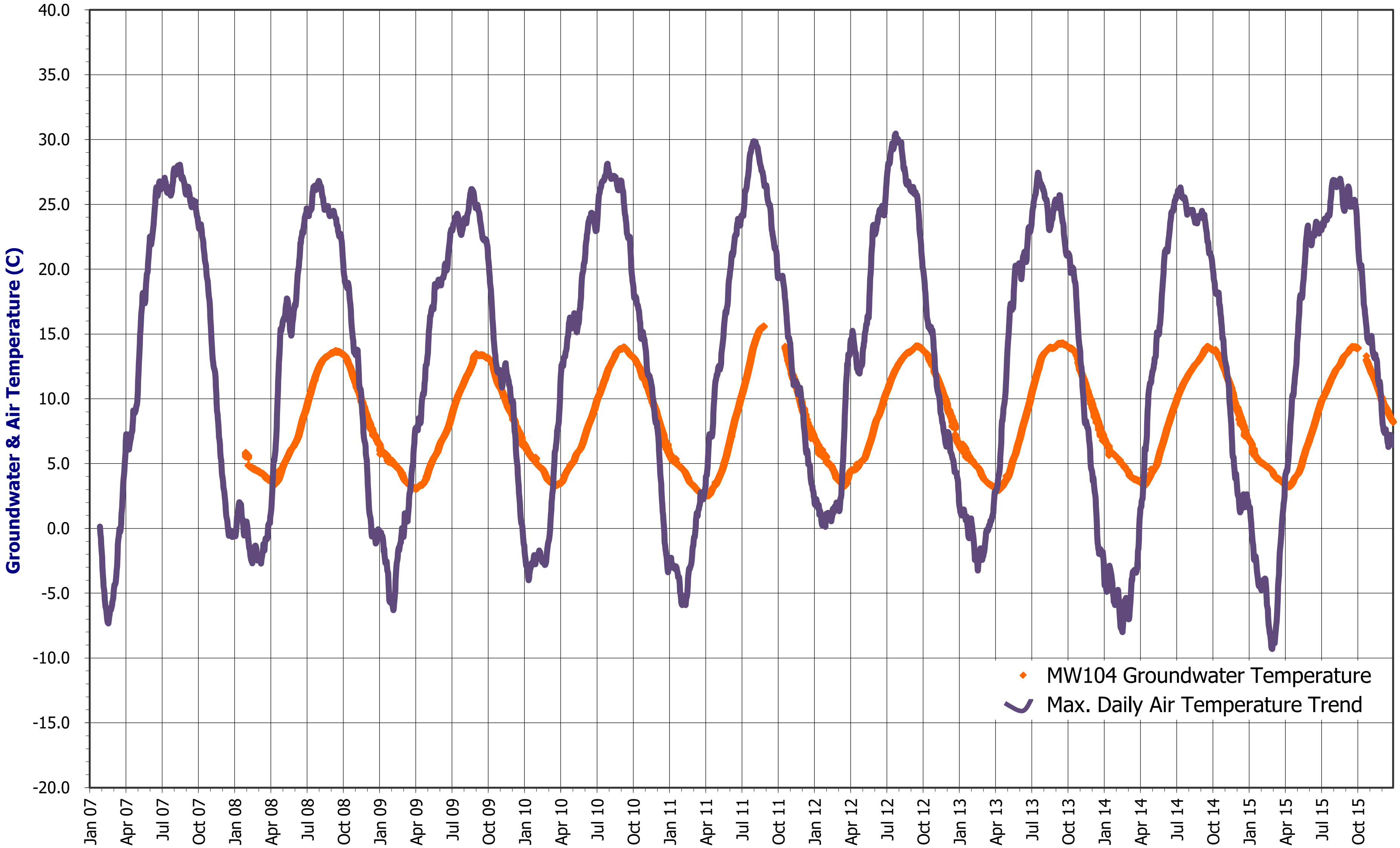
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 12**

Groundwater & Maximum Daily Air Temperature - MW104 (January 2008 to December 2015)



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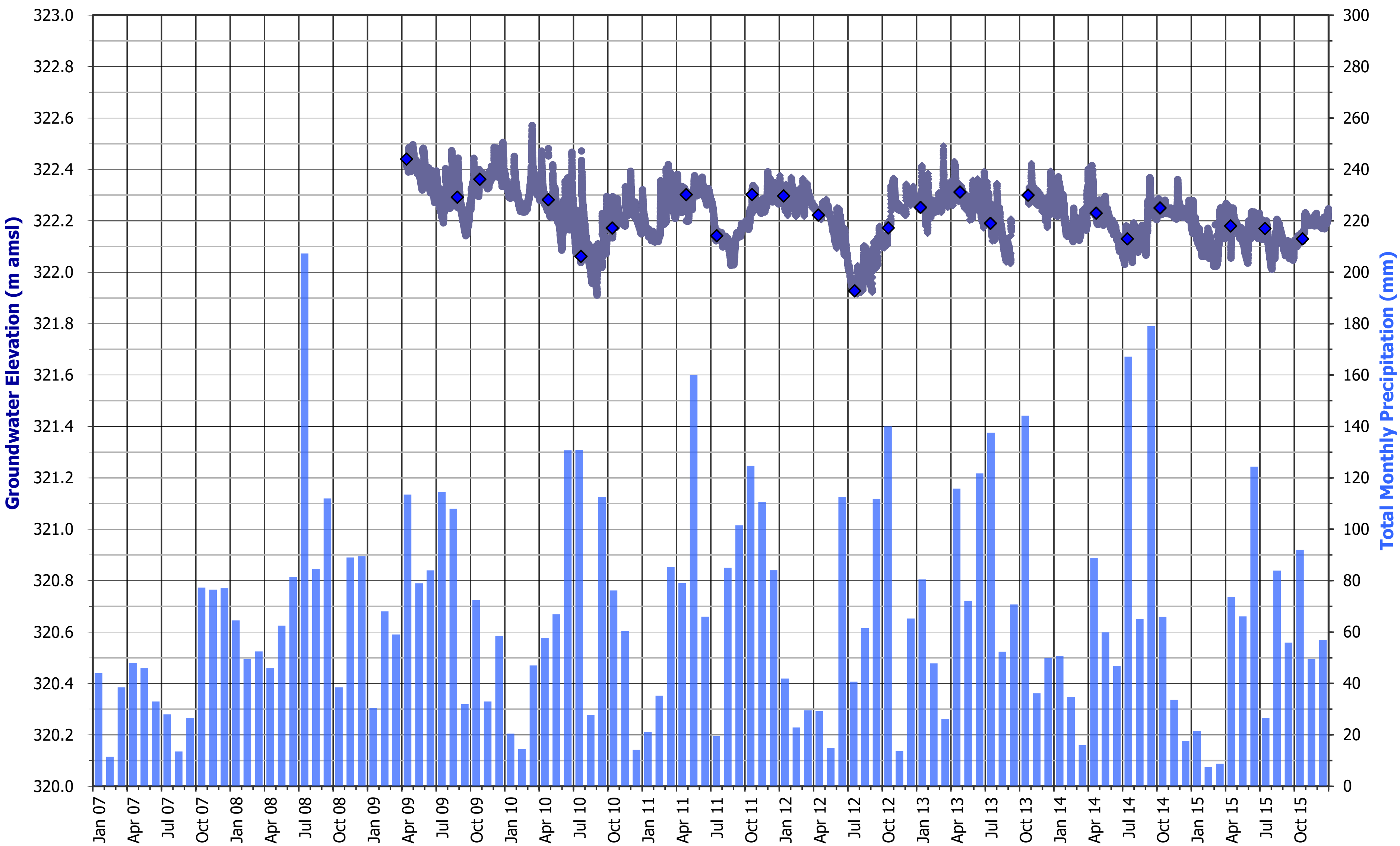
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Phase 1 - Core PSW Graph G 12a

Groundwater Elevation & Precipitation - PZ-4D (April 2009 to December 2015)



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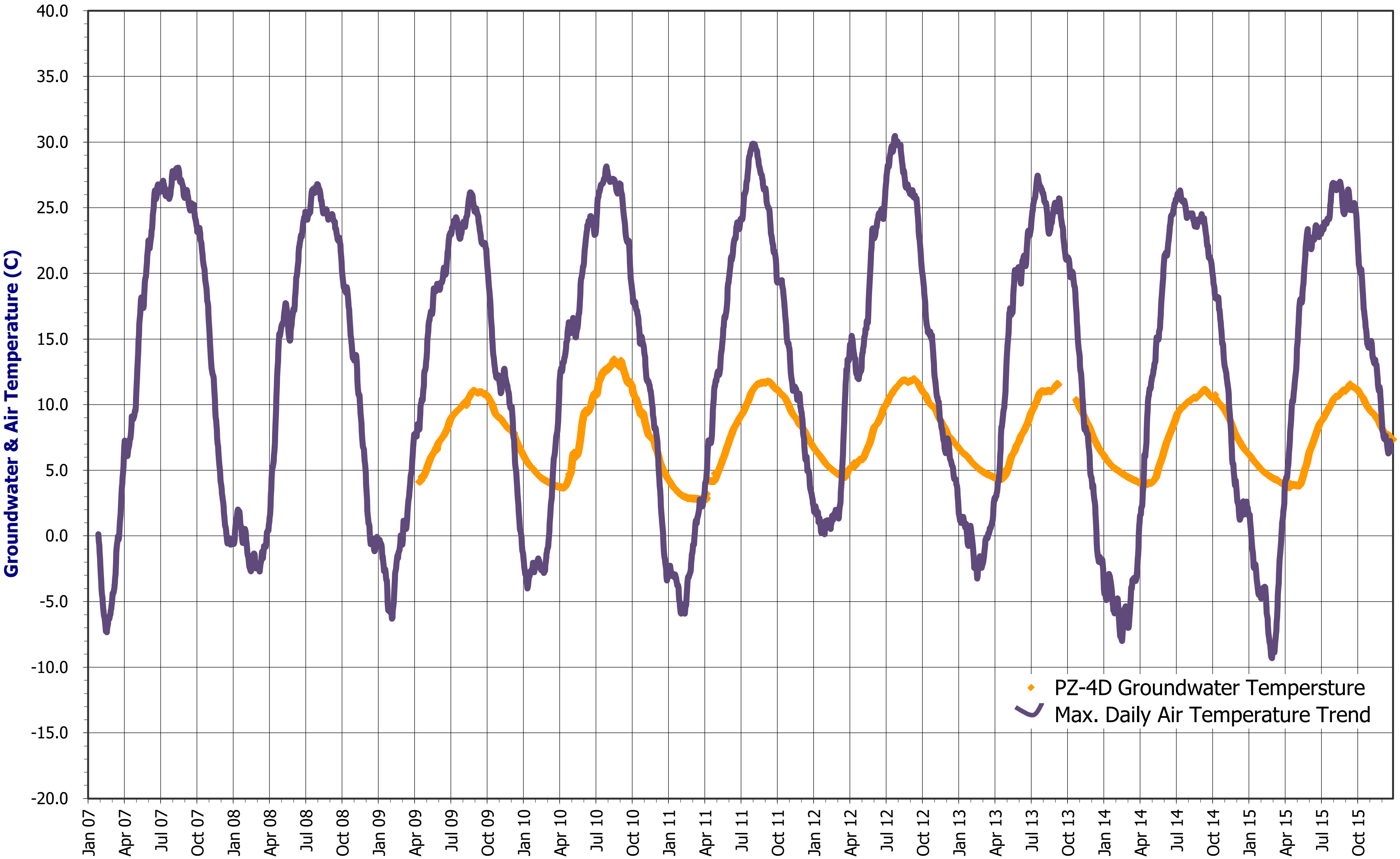
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 13**

Groundwater & Maximum Daily Air Temperature - PZ-4D (April 2009 to December 2015)



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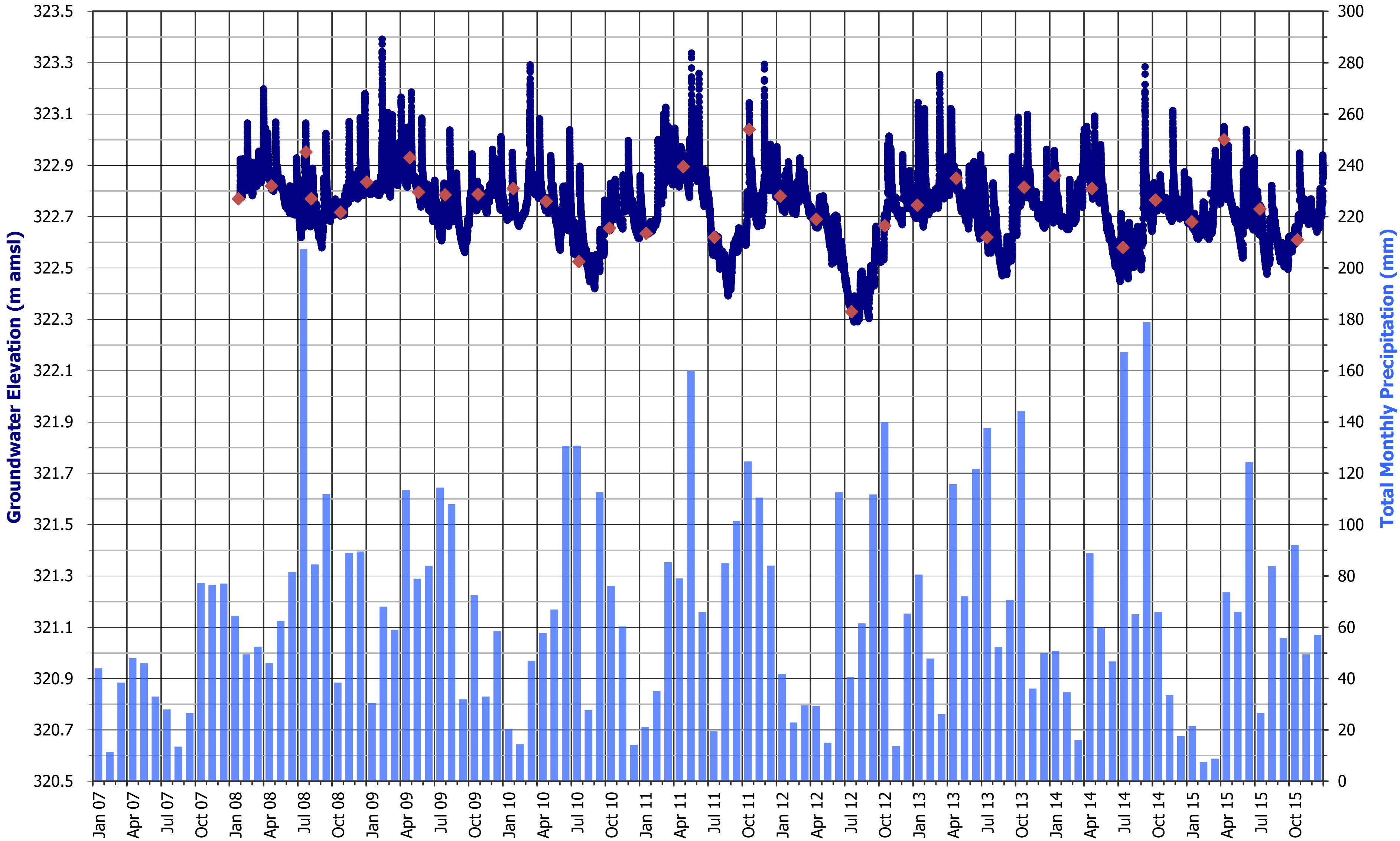
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 13a**

Groundwater Elevation & Precipitation - MW105 (January 2008 to December 2015)



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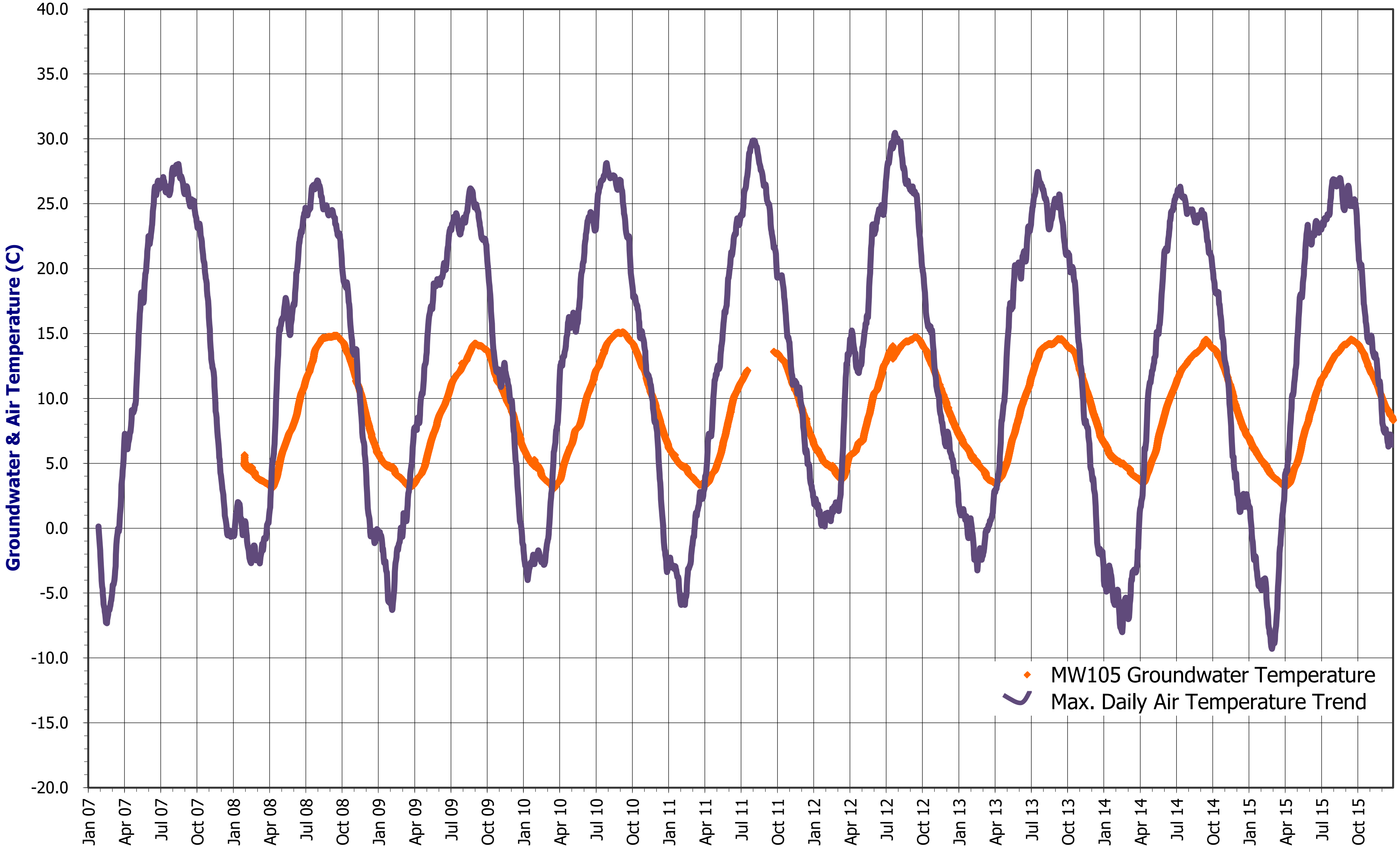
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 14**

Groundwater & Maximum Daily Air Temperature - MW105 (January 2008 to December 2015)



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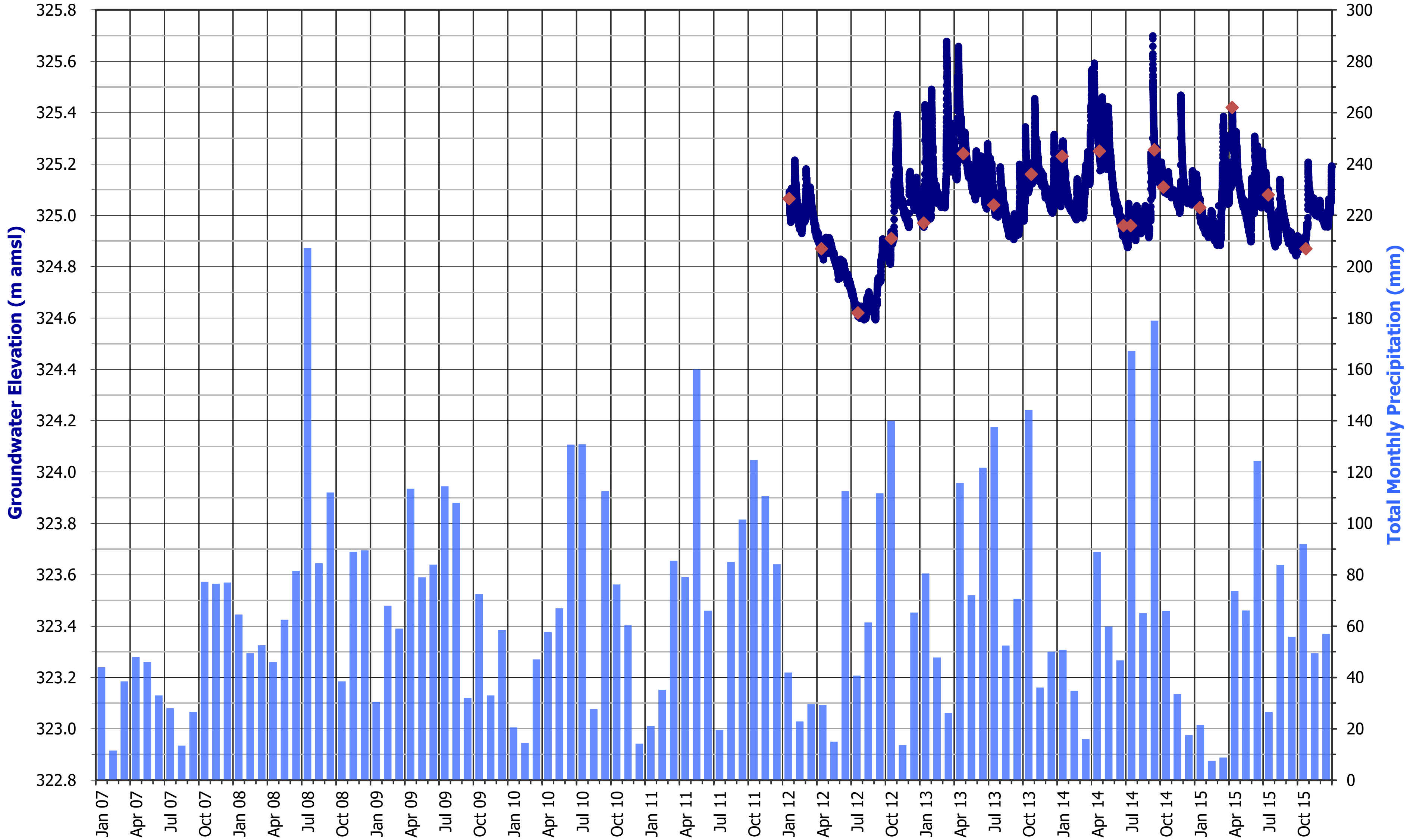
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 14a**

Groundwater Elevation & Precipitation - MW129 (January 2012 to December 2015)



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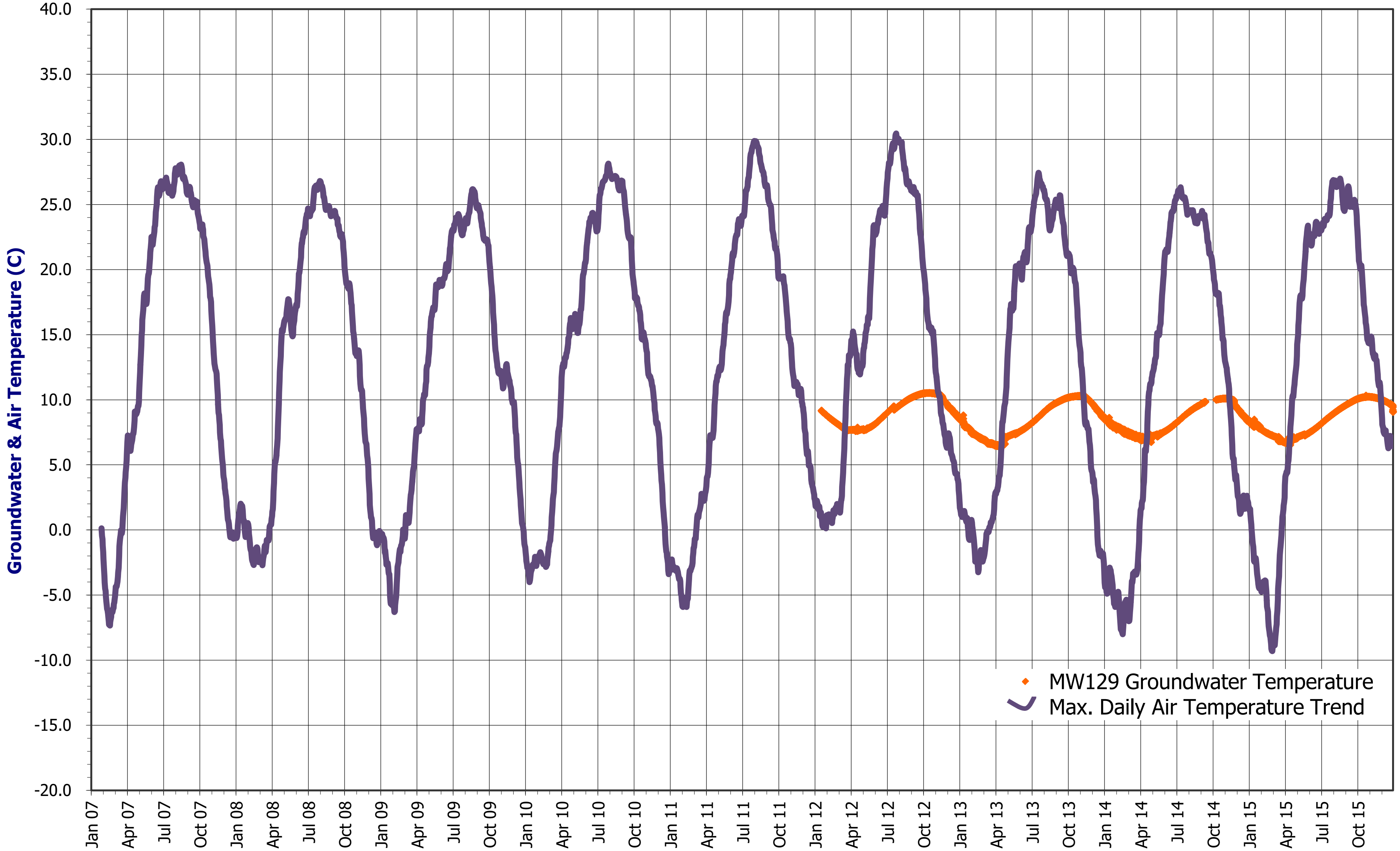
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 15**

Groundwater & Maximum Daily Air Temperature - MW129 (January 2012 to December 2015)



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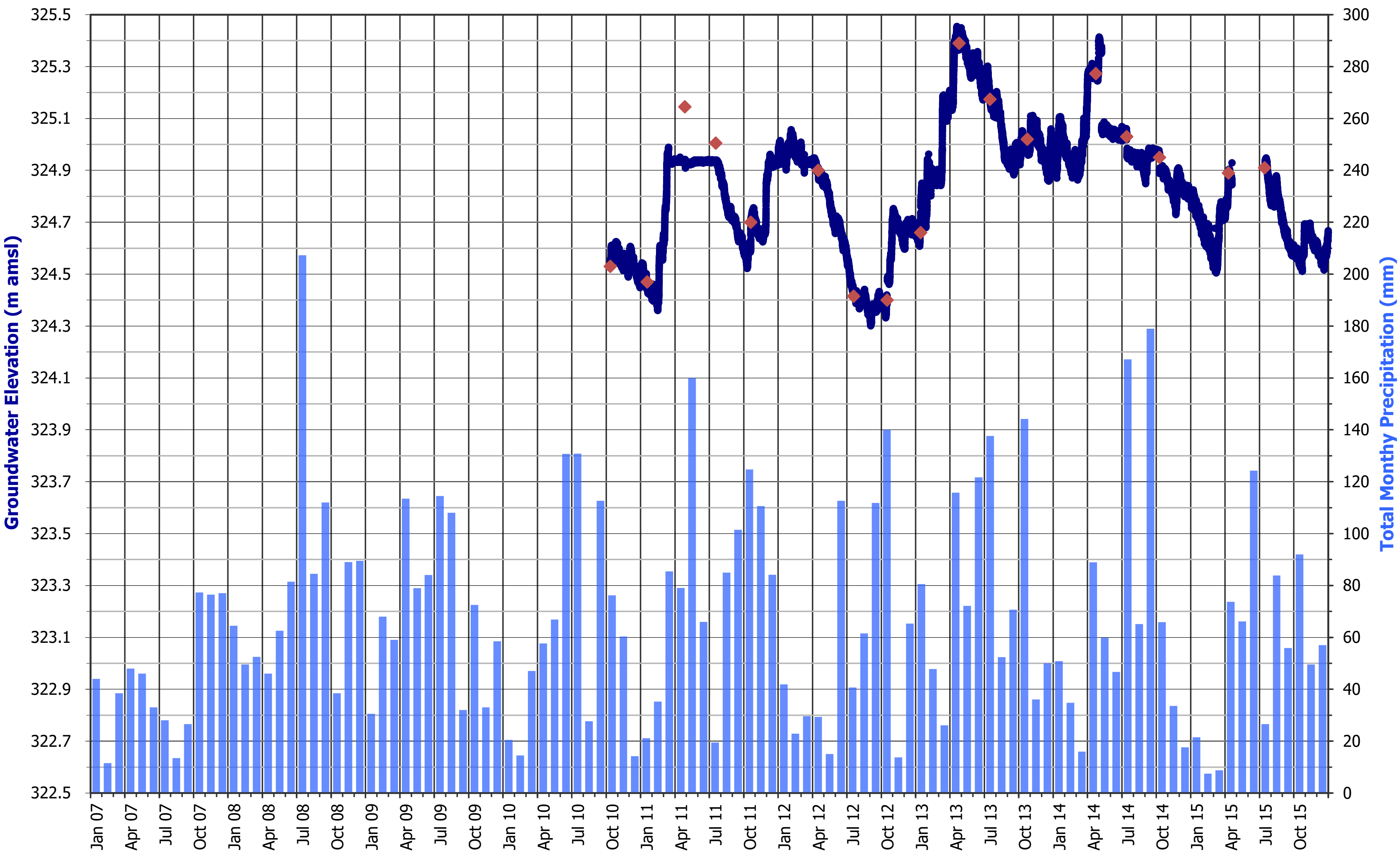
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 15a**

Groundwater Elevation & Precipitation - MW111 (October 2010 to December 2015)



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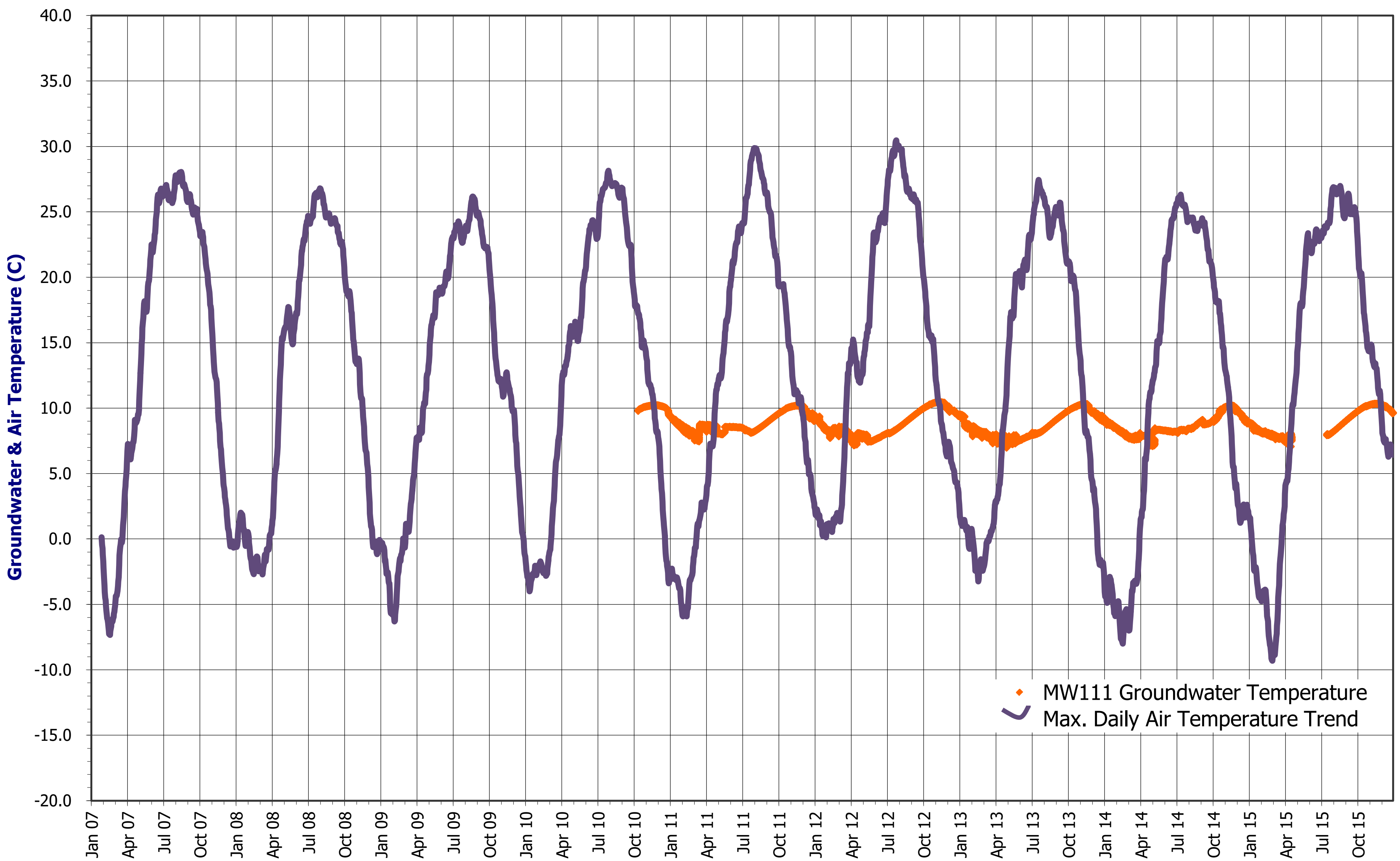
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 16**

Groundwater & Maximum Daily Air Temperature - MW111 (October 2010 to December 2015)



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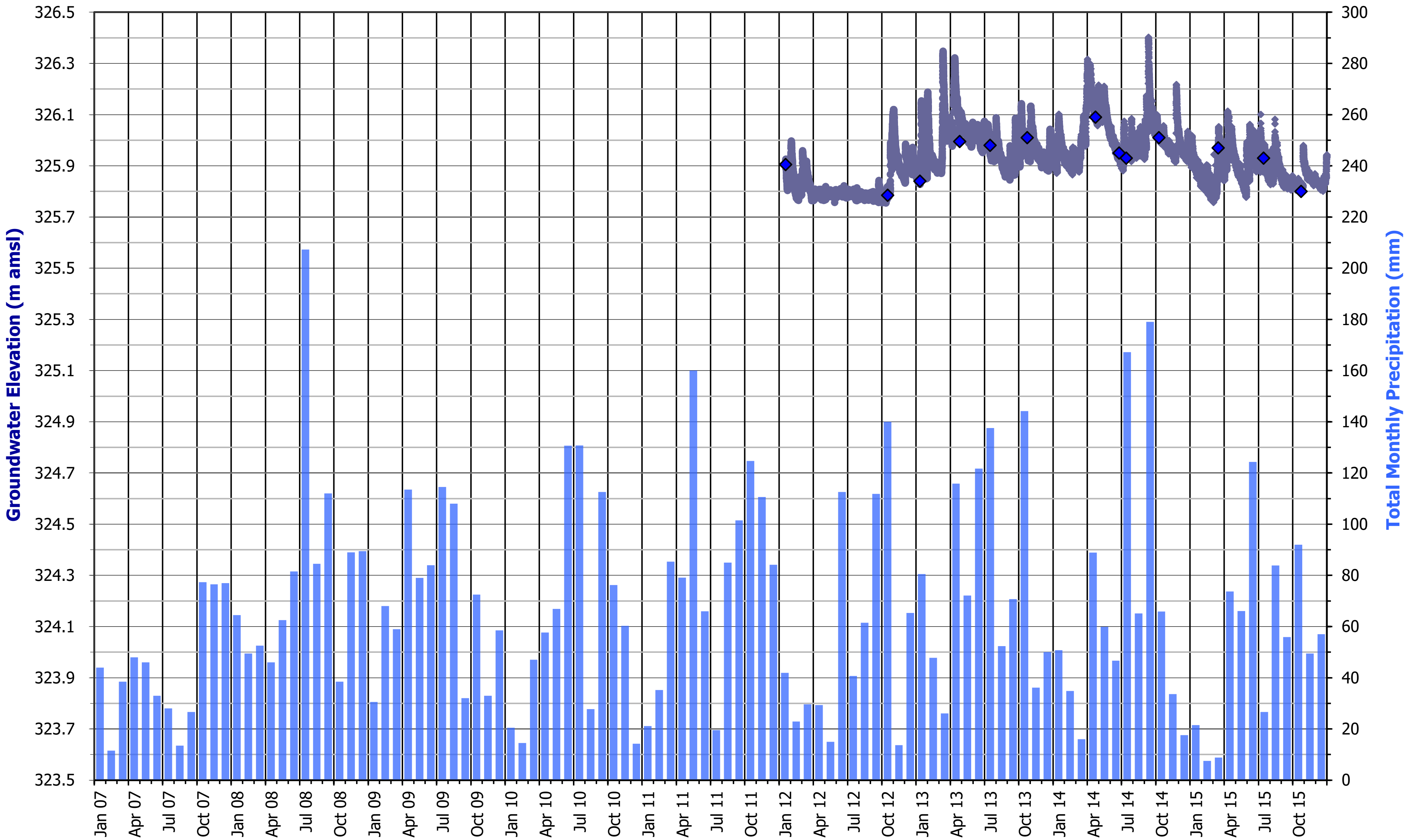
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Core PSW** **Graph G 16a**

Groundwater Elevation & Precipitation - PZ-12D (January 2012 to December 2015)



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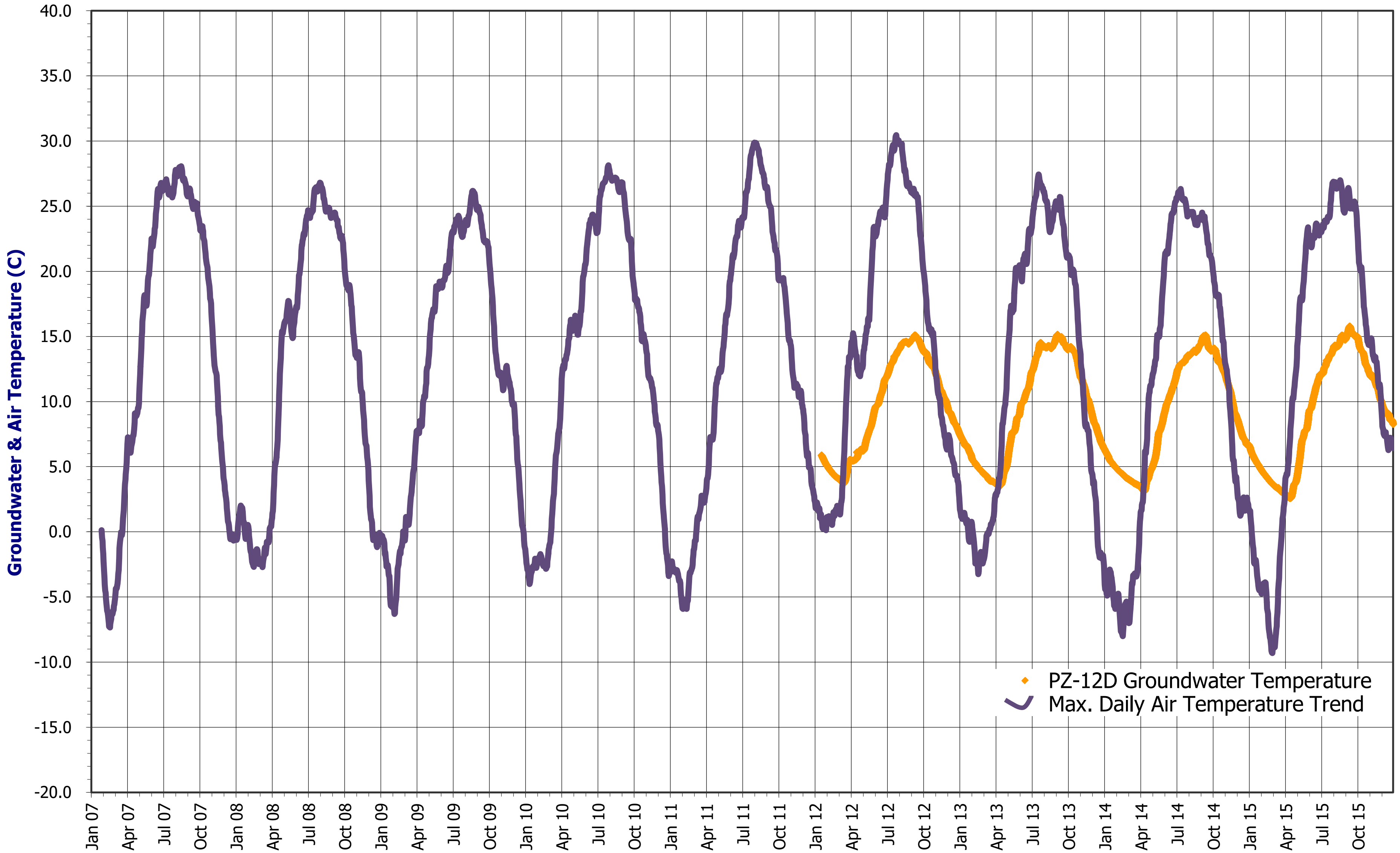
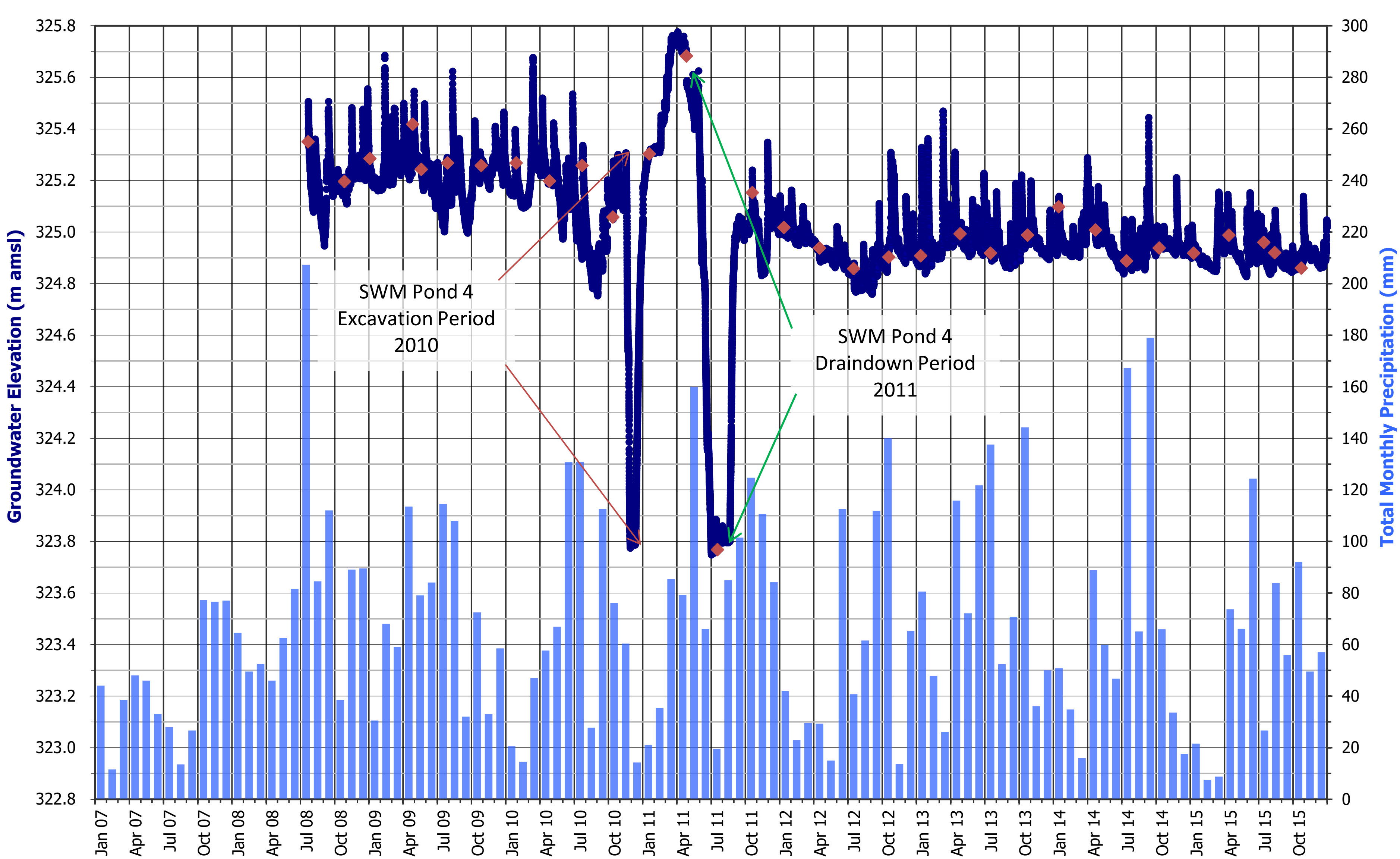
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 17**

Groundwater & Maximum Daily Air Temperature - PZ-12D (January 2012 to December 2015)



Groundwater Elevation & Precipitation - MW119A (July 2008 to December 2015)



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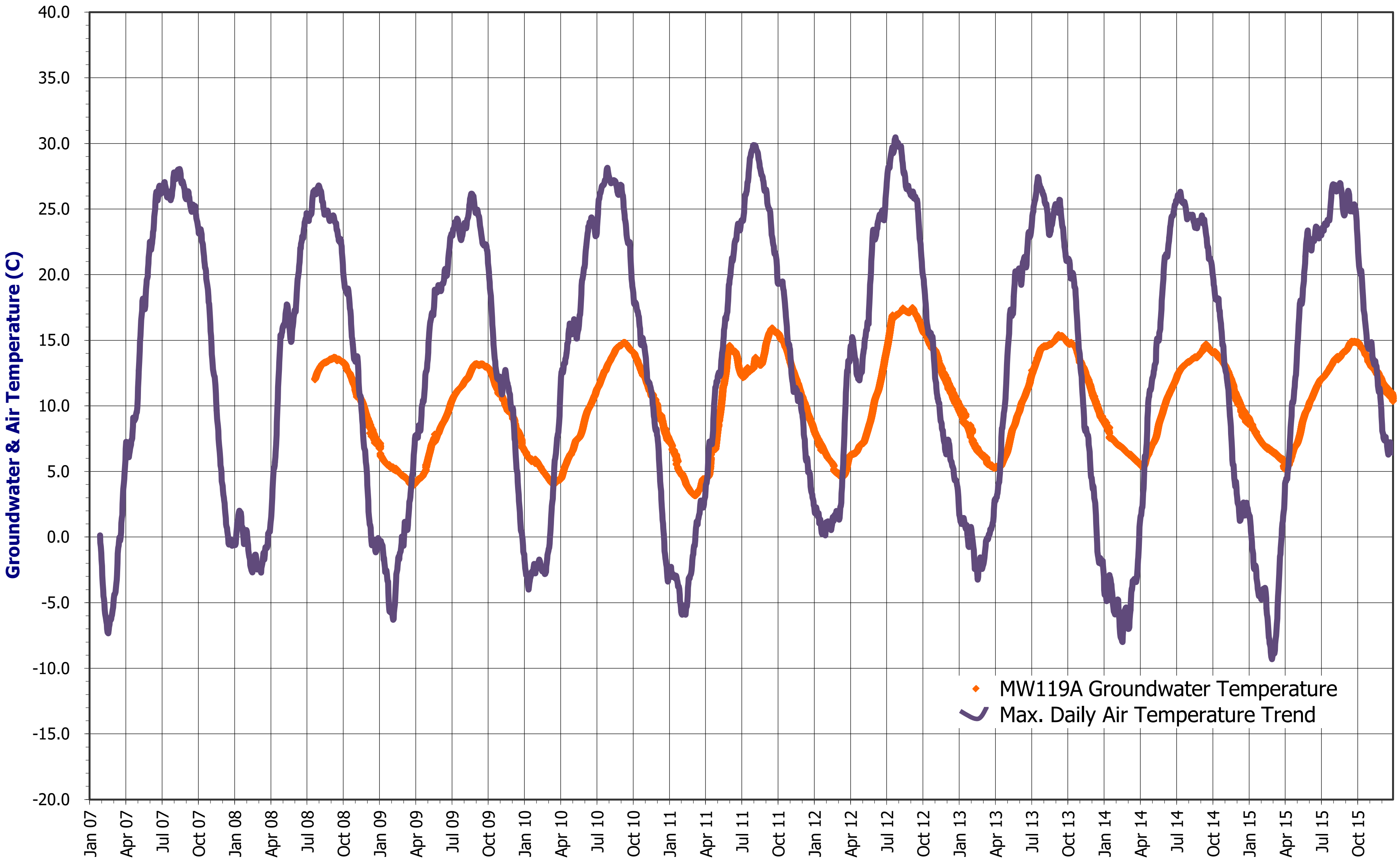
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 18**

Groundwater & Maximum Daily Air Temperature - MW119A (July 2008 to December 2015)



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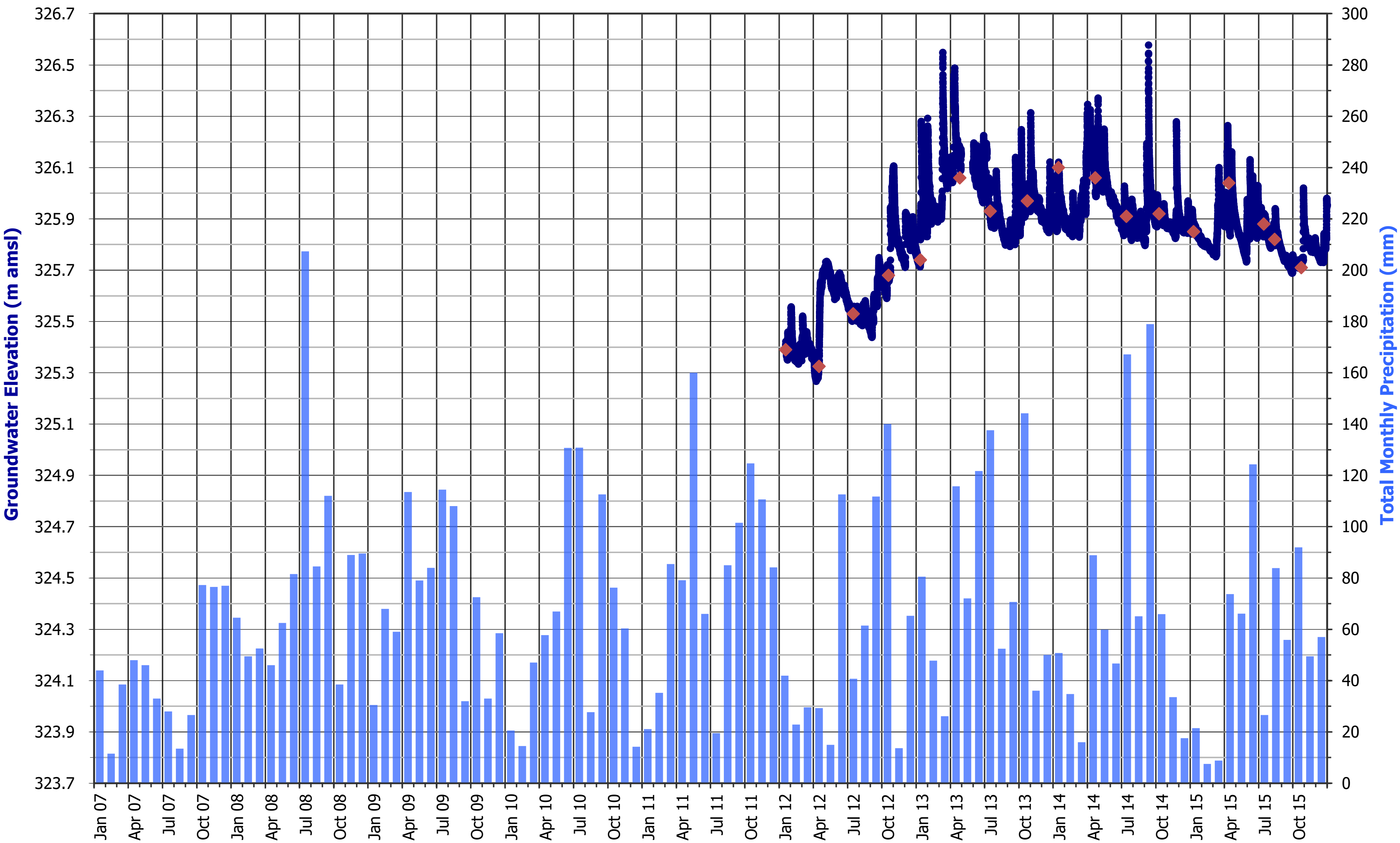
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 18a**

Groundwater Elevation & Precipitation - MW131 (January 2012 to December 2015)



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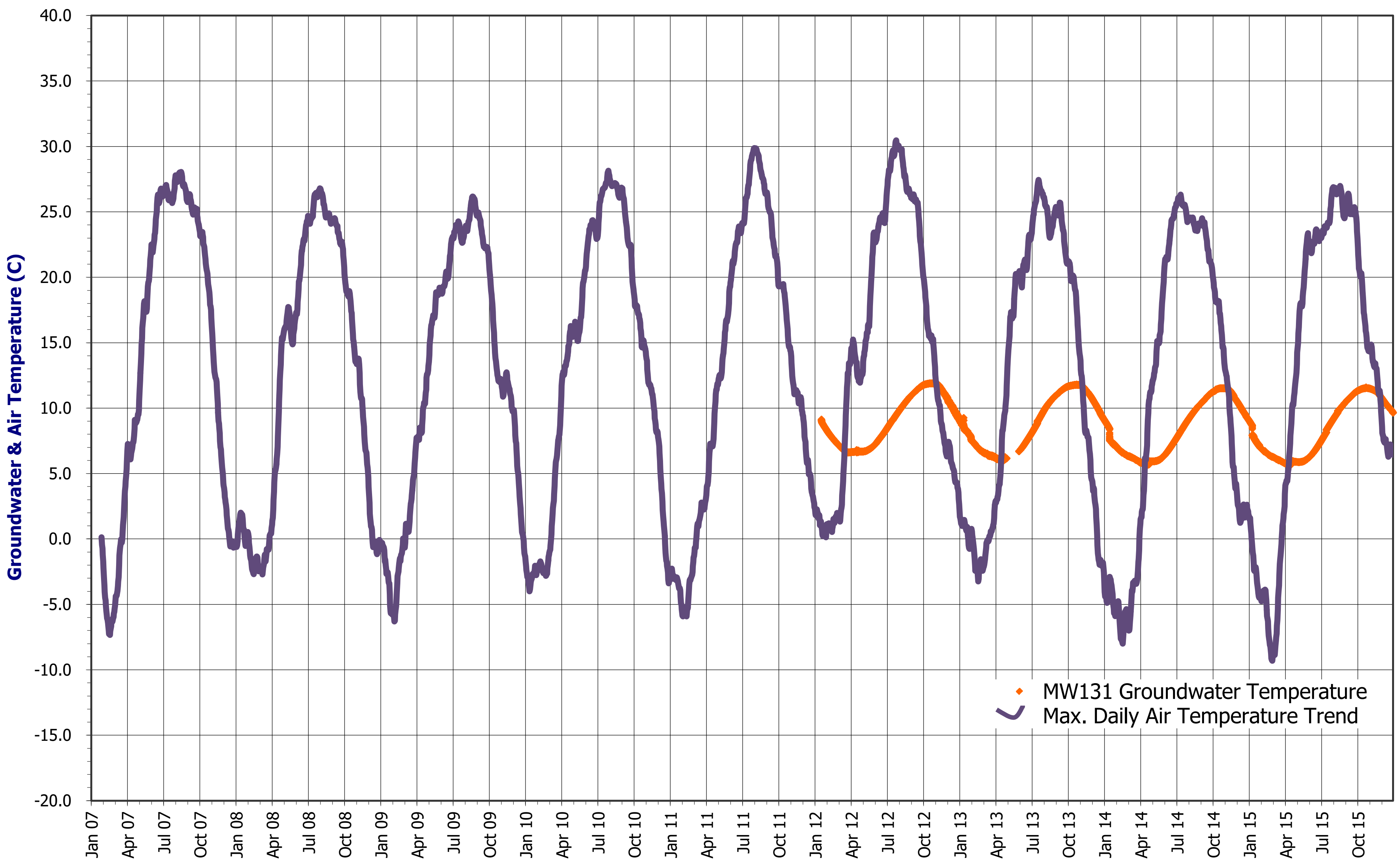
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 19**

Groundwater & Maximum Daily Air Temperature - MW131 (January 2012 to December 2015)



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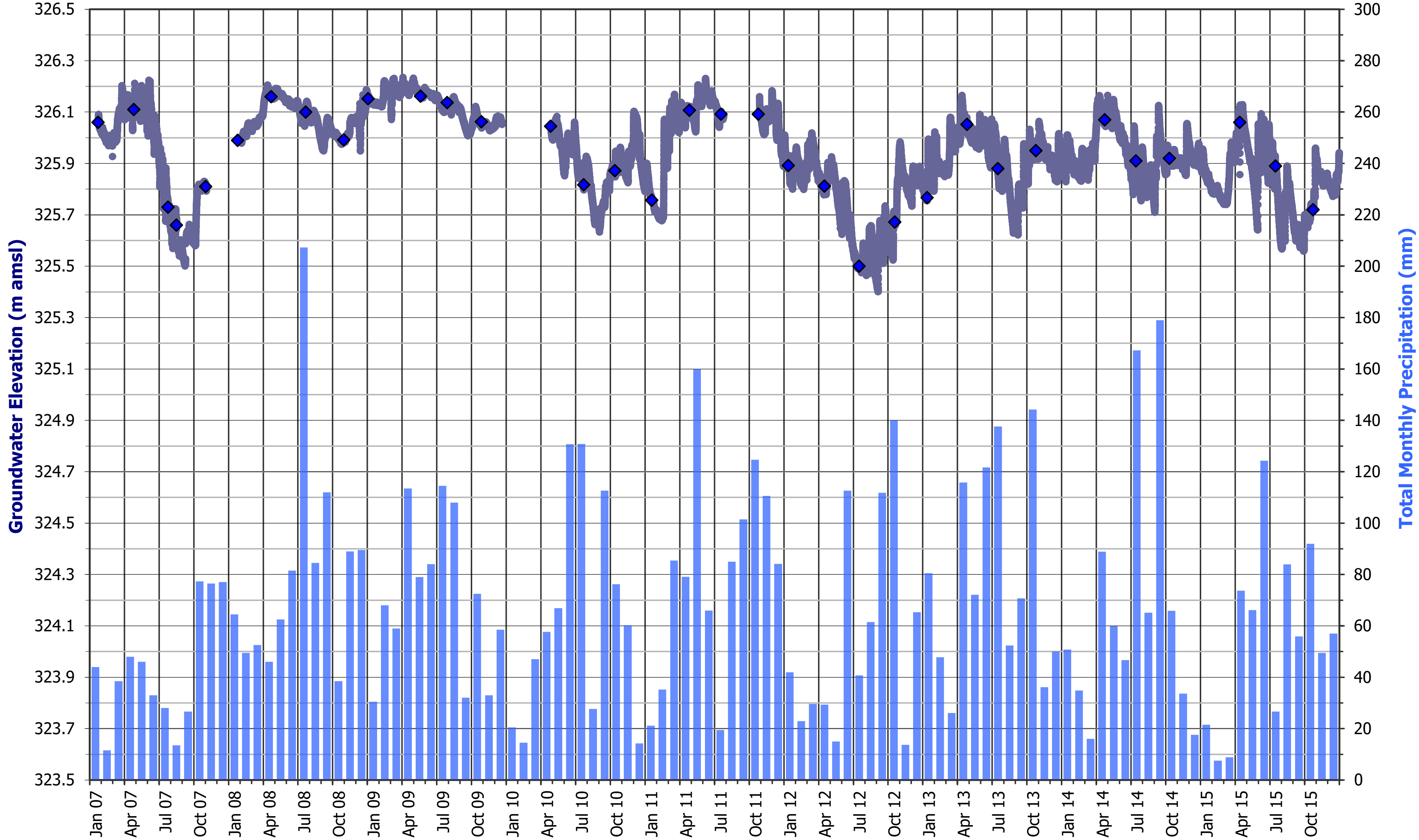
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 19a**

Groundwater Elevation & Precipitation - PZ-2D (January 2007 to December 2015)



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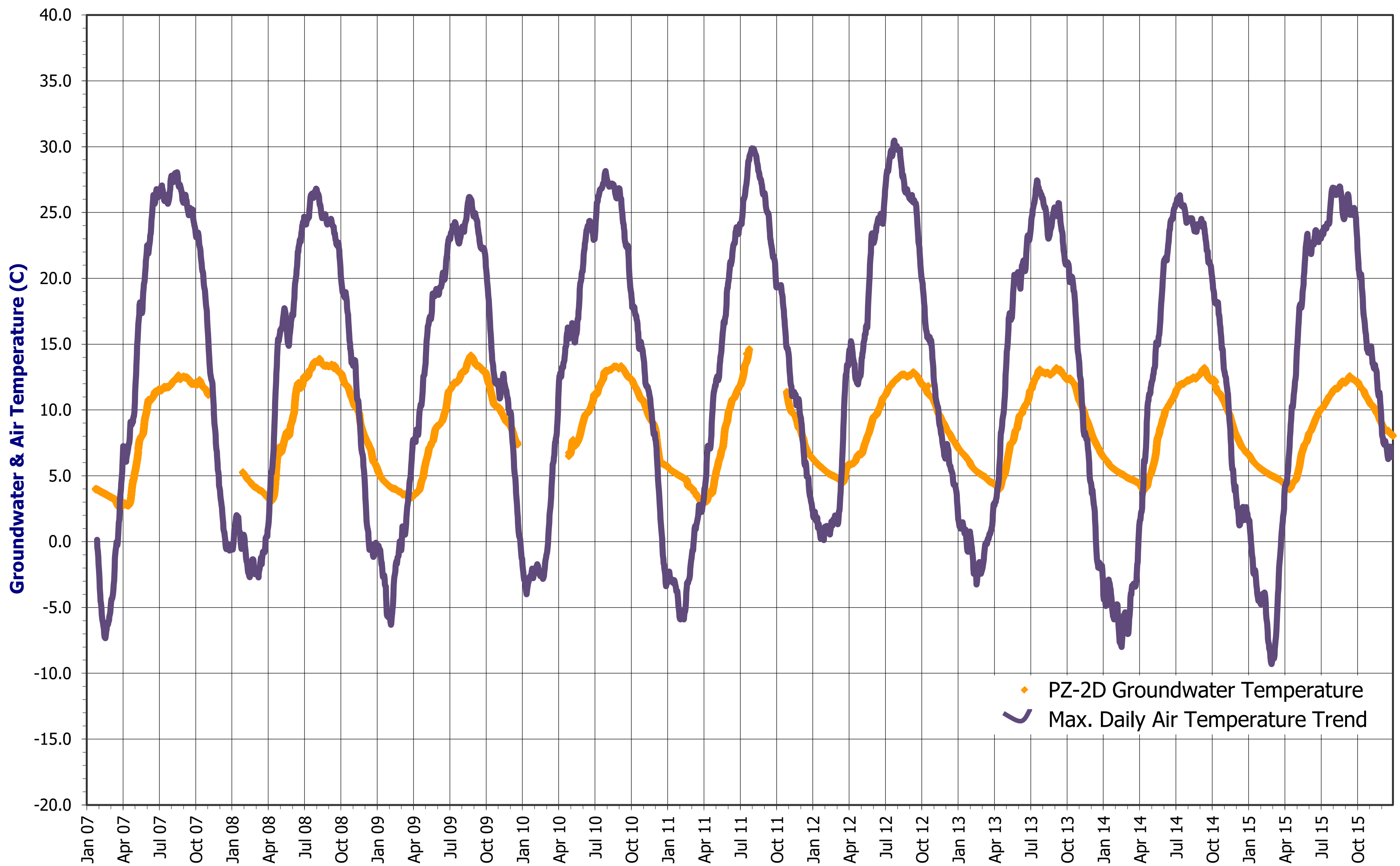
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phases 2 & 3 - Core PSW** **Graph G 20**

Groundwater & Maximum Daily Air Temperature - PZ-2D (March 2007 to December 2015)



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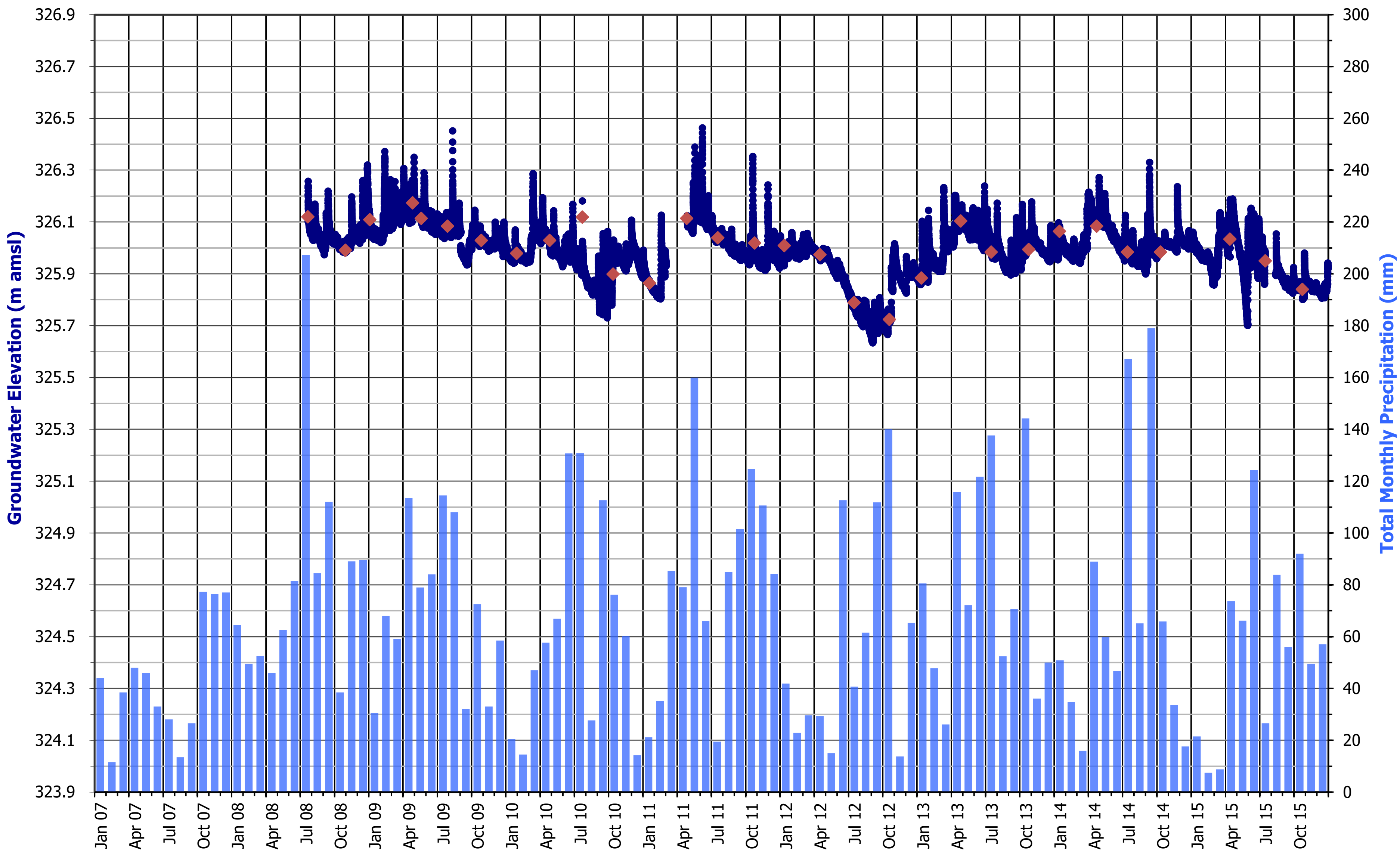
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phases 2 & 3 - Core PSW** **Graph G 20a**

Groundwater Elevation & Precipitation - MW122A (July 2008 to December 2015)



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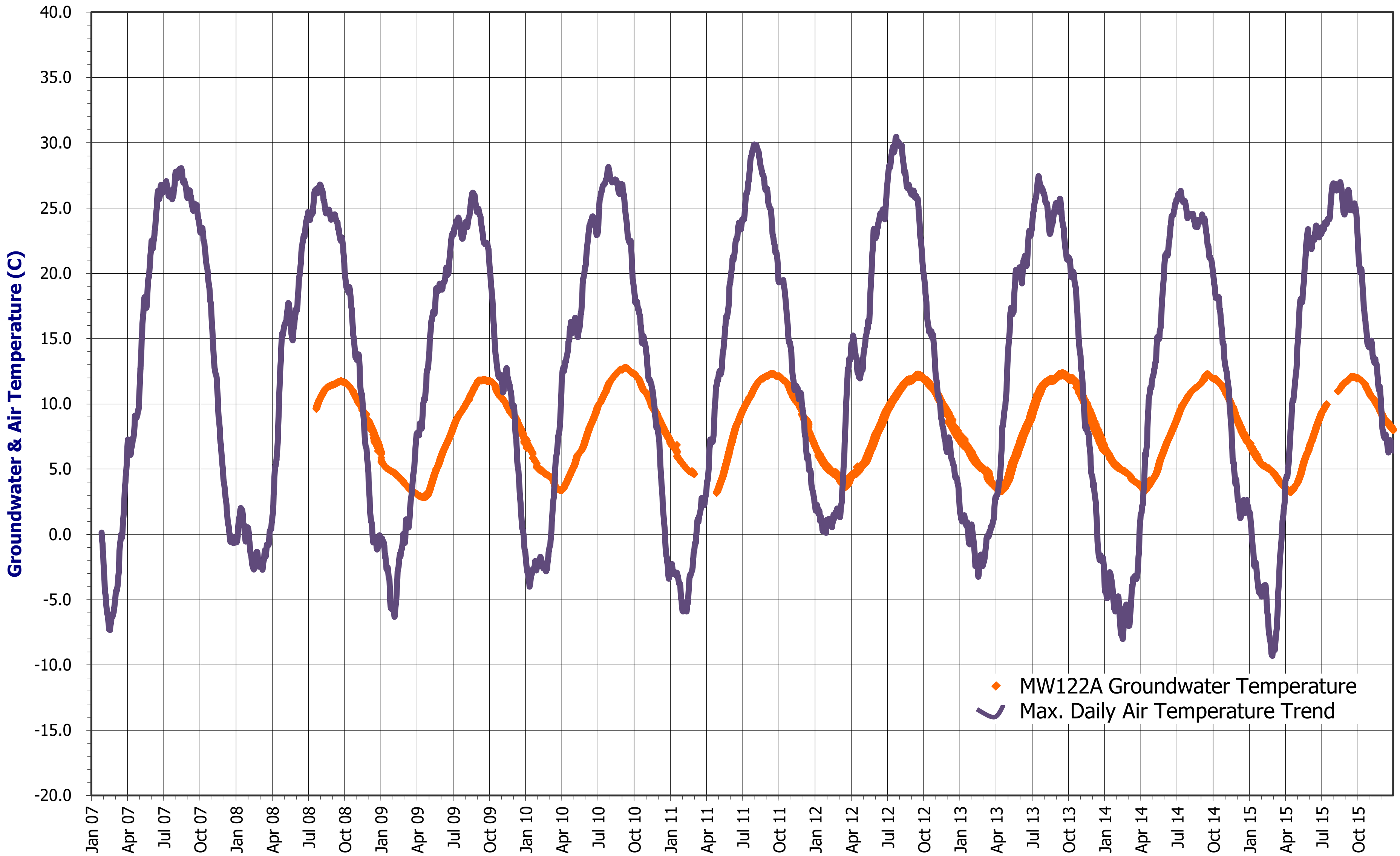
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Core PSW** **Graph G 21**

Groundwater & Maximum Daily Air Temperature - MW122A (July 2008 to December 2015)

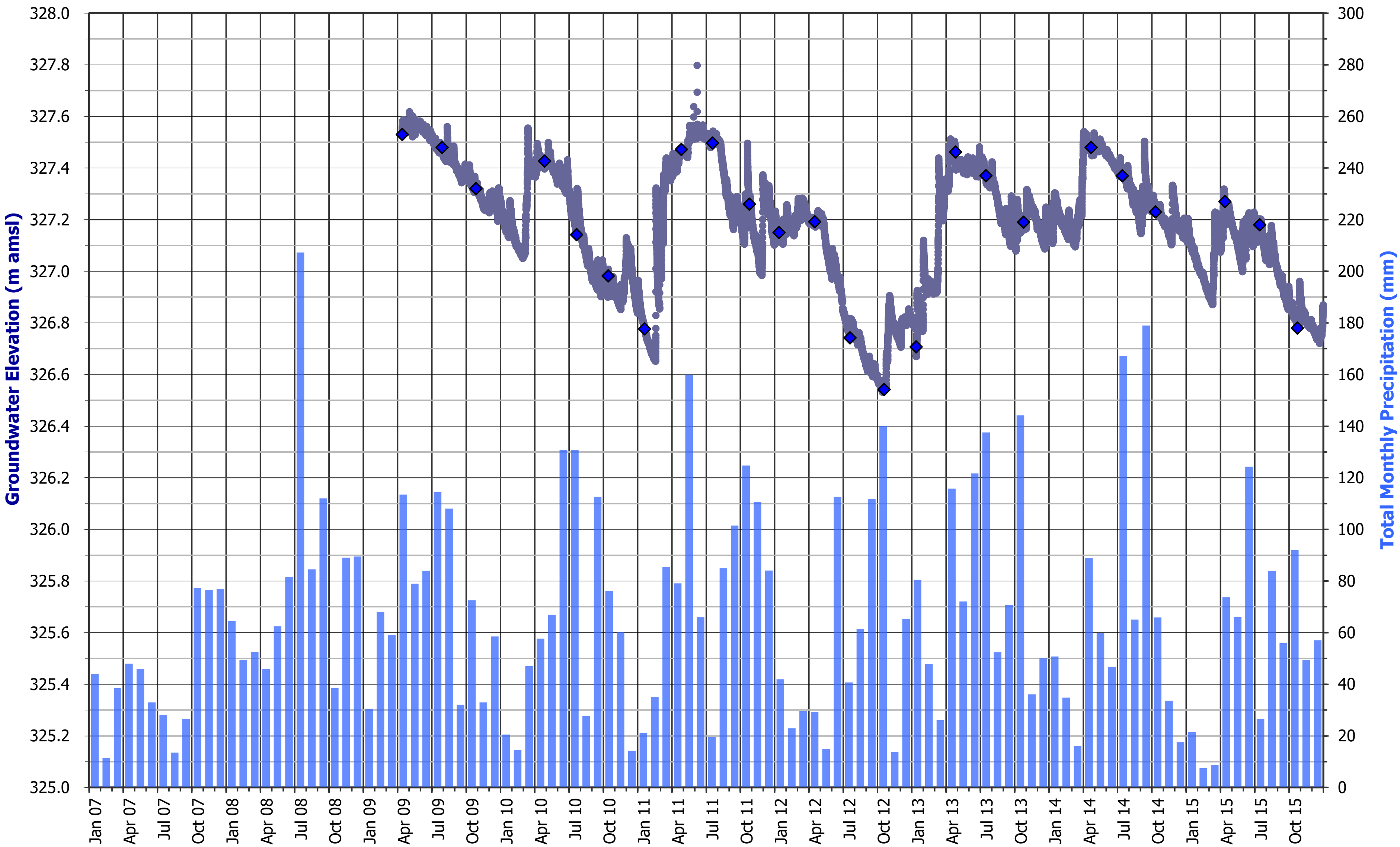


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Core PSW** **Graph G 21a**

Groundwater Elevation & Precipitation - PZ-1D (April 2009 to December 2015)



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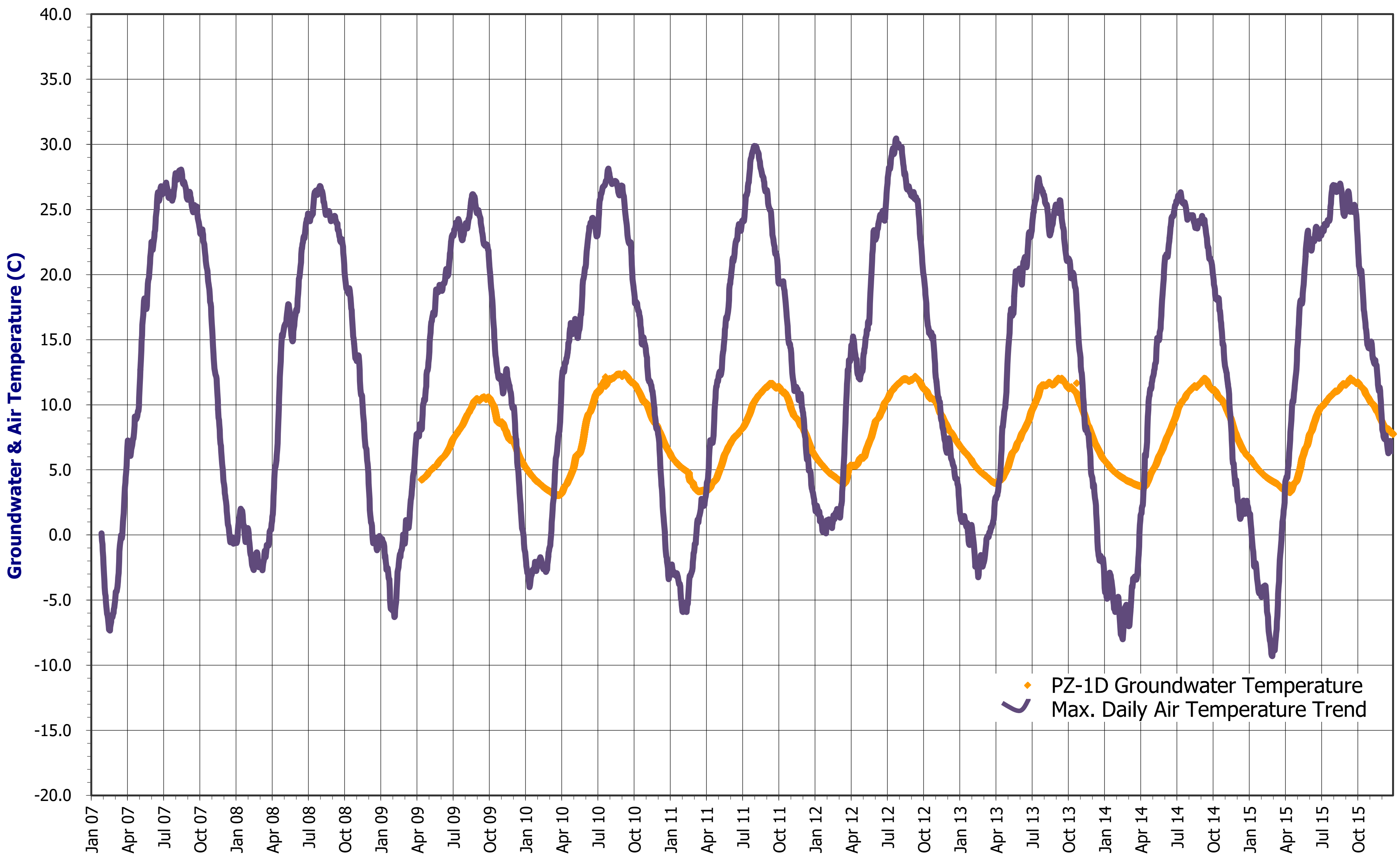
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Core PSW** **Graph G 22**

Groundwater & Maximum Daily Air Temperature - PZ-1D (April 2009 to December 2015)



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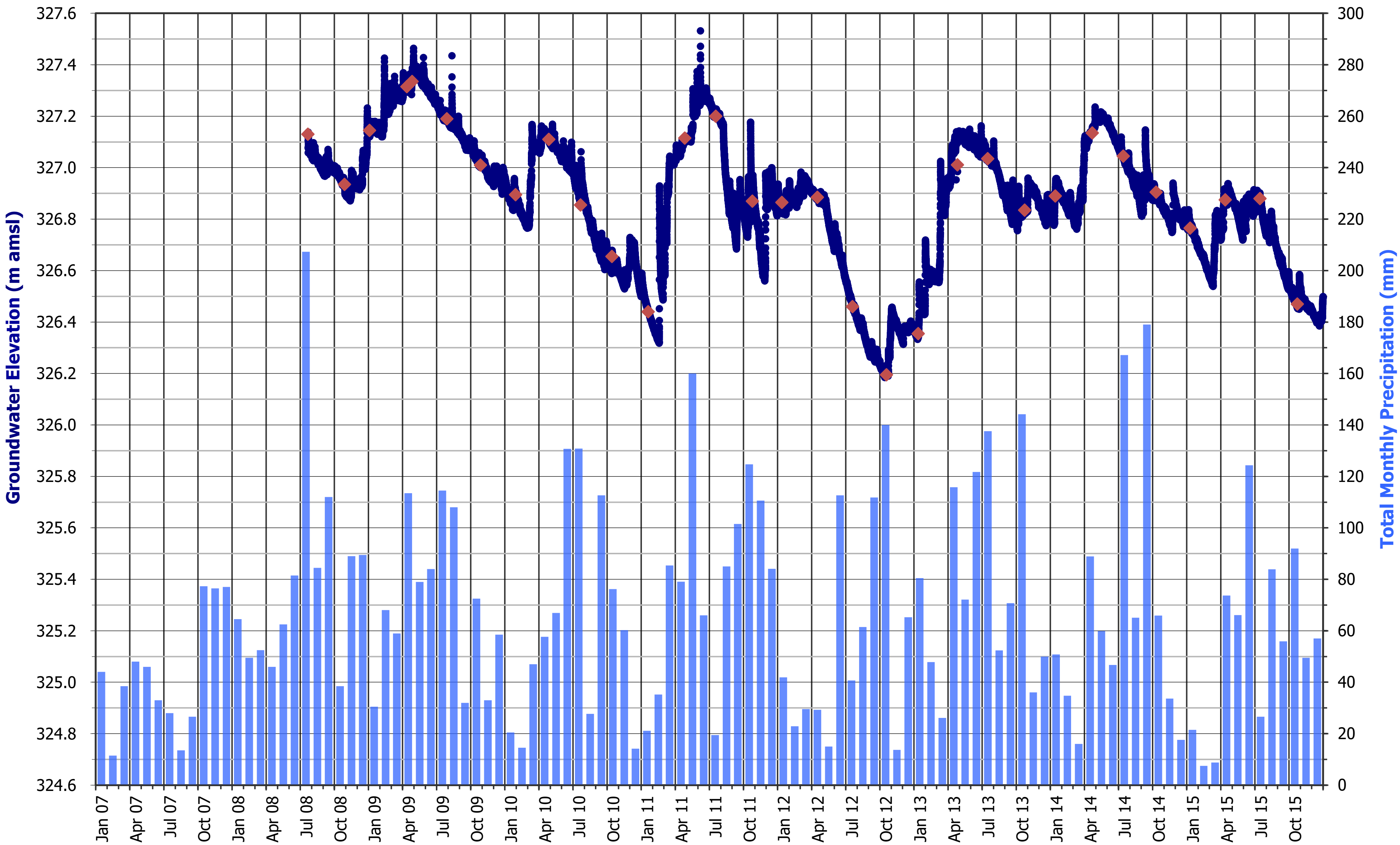
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Core PSW** **Graph G 22a**

Groundwater Elevation & Precipitation - MW121A (July 2008 to December 2015)



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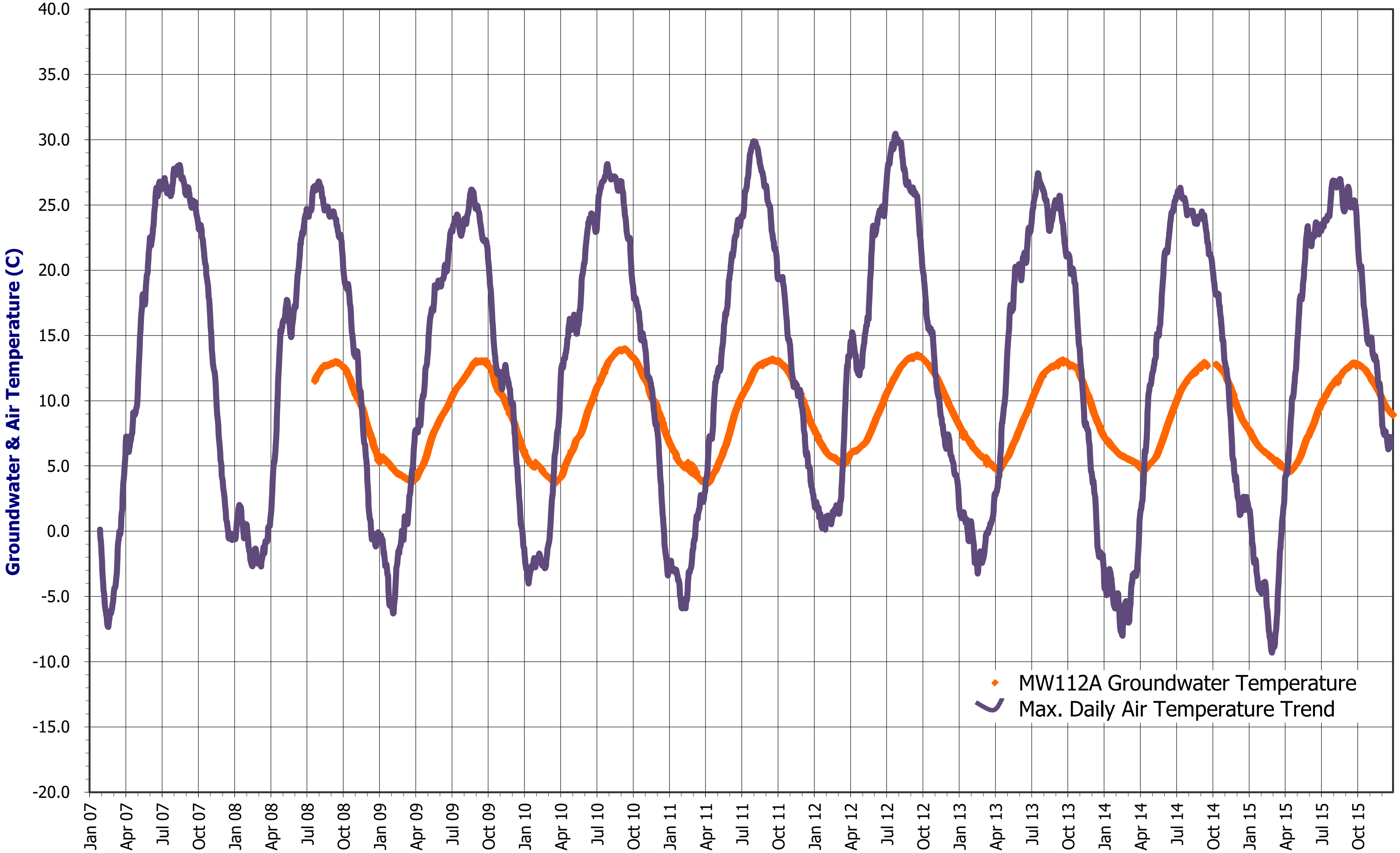
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 23**

Groundwater & Maximum Daily Air Temperature - MW121A (July 2008 to December 2015)



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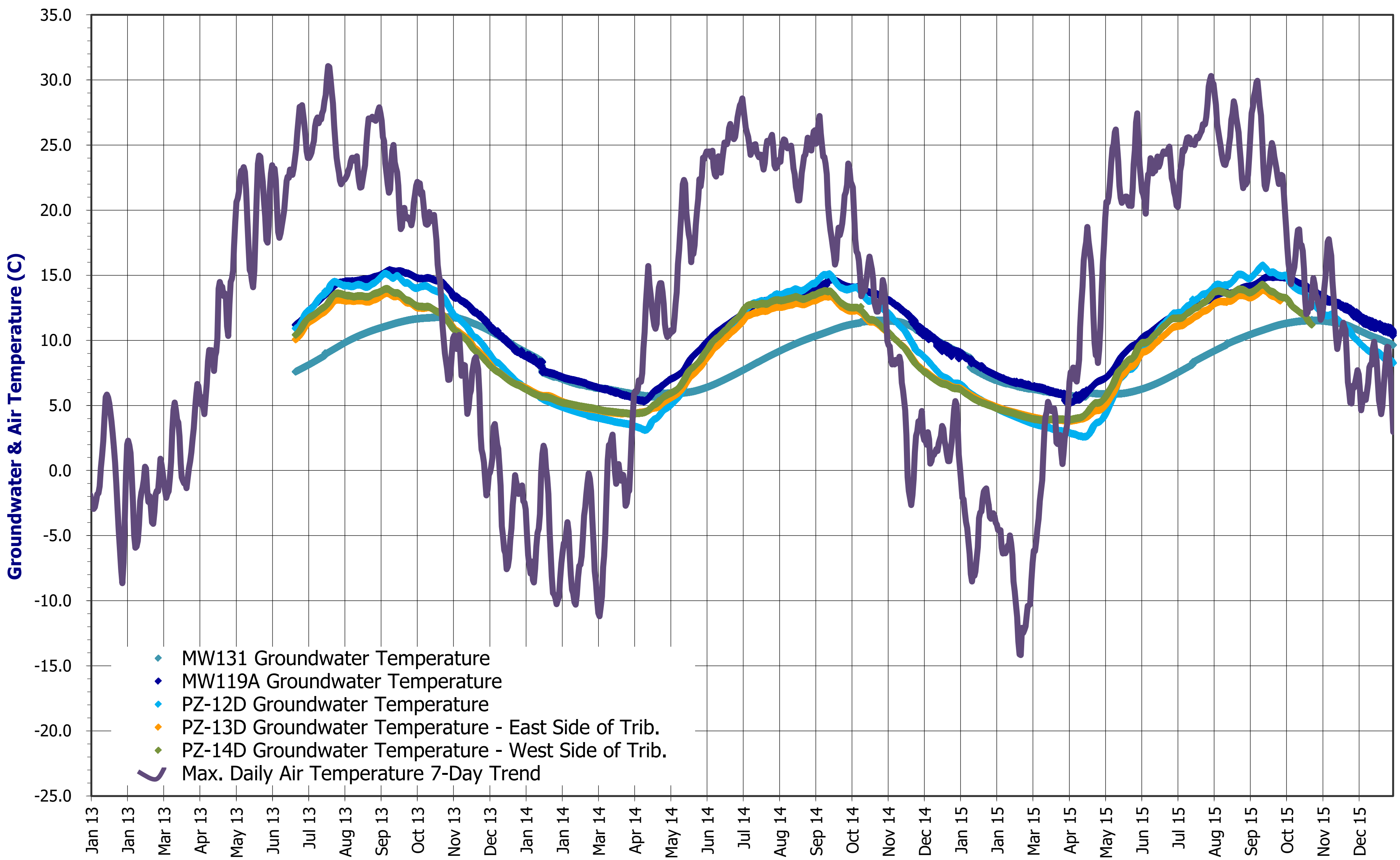
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 23a**

Groundwater & Maximum Daily Air Temperature - PZ-13D, PZ-14D, MW119A & MW131 (21 June to 31 December 2015)



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Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Core PSW** **Graph G 24a**

Appendix H

HCBP Perimeter Groundwater Monitoring 2007 – 2015

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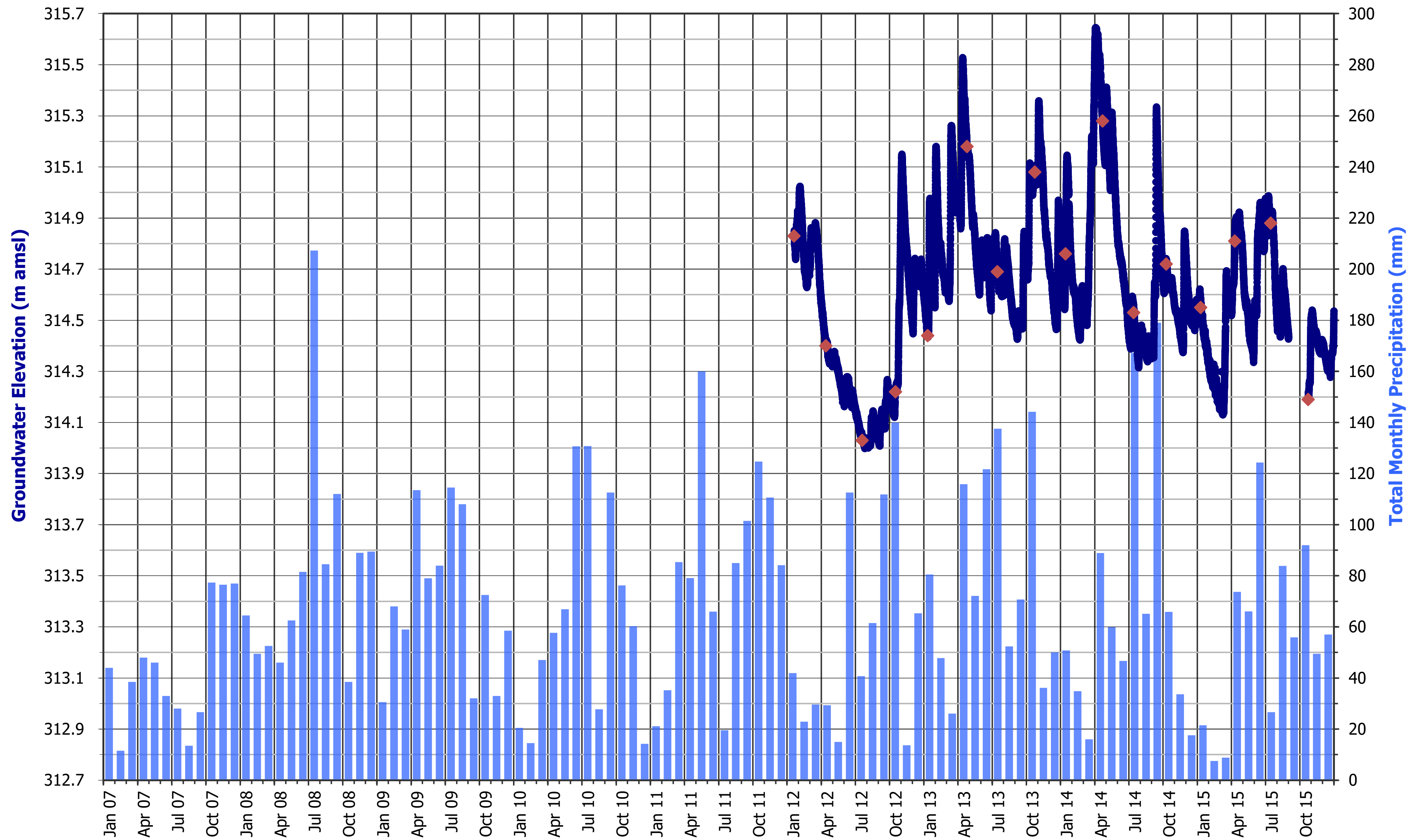
Groundwater Elevation & Precipitation - MW125 (January 2012 to December 2015)



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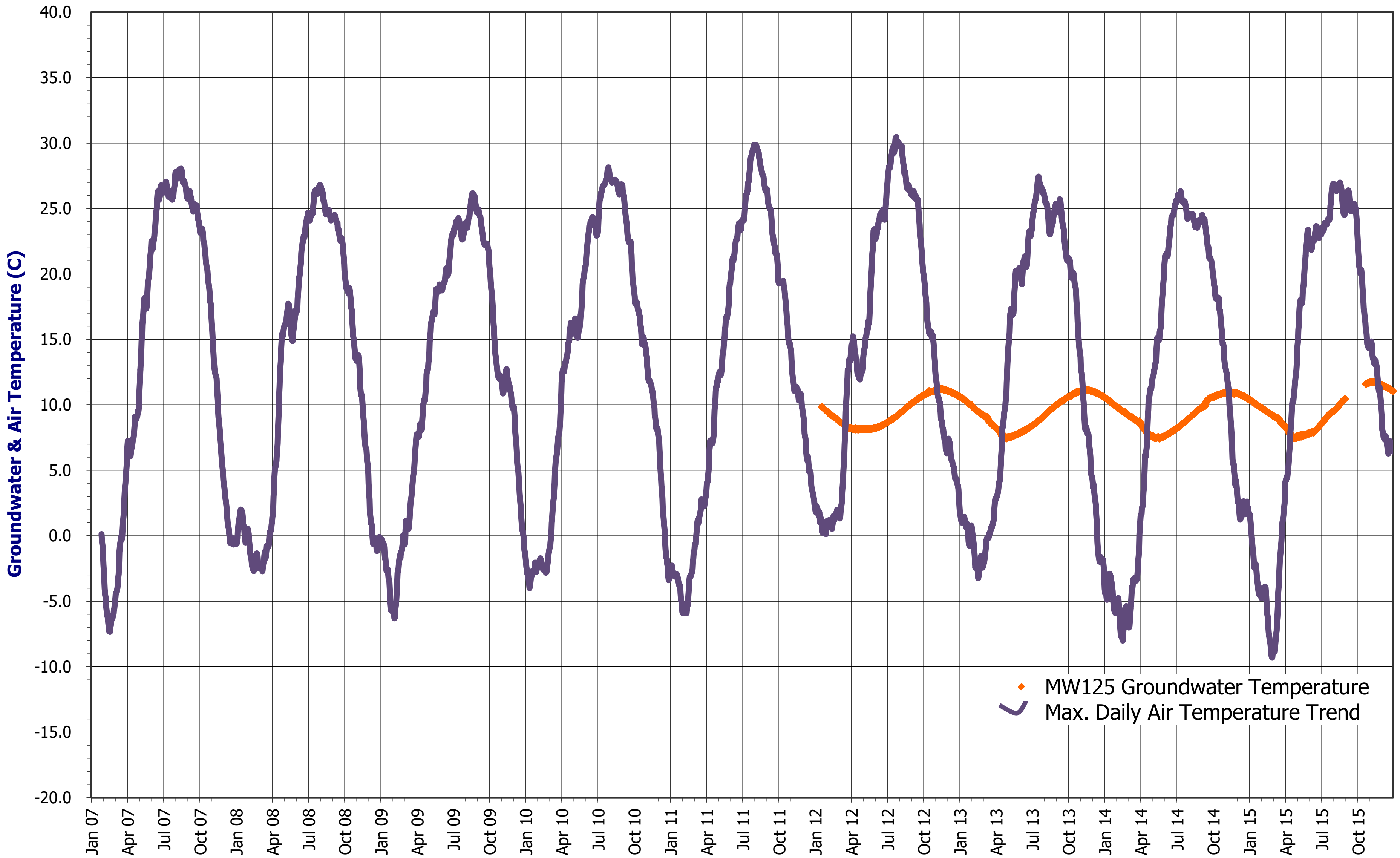
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 1**

Groundwater & Maximum Daily Air Temperature - MW125 (January 2012 to December 2015)

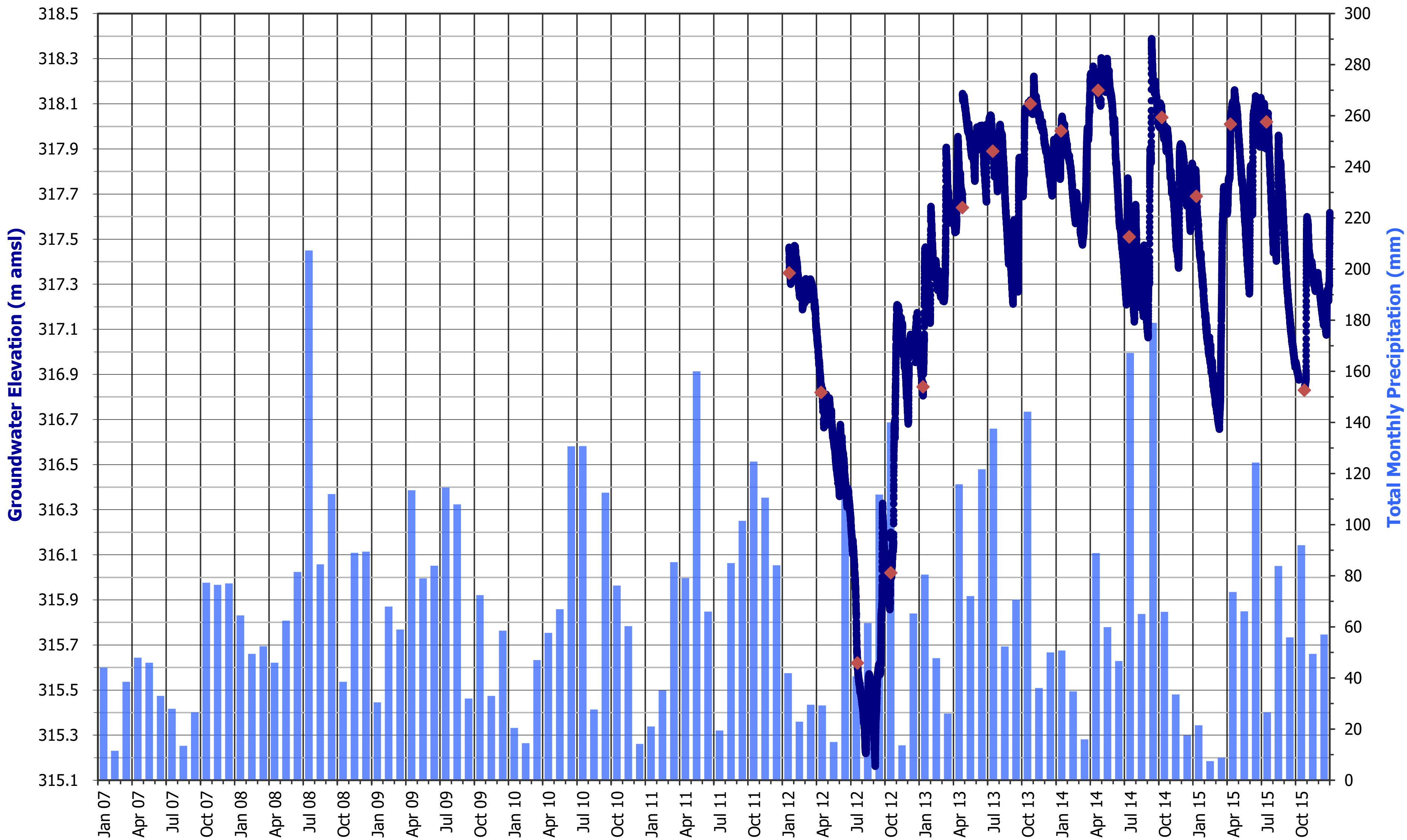


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 1a**

Groundwater Elevation & Precipitation - MW126 (January 2012 to December 2015)

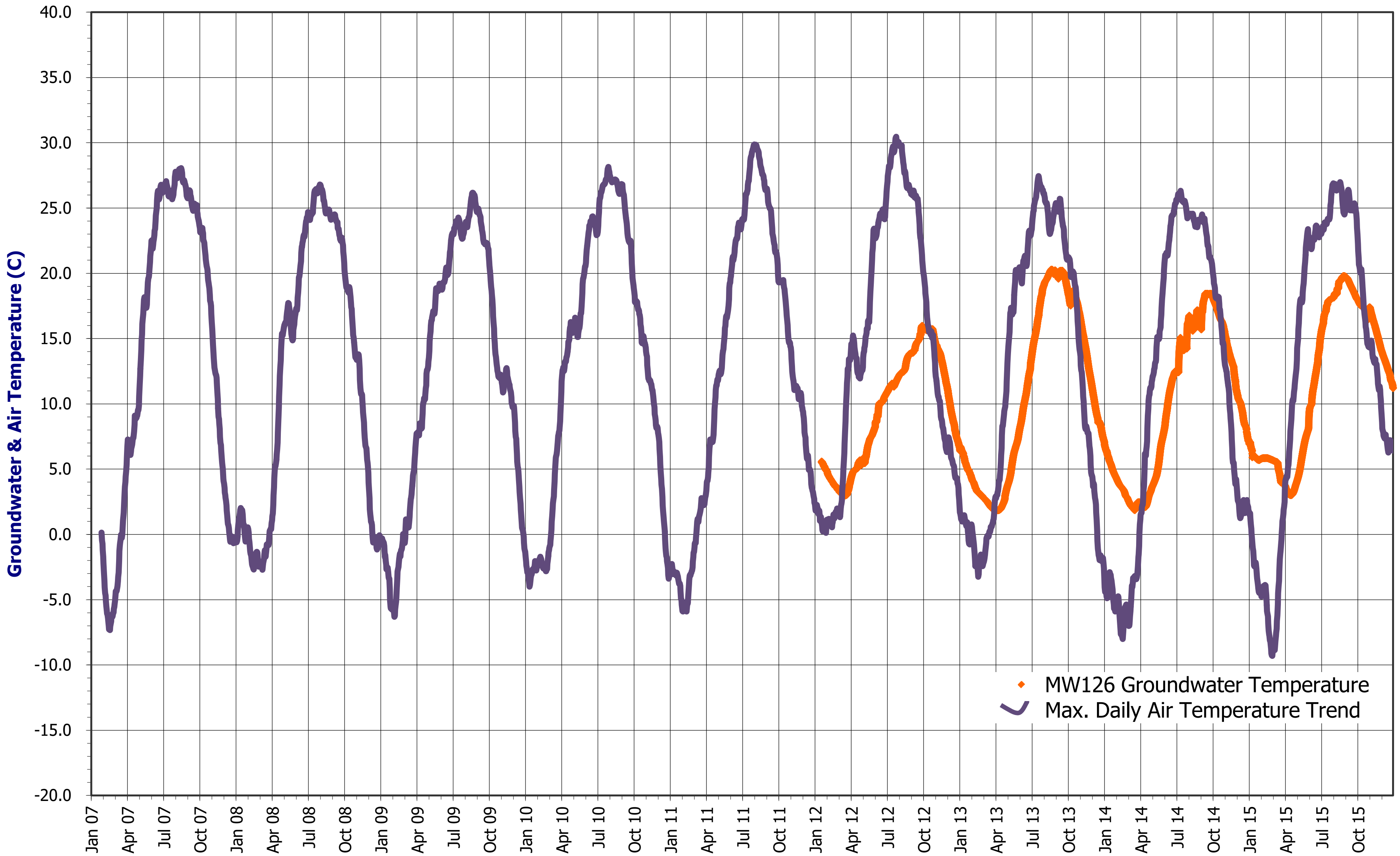


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 2**

Groundwater & Maximum Daily Air Temperature - MW126 (January 2012 to December 2015)

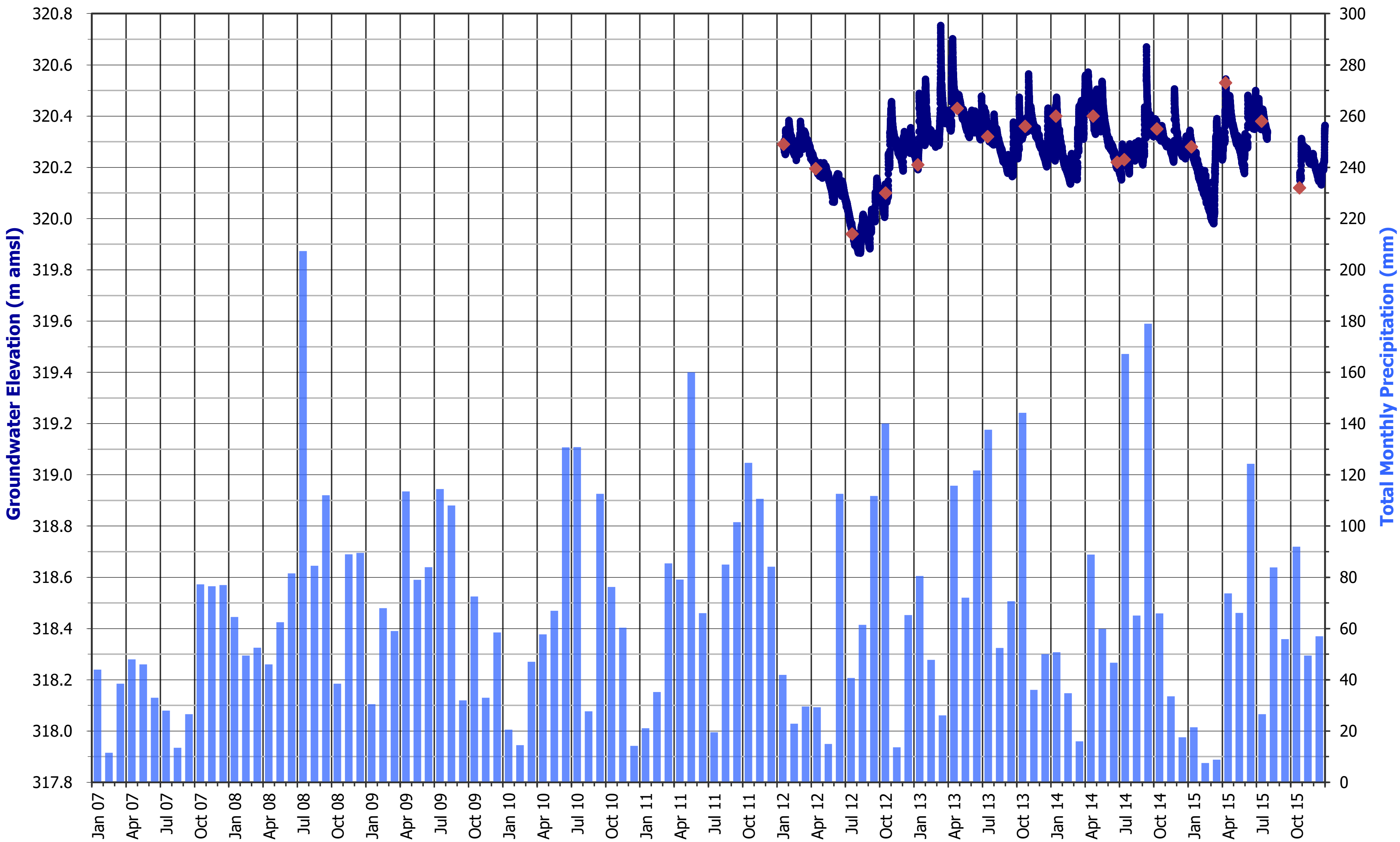


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 2a**

Groundwater Elevation & Precipitation - MW128 (January 2012 to December 2015)



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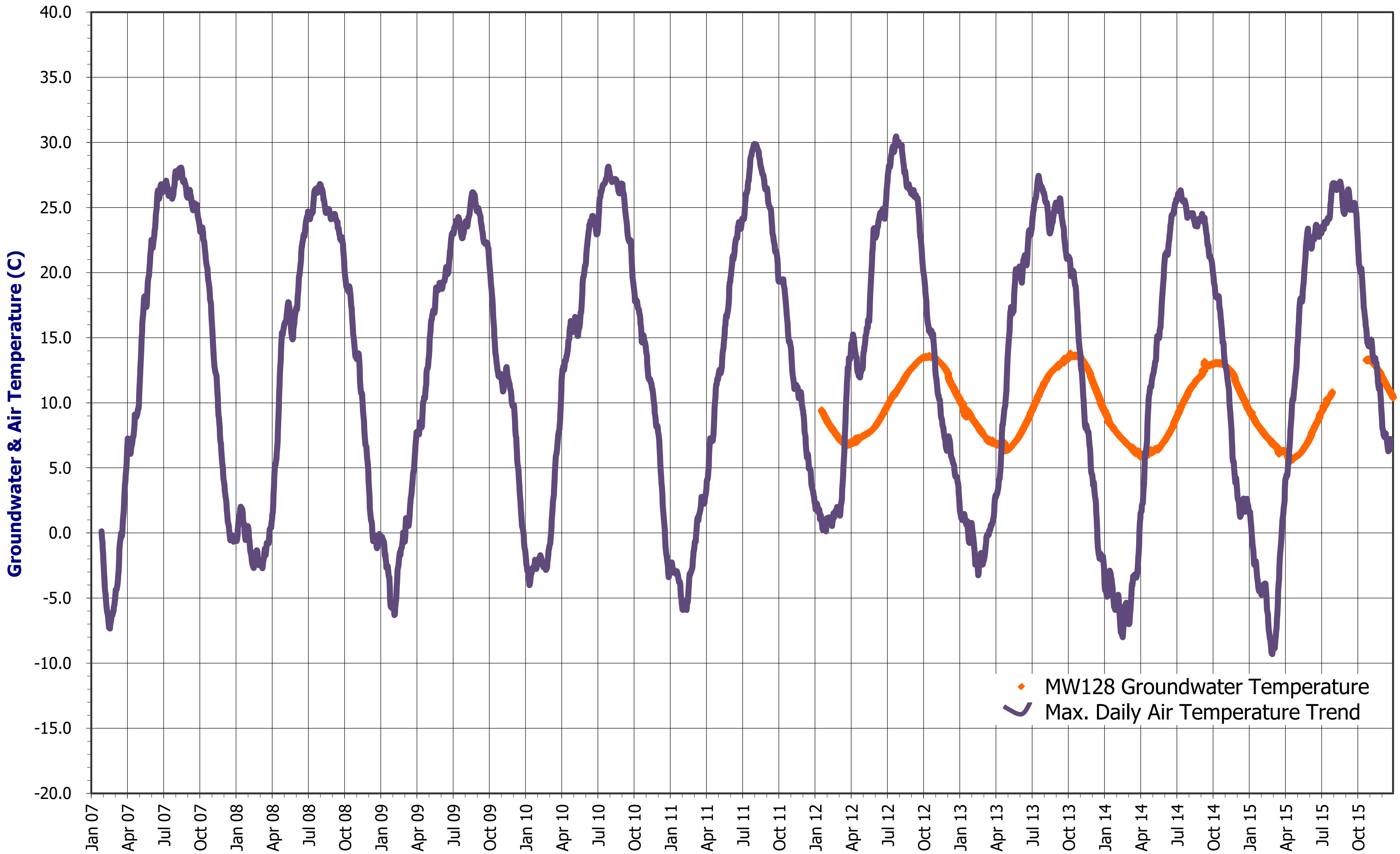
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 3**

Groundwater & Maximum Daily Air Temperature - MW128 (January 2012 to December 2015)



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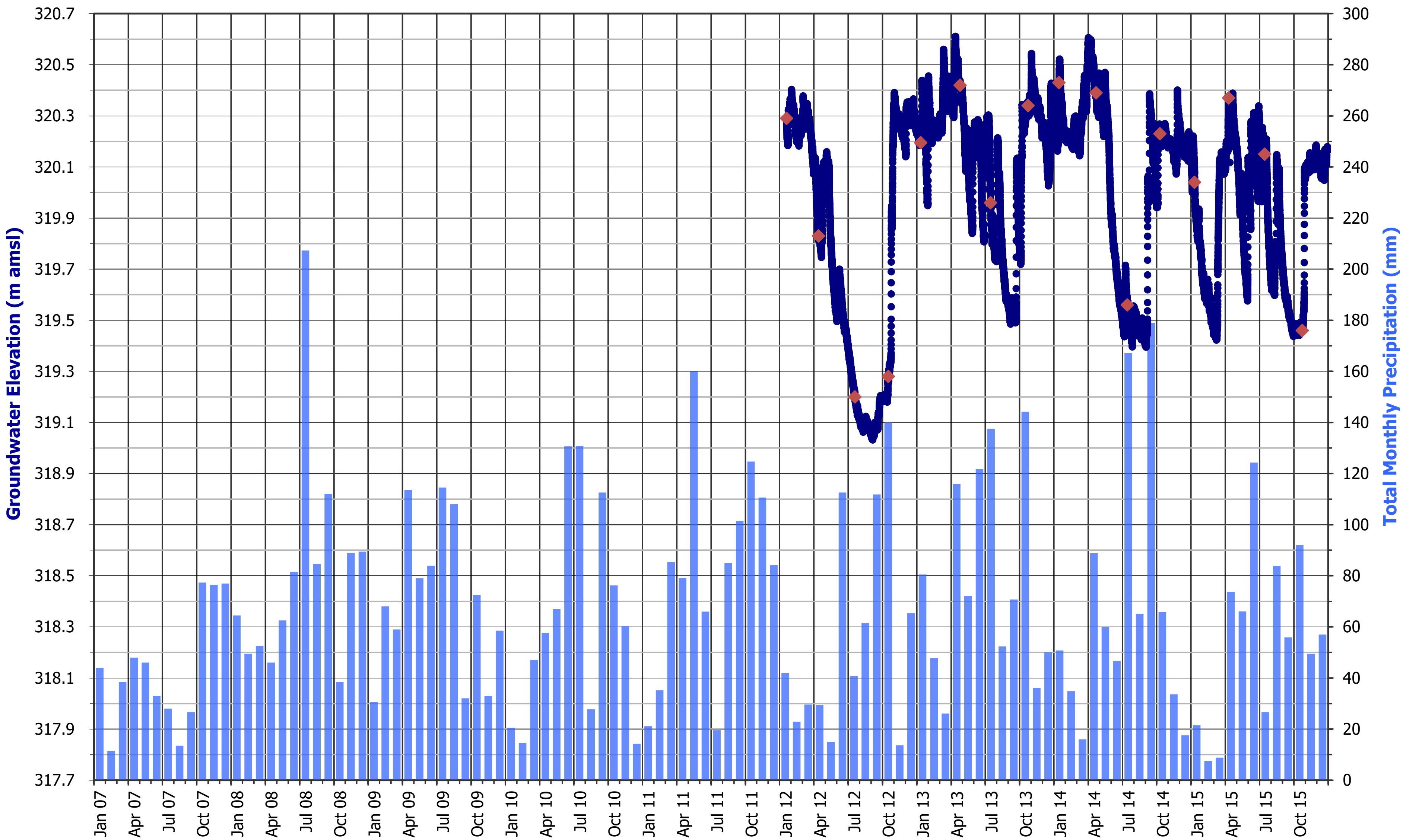
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 3a**

Groundwater Elevation & Precipitation - MW124 (January 2012 to December 2015)



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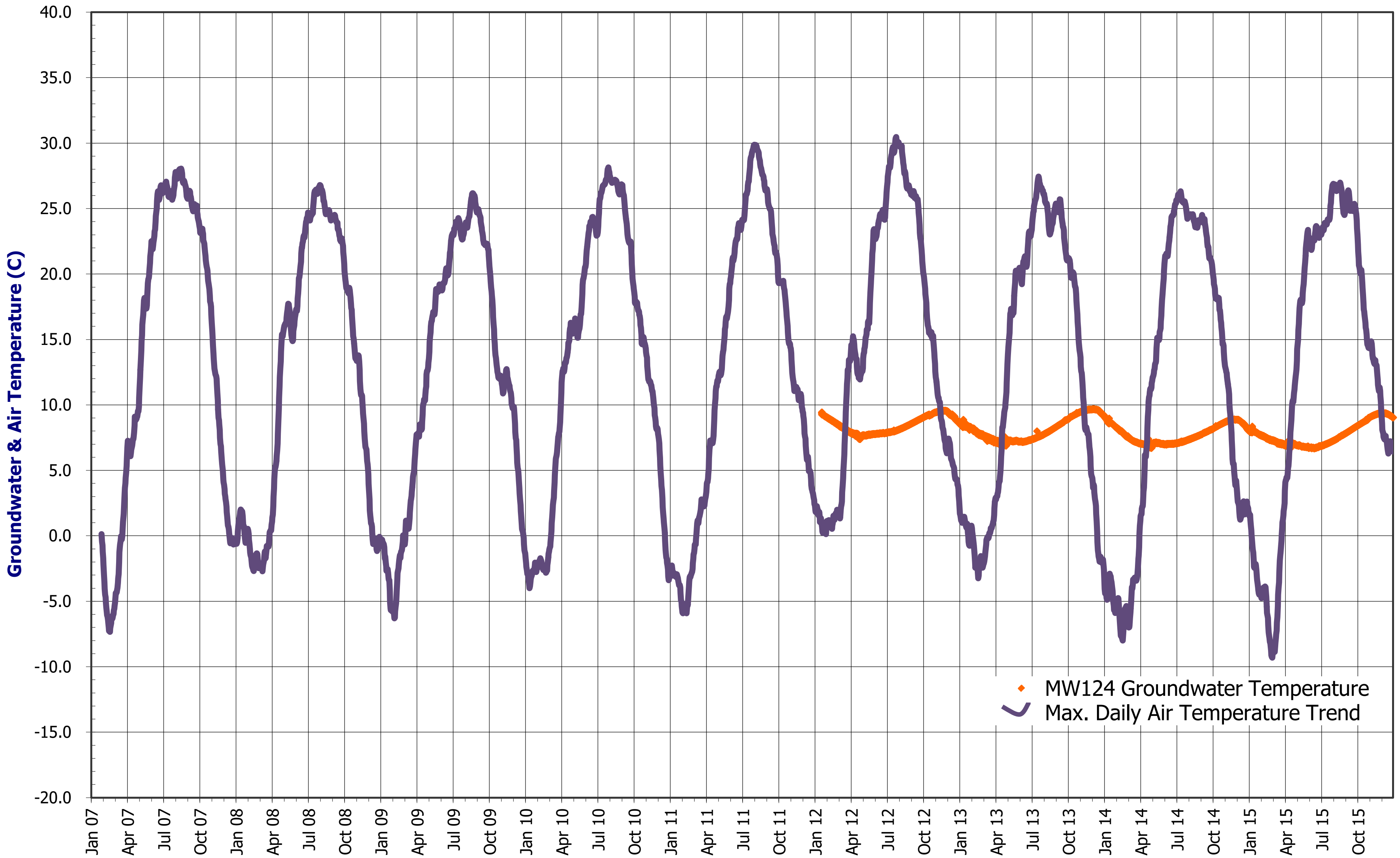
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 4**

Groundwater & Maximum Daily Air Temperature - MW124 (January 2012 to December 2015)



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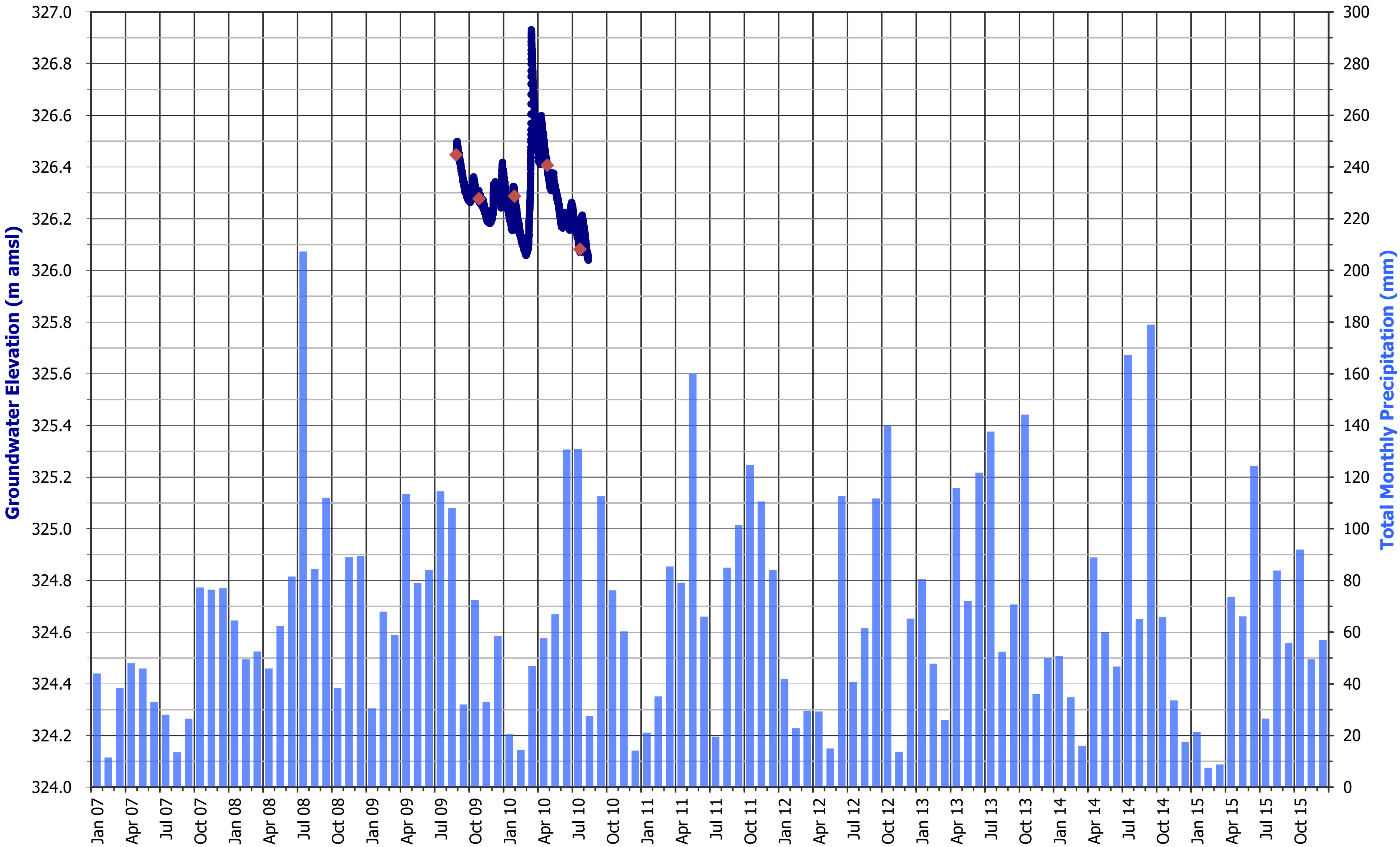
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 1 - Perimeter** **Graph H 4a**

Groundwater Elevation & Precipitation - MW106 (August 09 to August 10) Abandoned 2012



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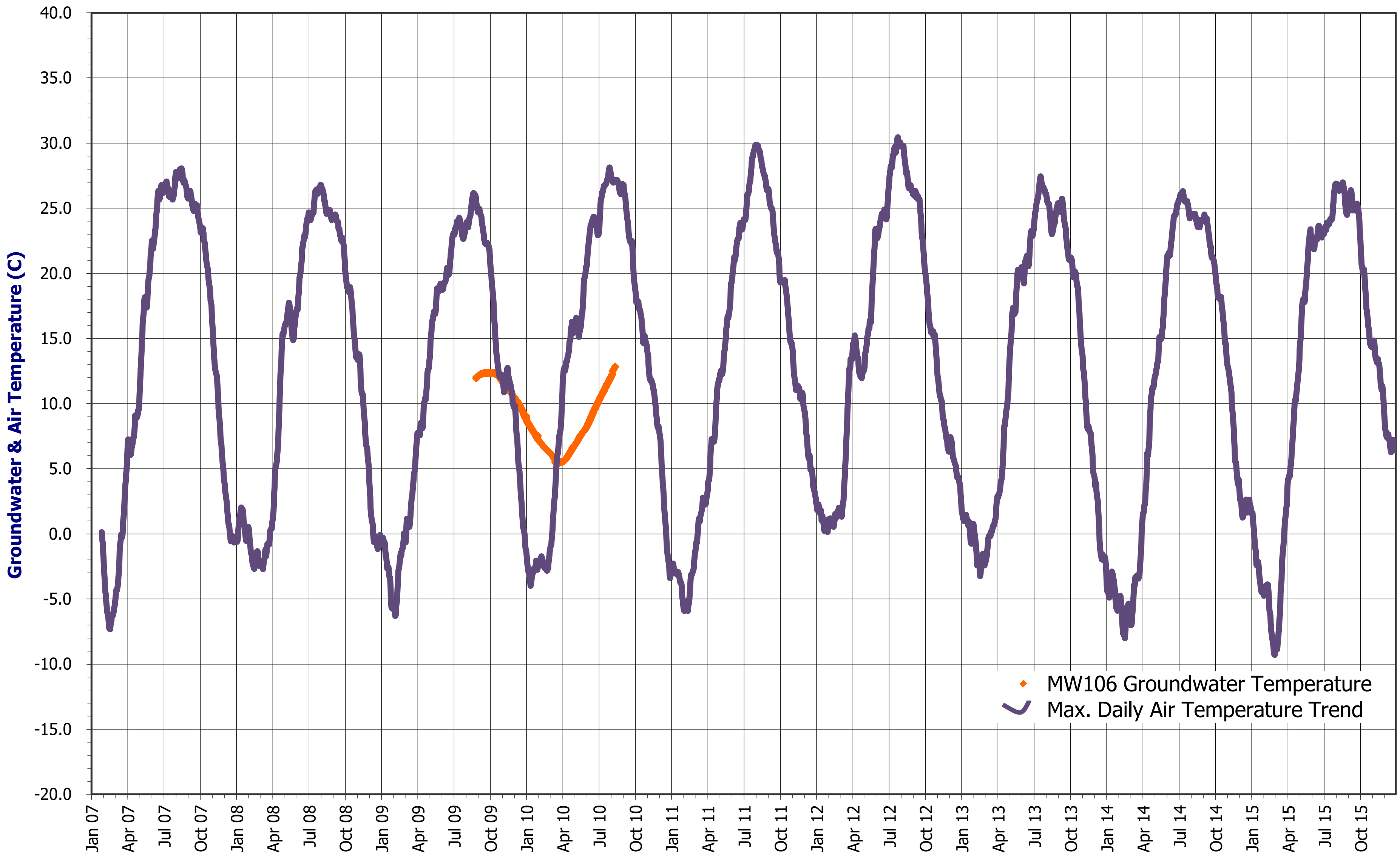
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 5**

Groundwater & Maximum Daily Air Temperature - MW106 (August 09 to August 10) Abandoned 2012



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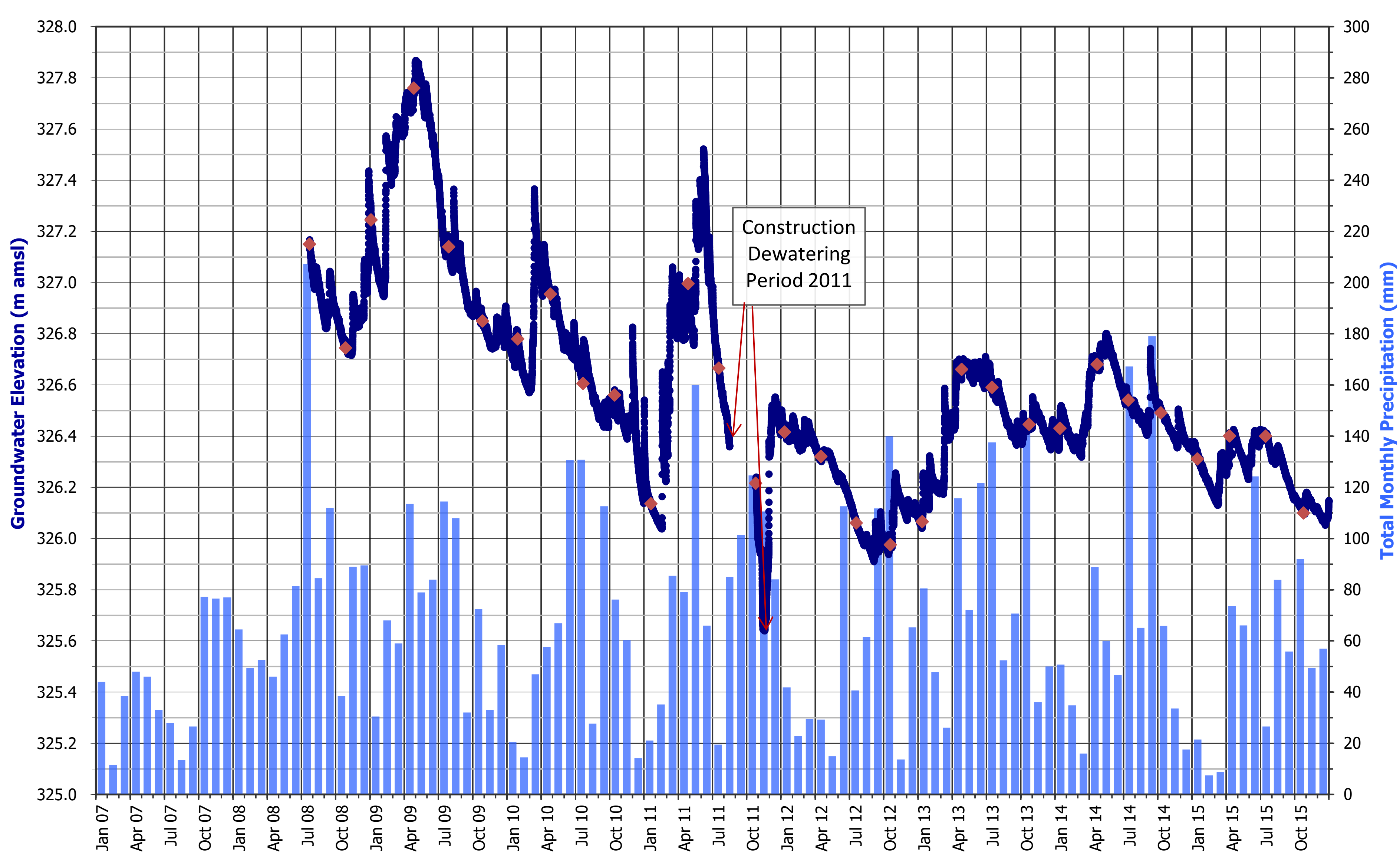
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 5a**

Groundwater Elevation & Precipitation - MW107 (July 2008 to December 2015)



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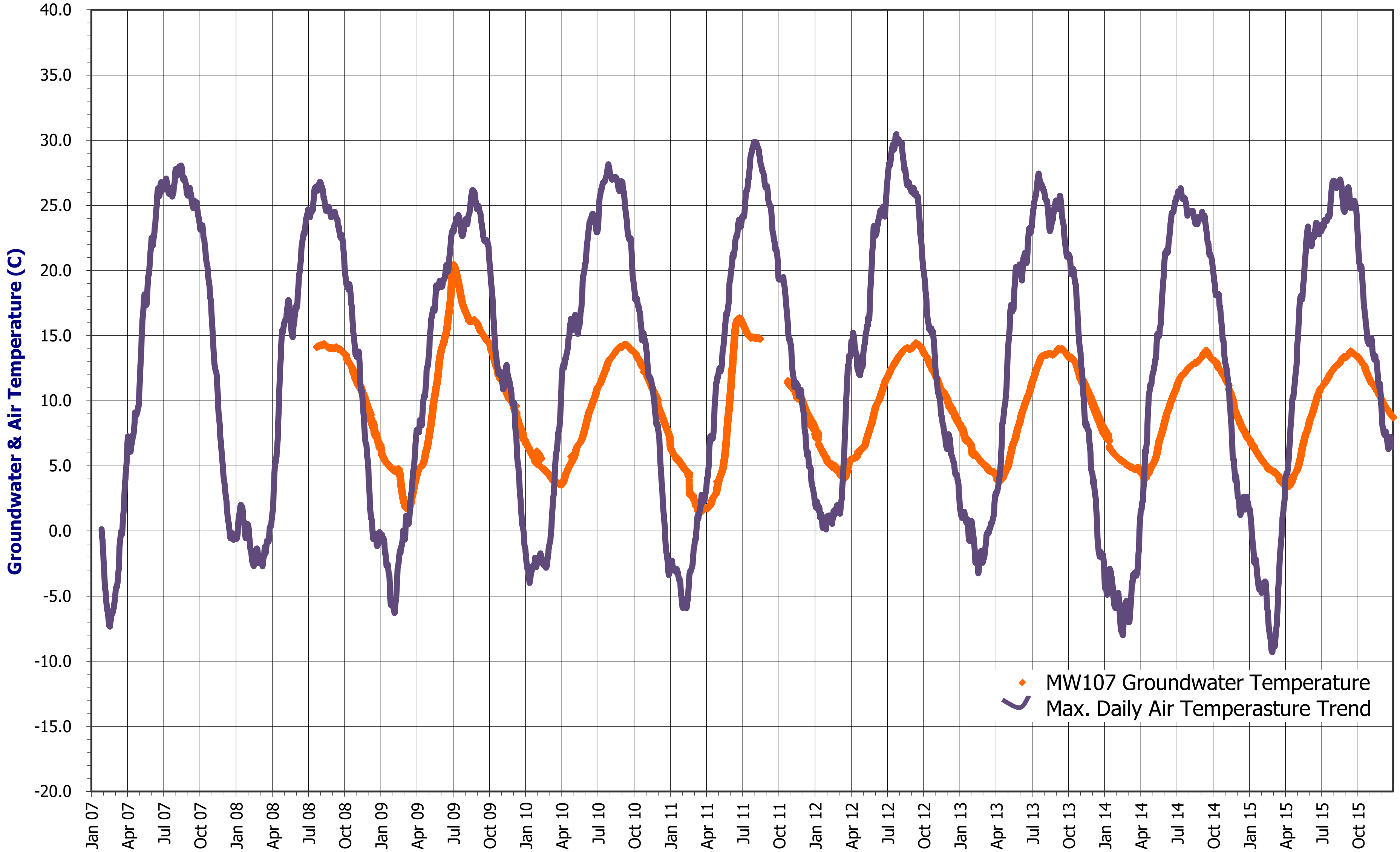
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 6**

Groundwater & Maximum Daily Air Temperature - MW107 (July 2008 to December 2015)

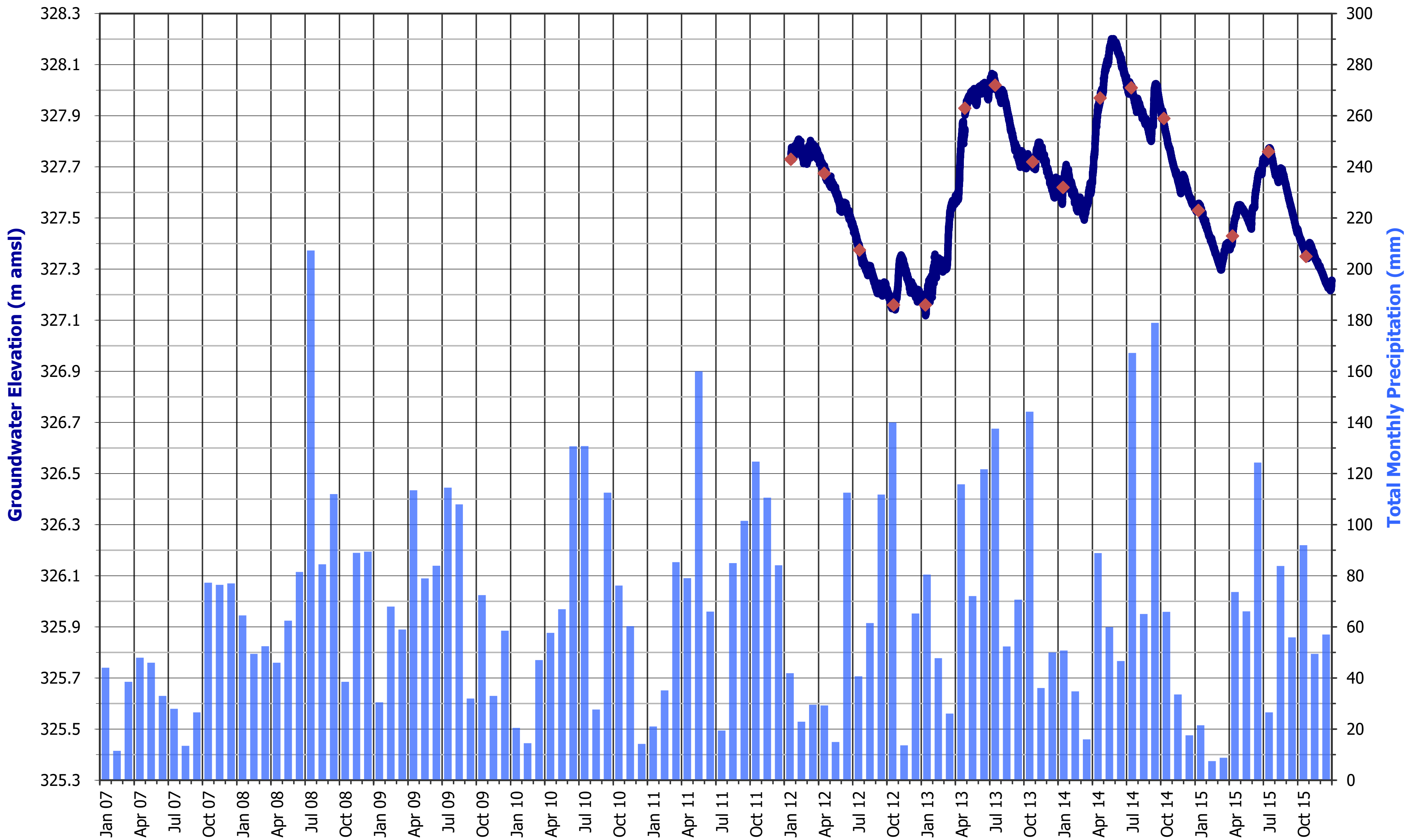


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 6a**

Groundwater Elevation & Precipitation - MW132 (January 2012 to December 2015)



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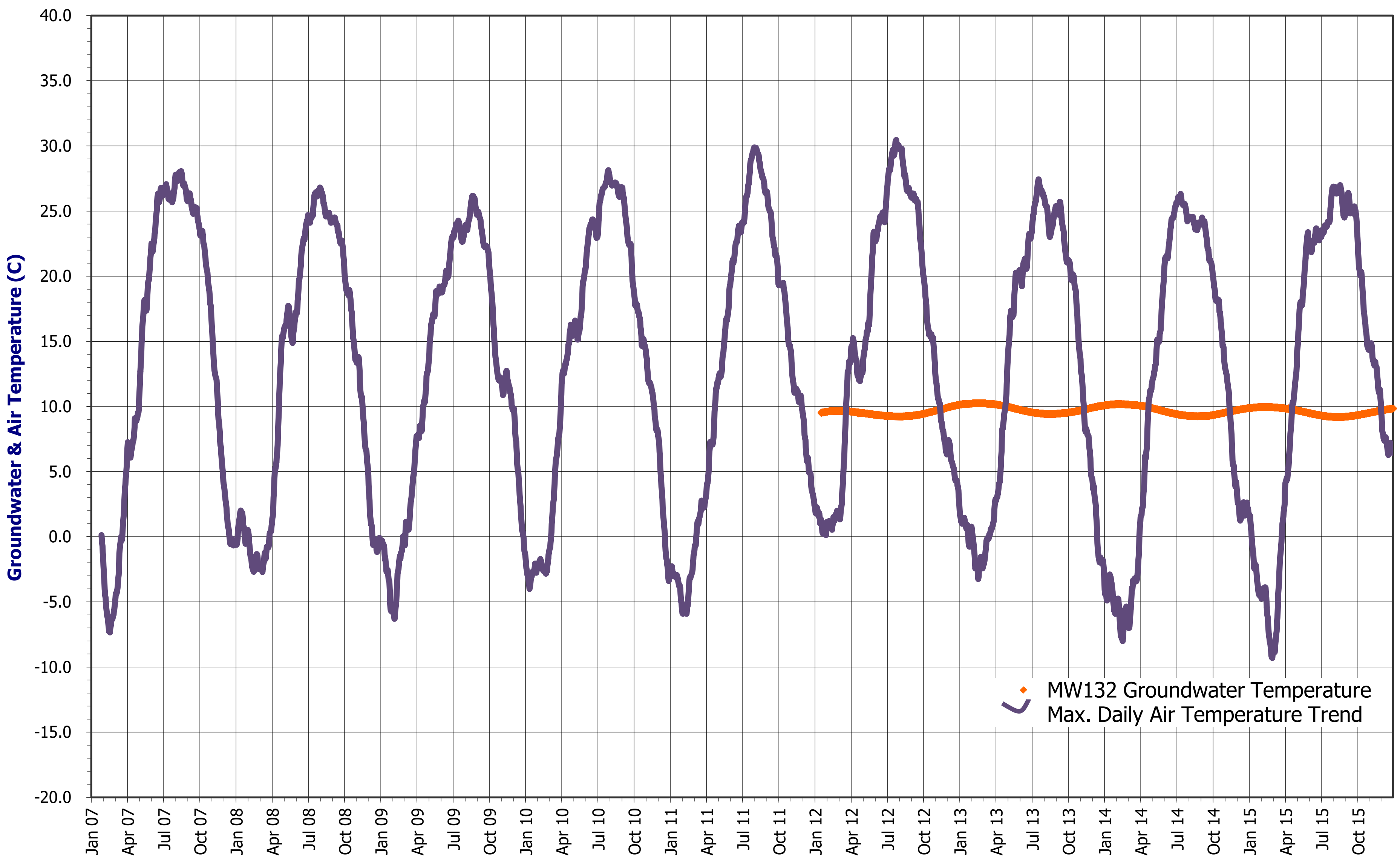
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 7**

Groundwater & Maximum Daily Air Temperature - MW132 (January 2012 to December 2015)



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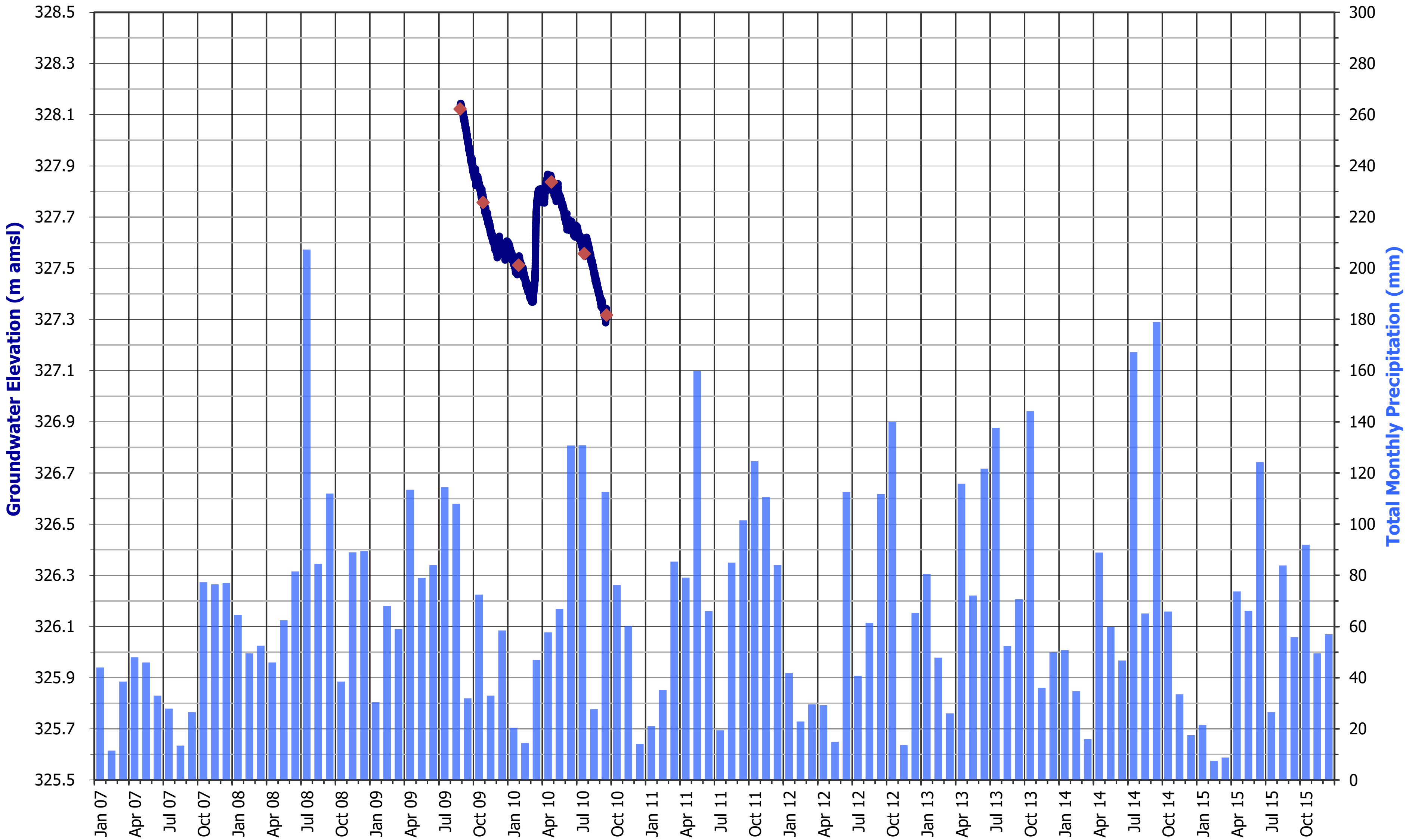
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 | **Phase 2 - Perimeter** | **Graph H 7a**

Groundwater Elevation & Precipitation - MW006 (August 09 to September 10) Abandoned 2010



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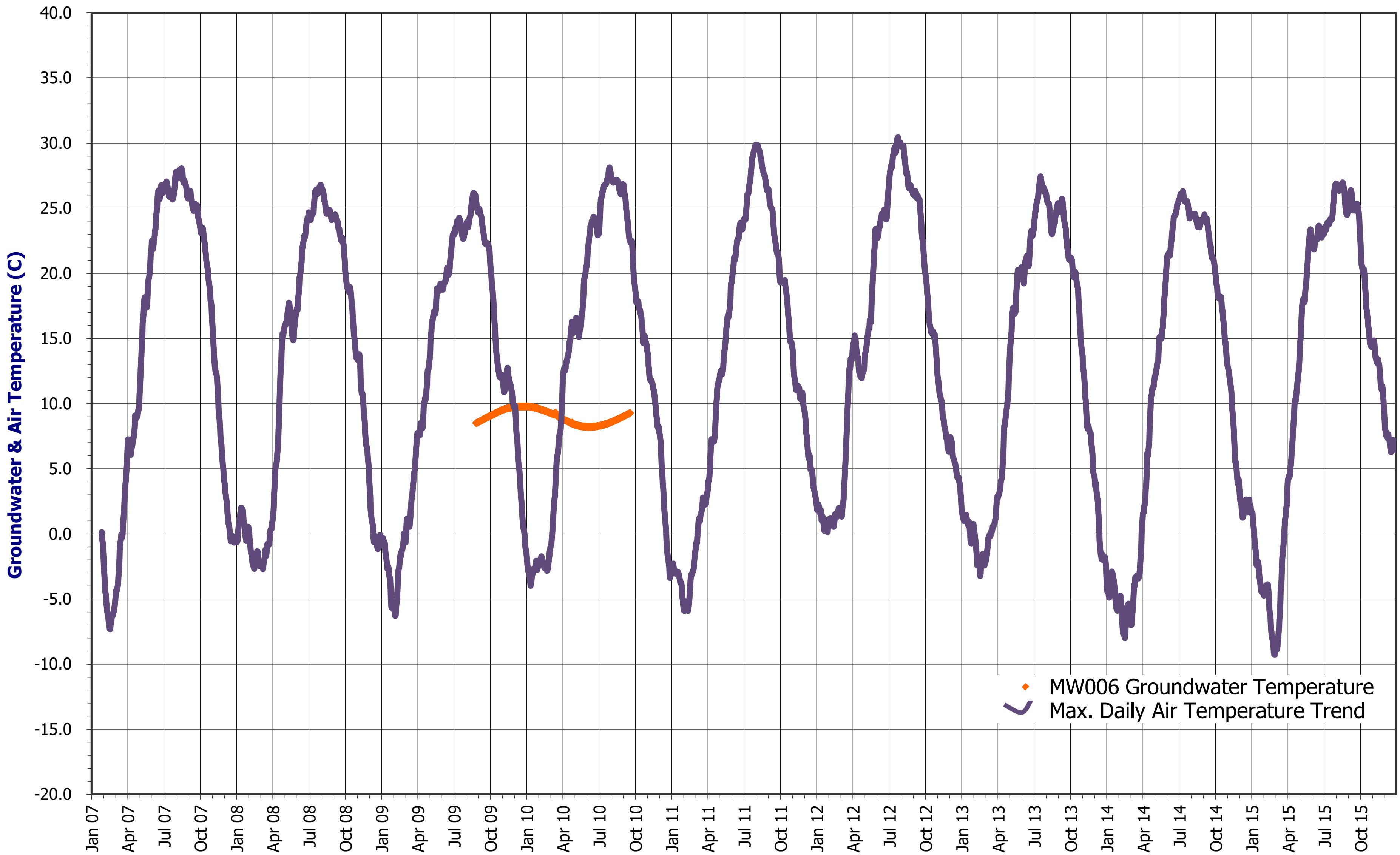
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter Graph H 8**

Groundwater & Maximum Daily Air Temperature - MW006 (August 09 to September 10) Abandoned 2010



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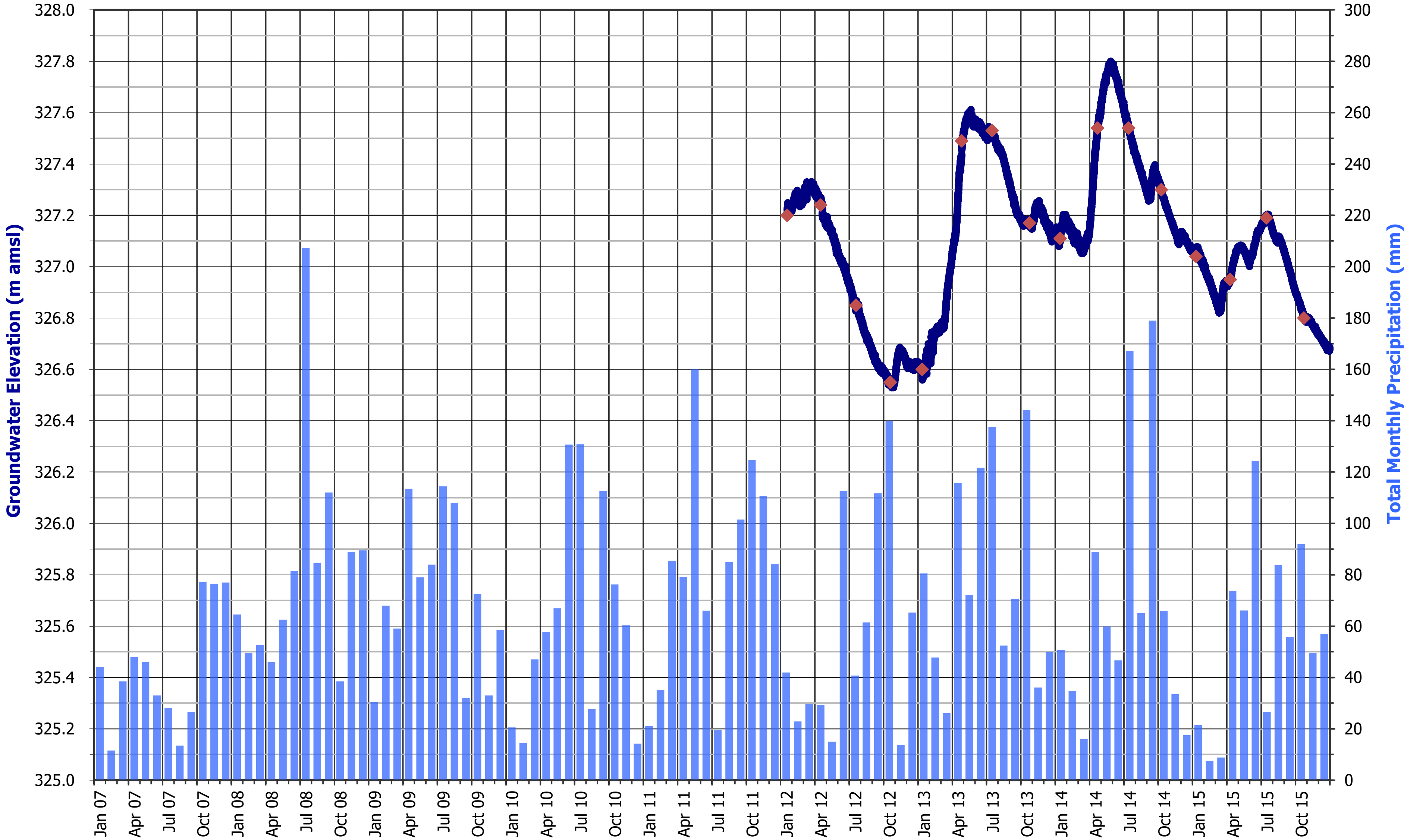
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 8a**

Groundwater Elevation & Precipitation - MW135 (January 2012 to December 2015)



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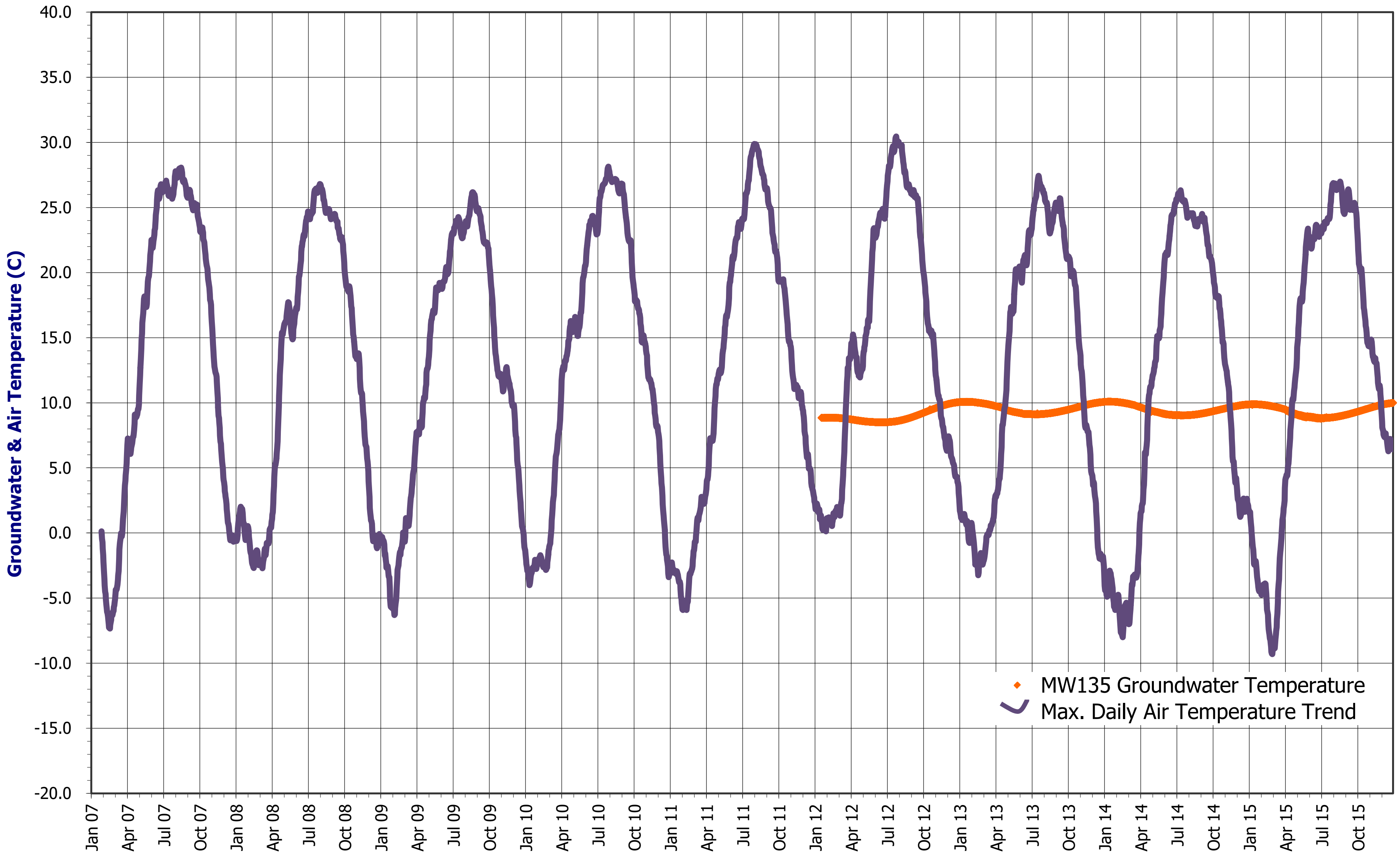
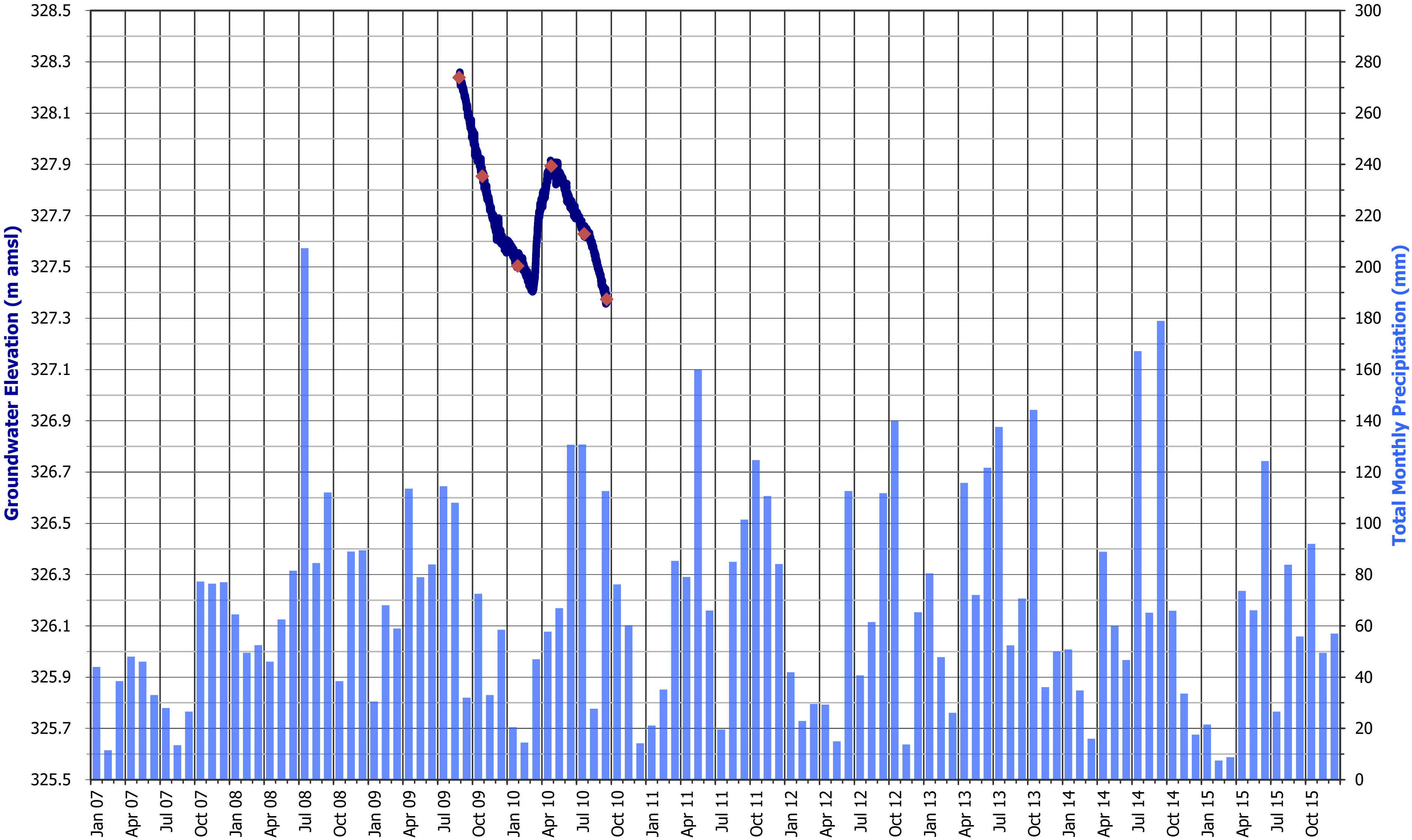
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 9**

Groundwater & Maximum Daily Air Temperature - MW135 (January 2012 to December 2015)



Groundwater Elevation & Precipitation - MW005I (August 09 to September 10) Abandoned 2010



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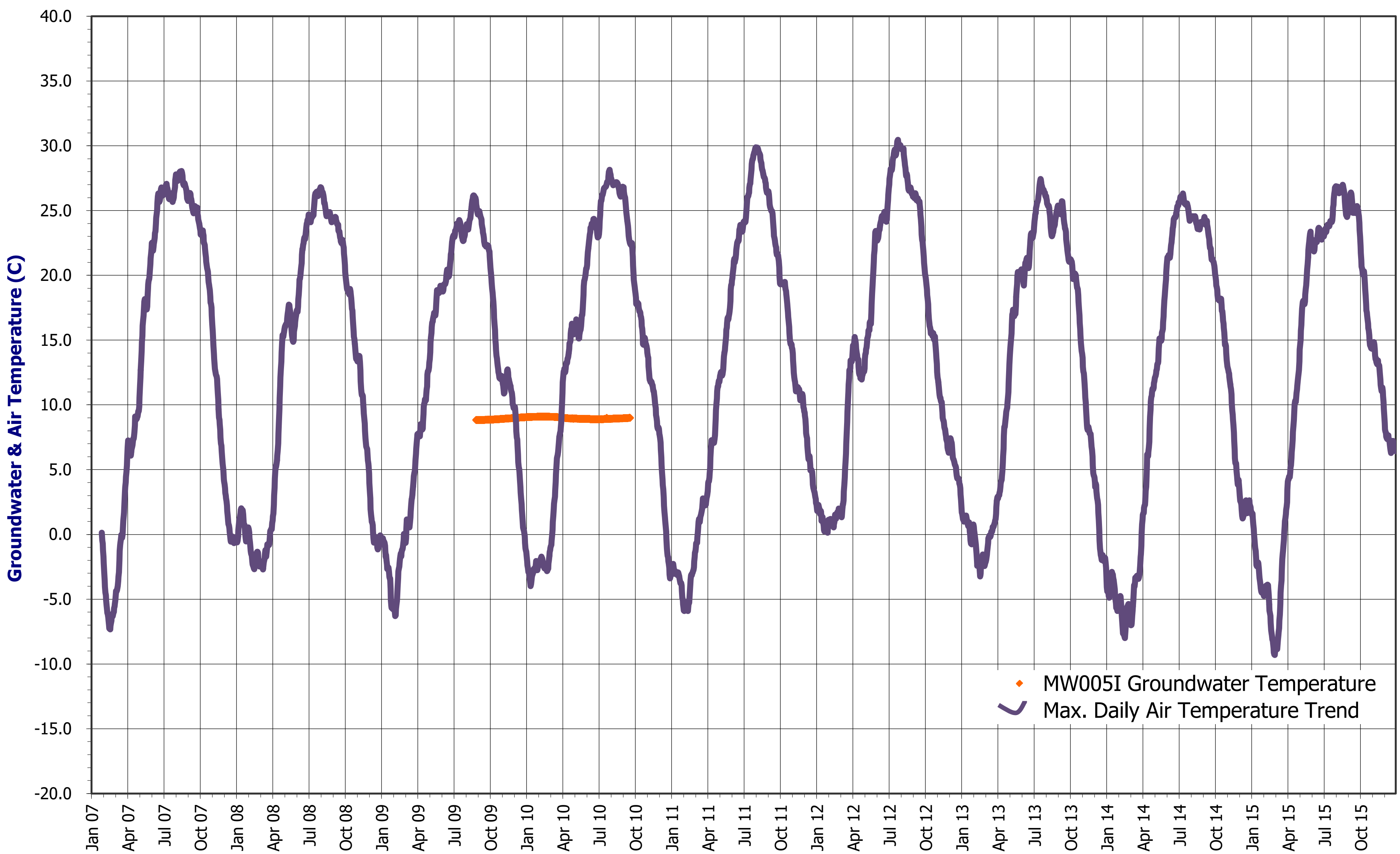
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 10**

Groundwater & Maximum Daily Air Temperature - MW005I (August 09 to September 10) Abandoned 2010



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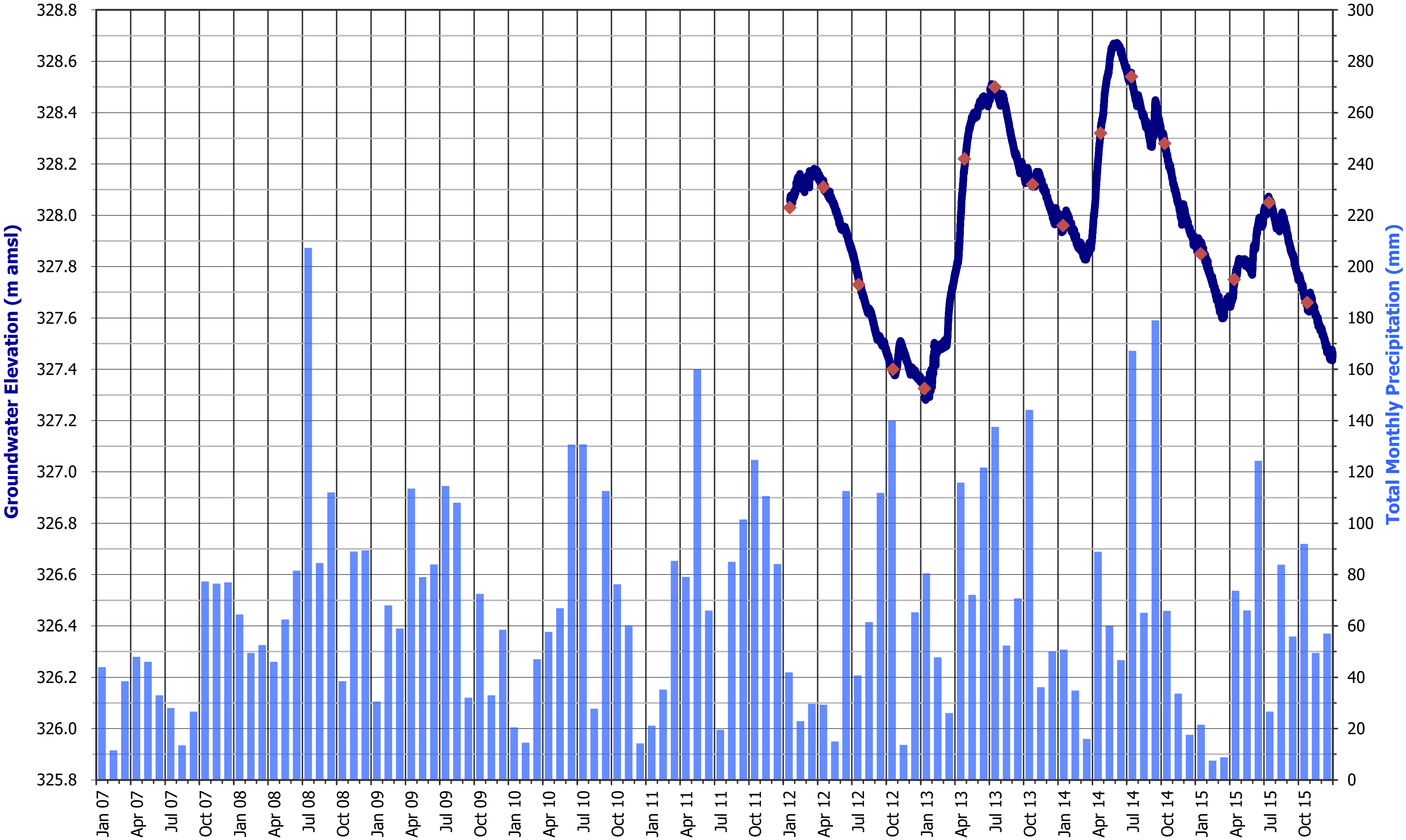
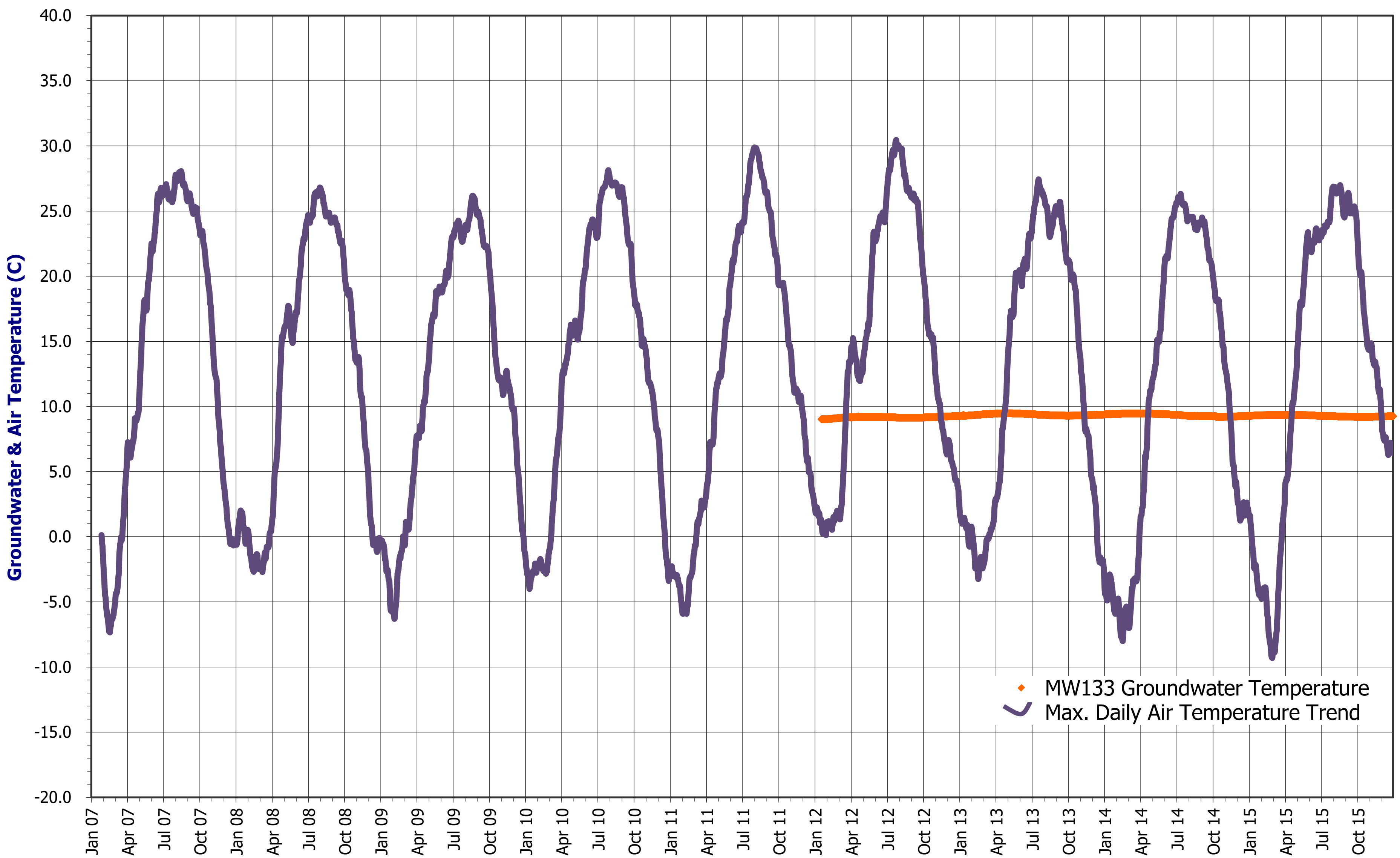
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 10a**

Groundwater Elevation & Precipitation - MW133 (January 2012 to December 2015)



Groundwater & Maximum Daily Air Temperature - MW133 (January 2012 to December 2015)



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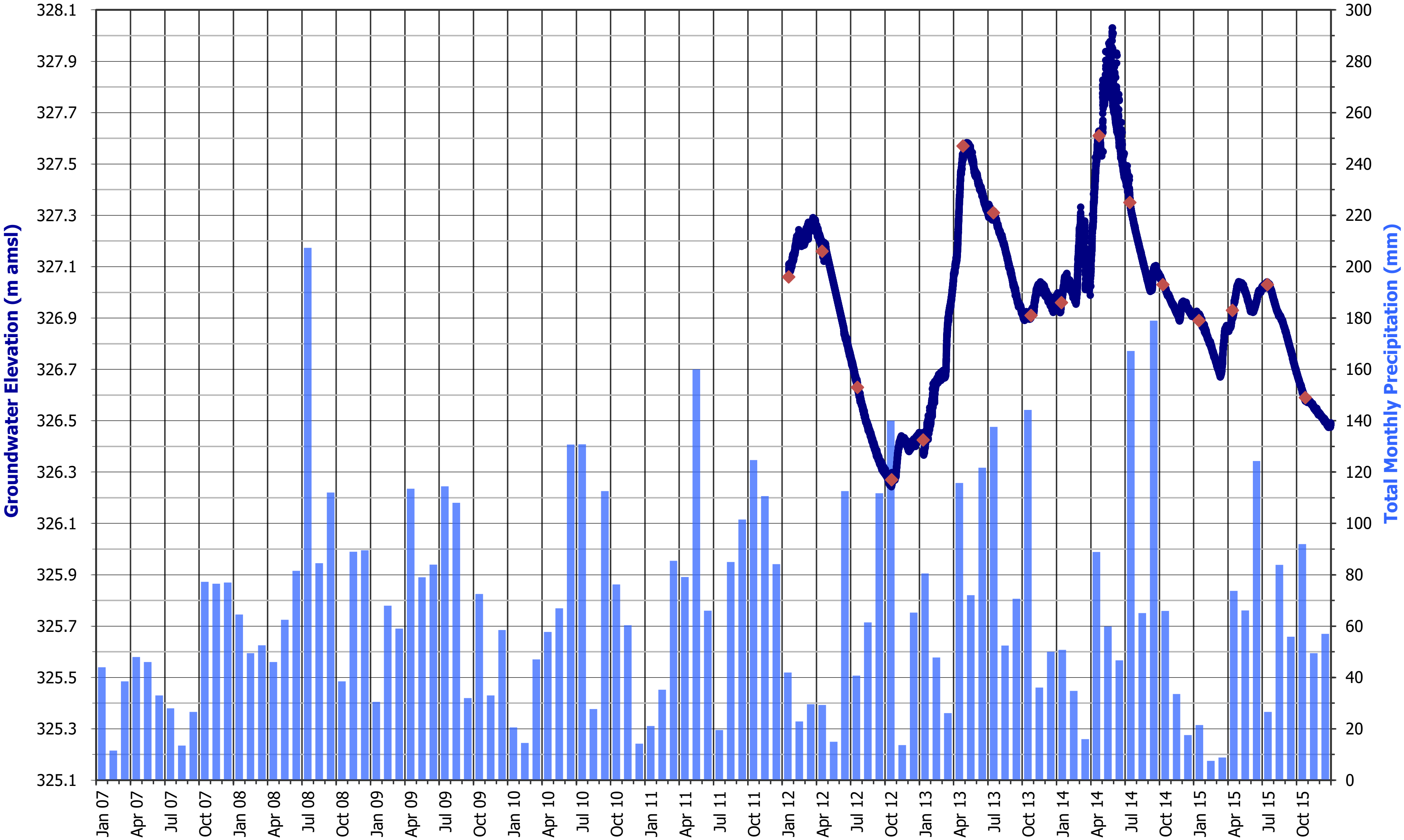
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 11a**

Groundwater Elevation & Precipitation - MW134 (January 2012 to December 2015)



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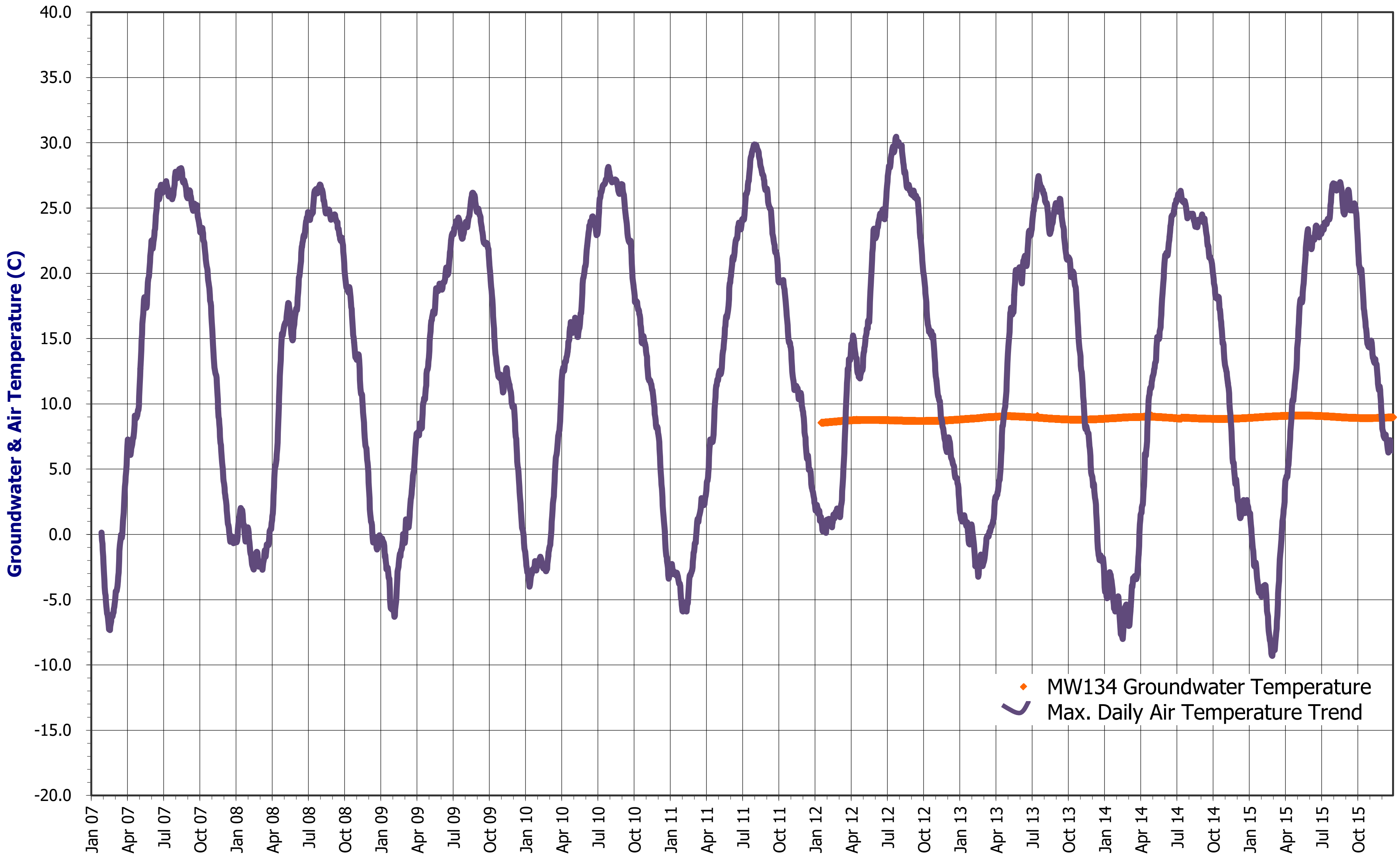
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 12**

Groundwater & Maximum Daily Air Temperature - MW134 (January 2012 to December 2015)



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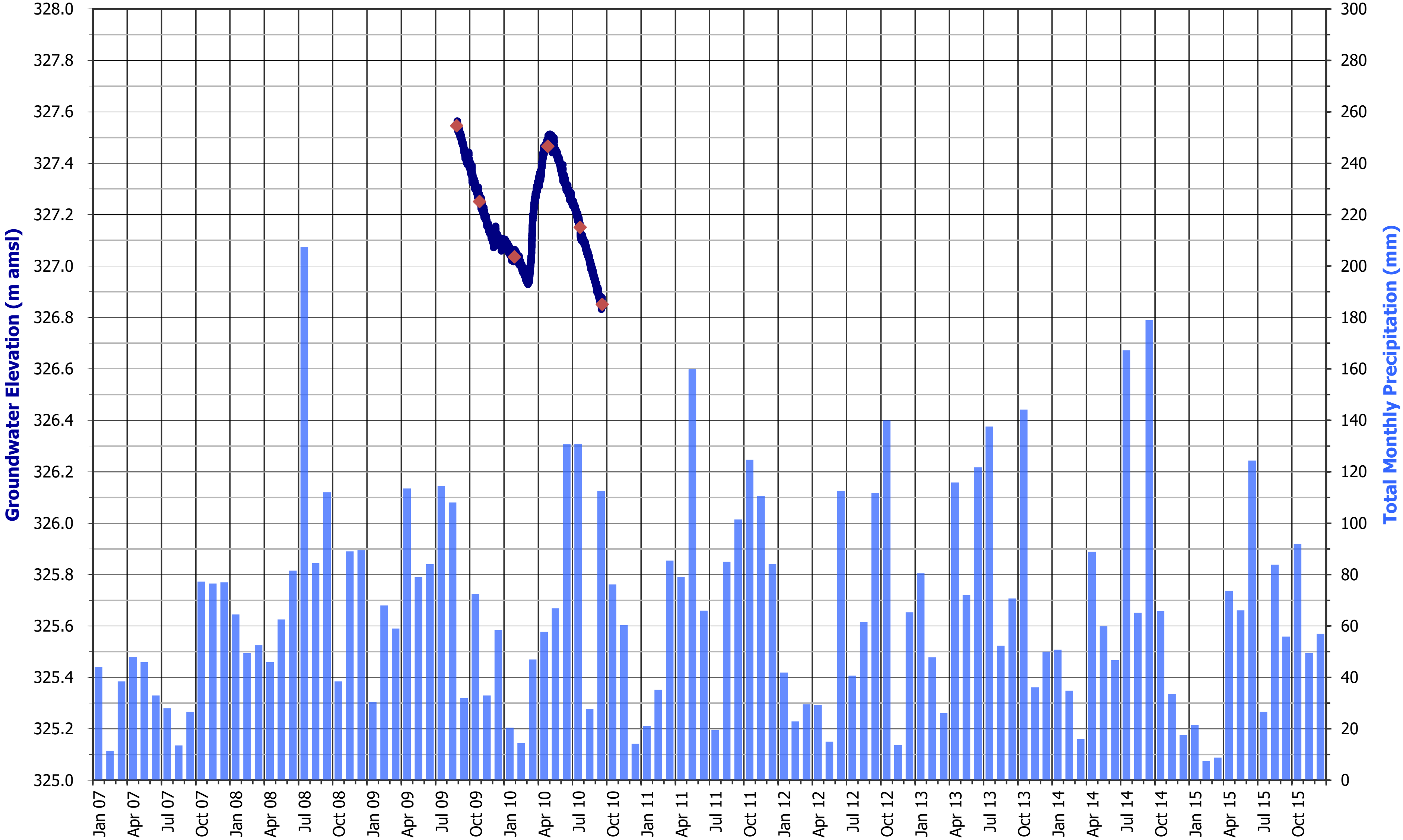
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 12a**

Groundwater Elevation & Precipitation - MW110 (August 09 to September 10) Abandoned 2010



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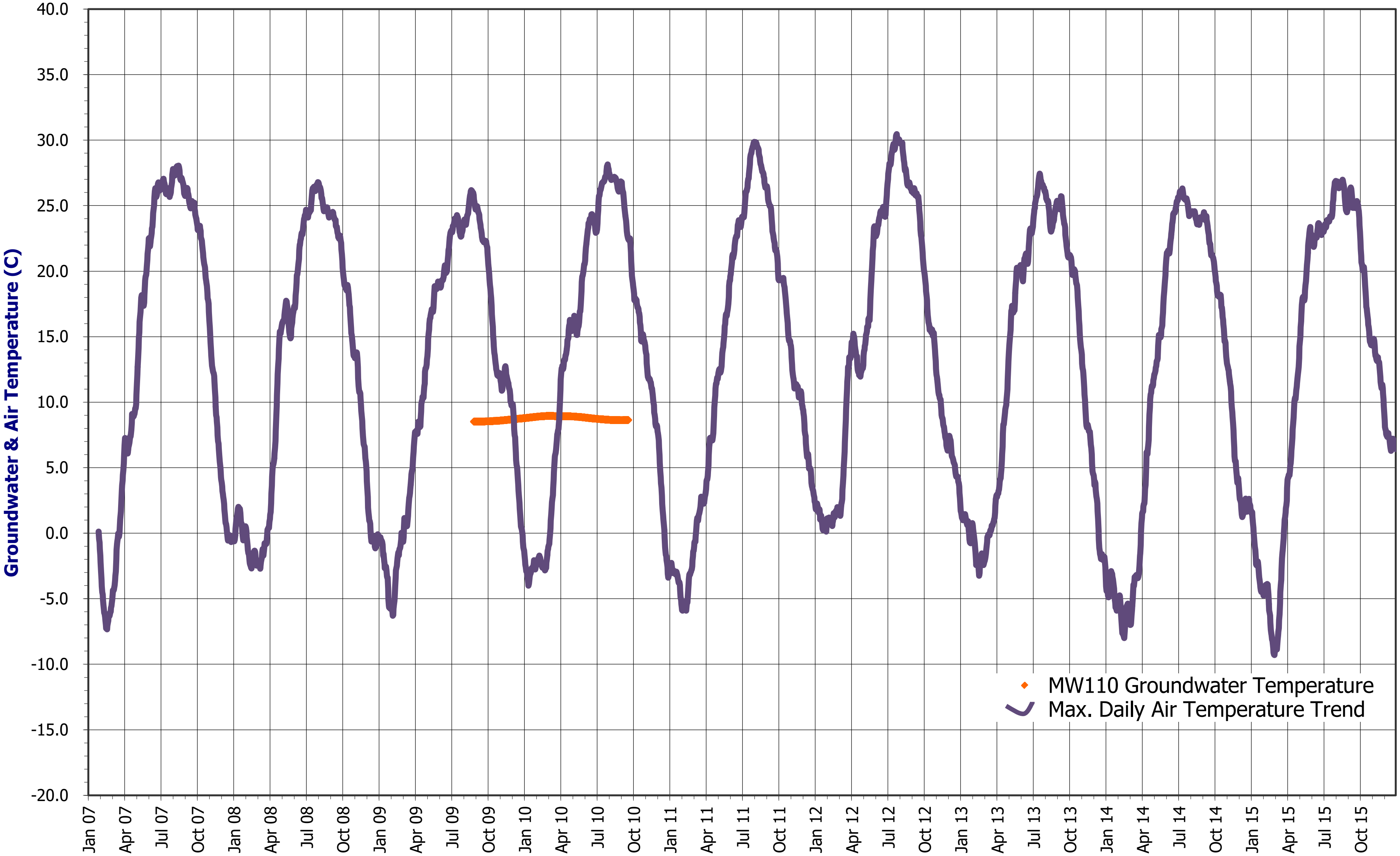
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 13**

Groundwater & Maximum Daily Air Temperature - MW110 (August 09 to September 10) Abandoned 2010



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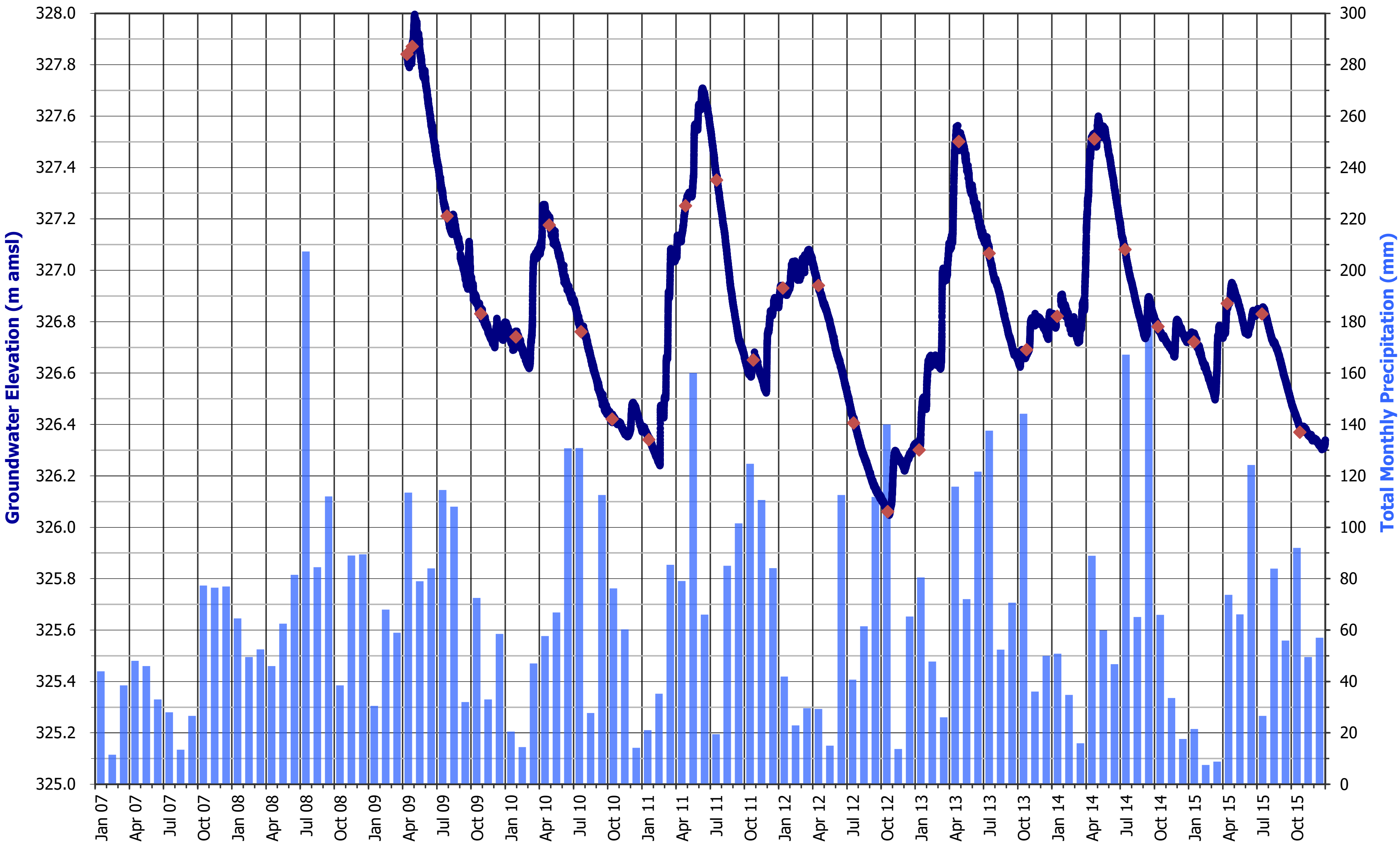
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 2 - Perimeter** **Graph H 13a**

Groundwater Elevation & Precipitation - MW109 (April 2009 to December 2015)



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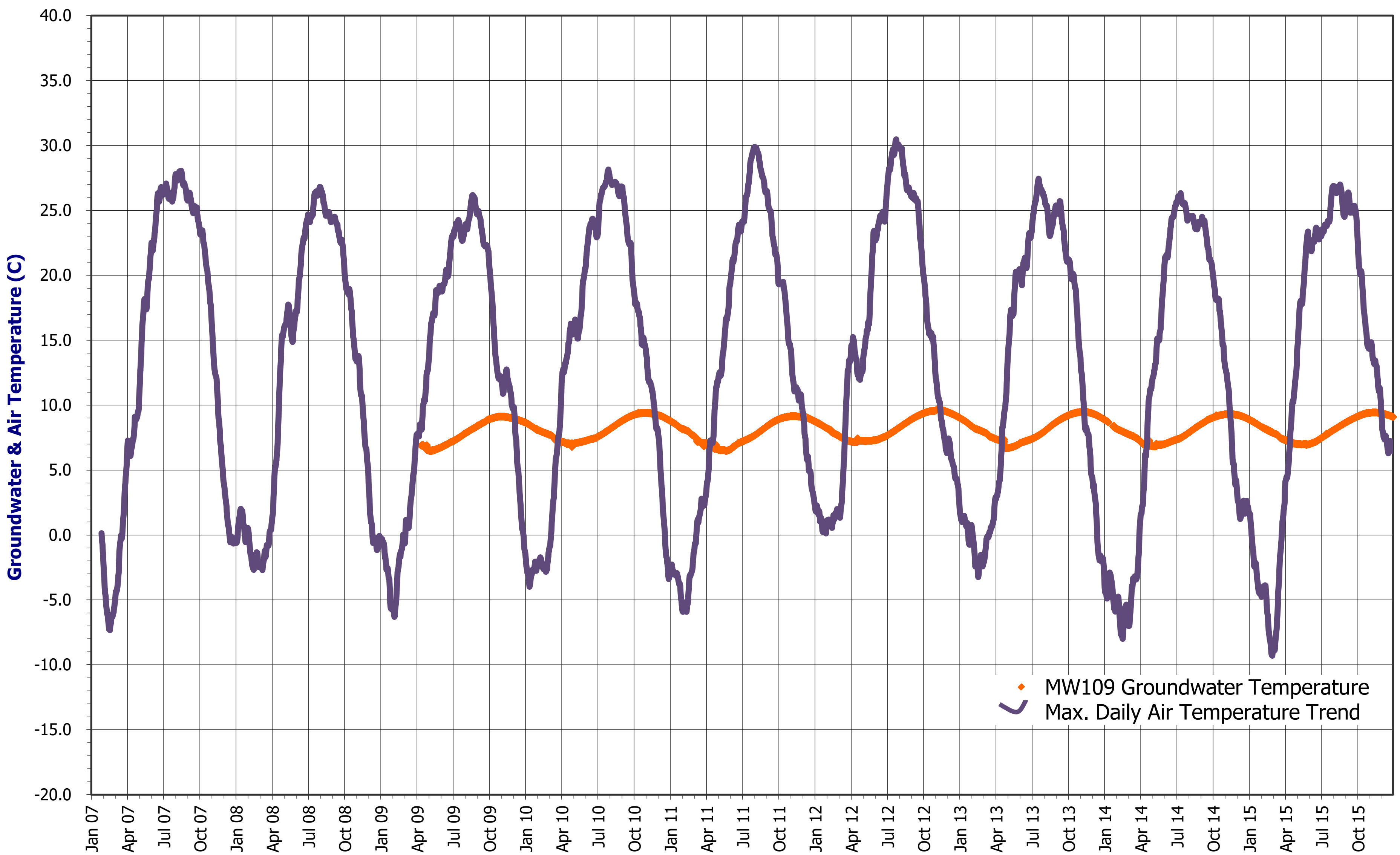
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph H 14**

Groundwater & Maximum Daily Air Temperature - MW109 (April 2009 to December 2015)

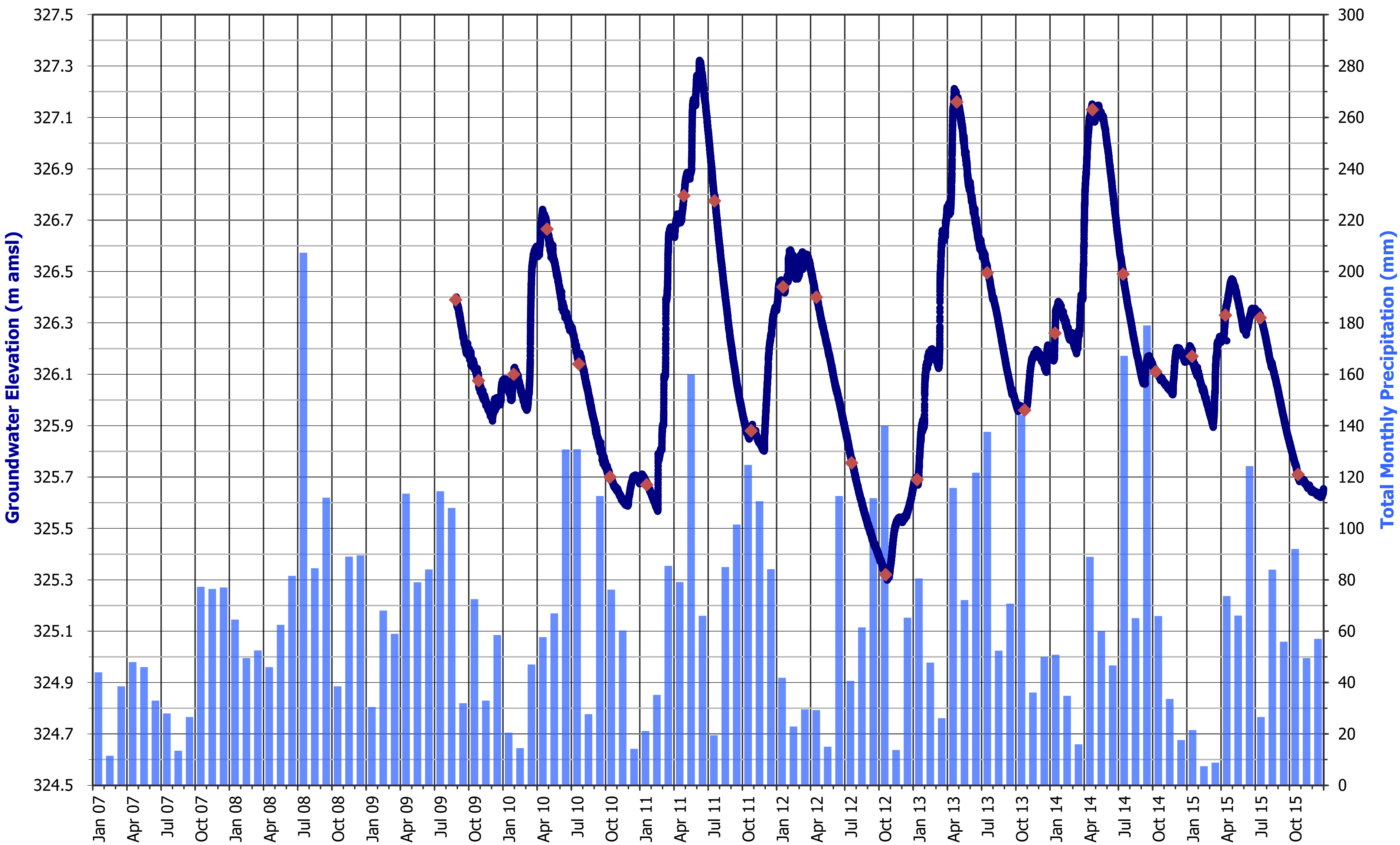


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph H 14a**

Groundwater Elevation & Precipitation - MW004 (August 2009 to December 2015)



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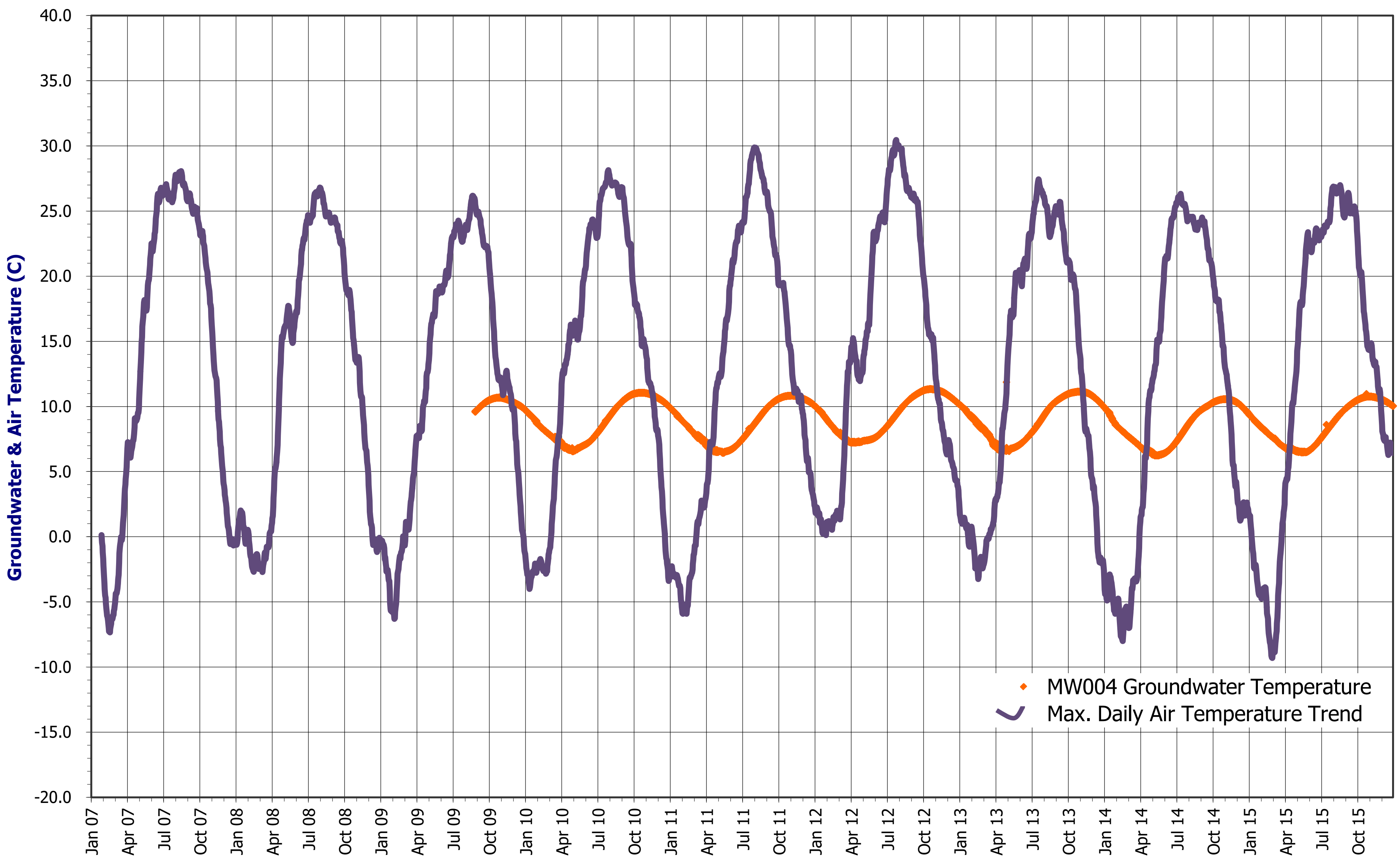
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph H 15**

Groundwater & Maximum Daily Temperature - MW004 (August 2009 to December 2015)



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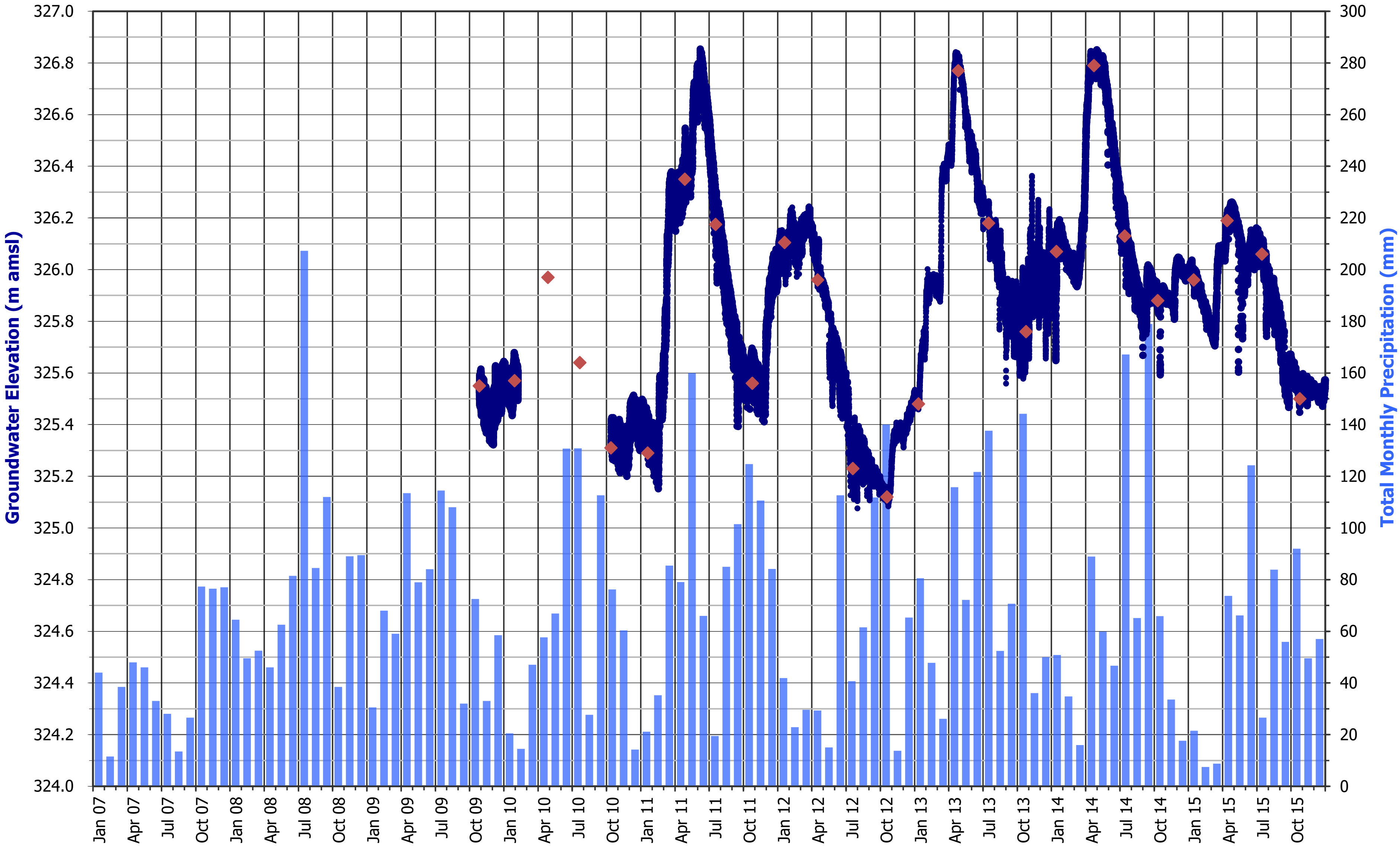
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph H 15a**

Groundwater Elevation & Precipitation - MW112 (October 2009 to December 2015)



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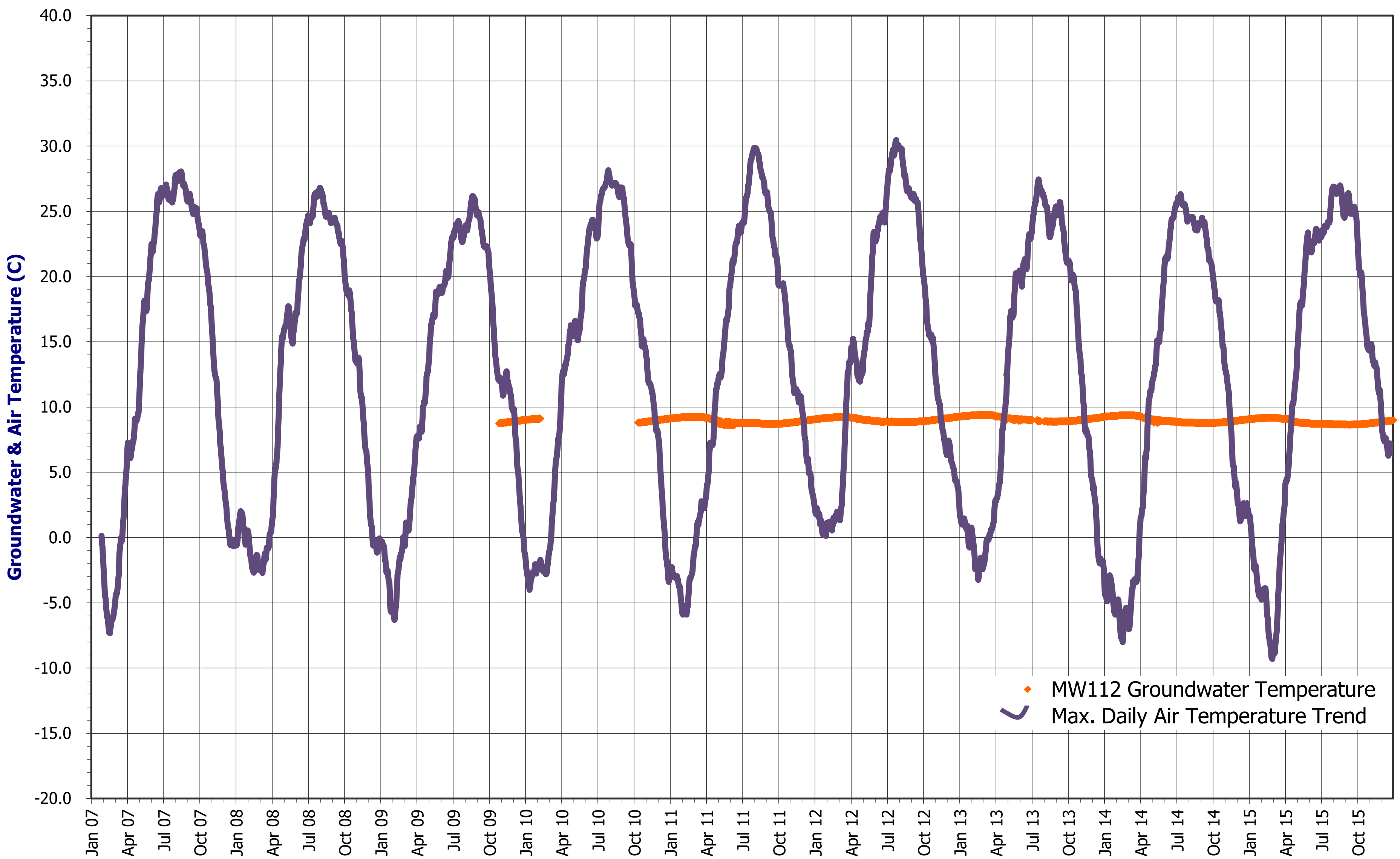
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph H 16**

Groundwater & Maximum Daily Air Temperature - MW112 (October 2009 to December 2015)



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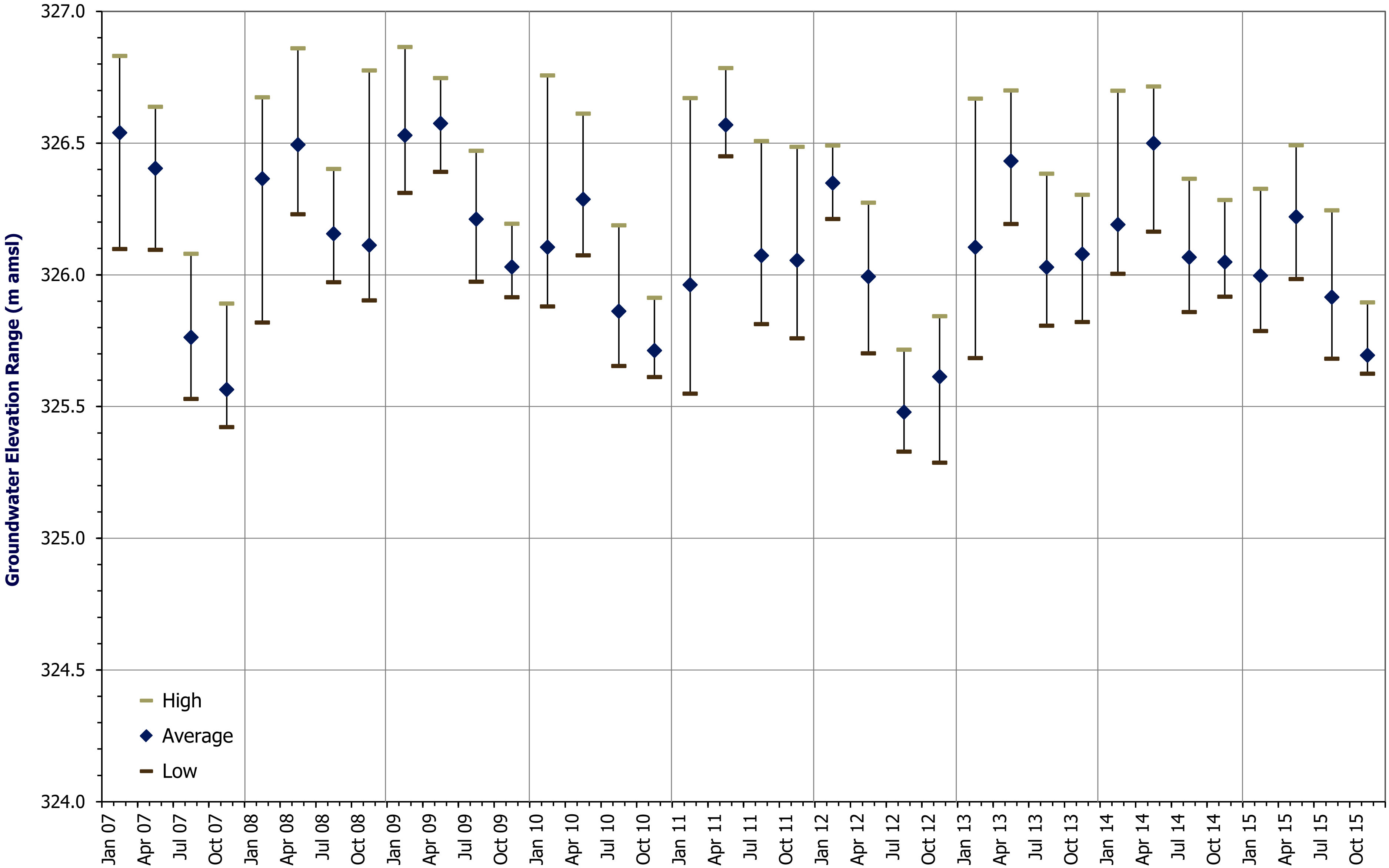
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Phase 3 - Perimeter** **Graph H 16a**

Appendix I

Quarterly Groundwater Elevation Range
2007 – 2015

Quarterly Groundwater Elevation Range - MW003



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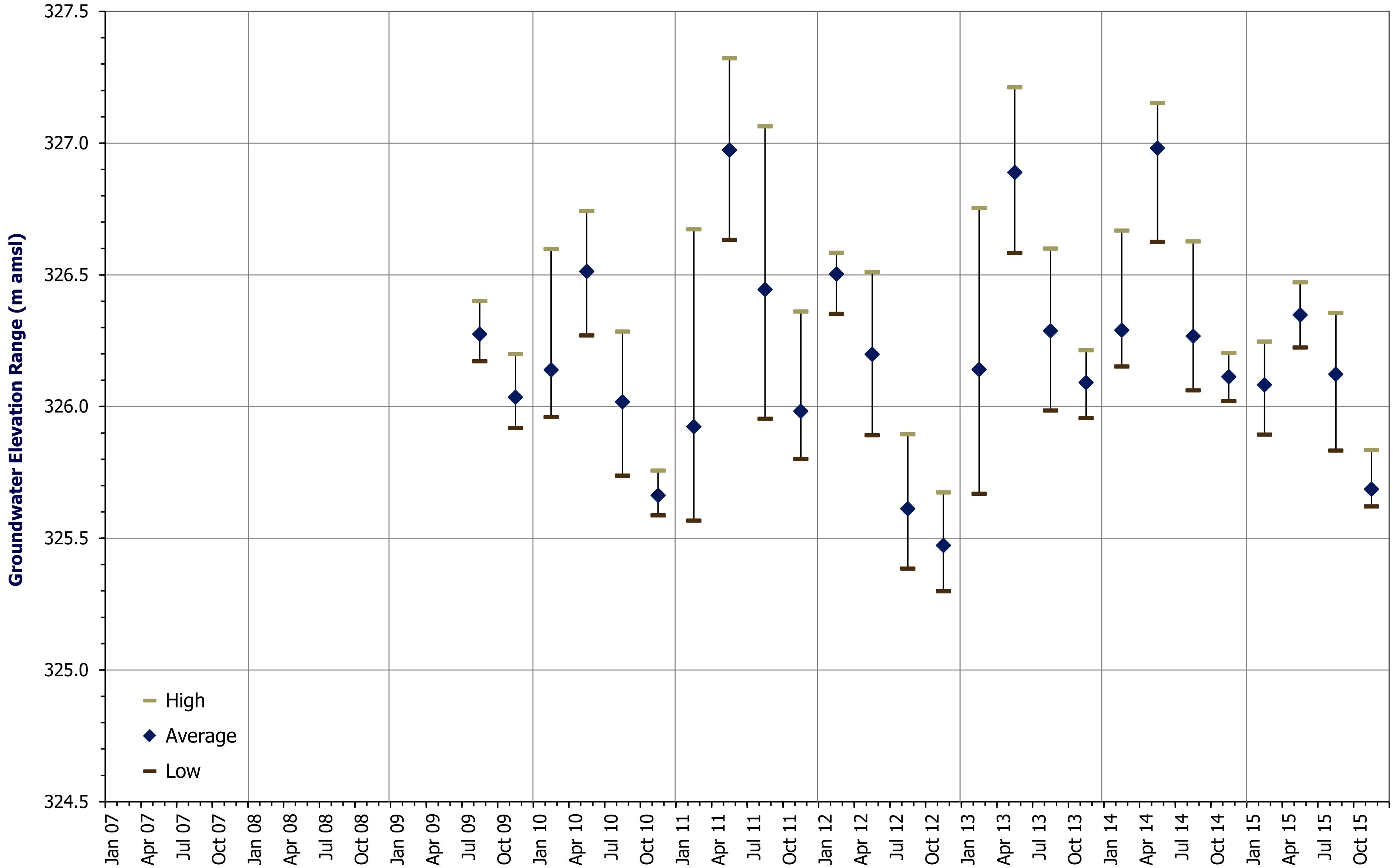
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-1

Quarterly Groundwater Elevation Range - MW004



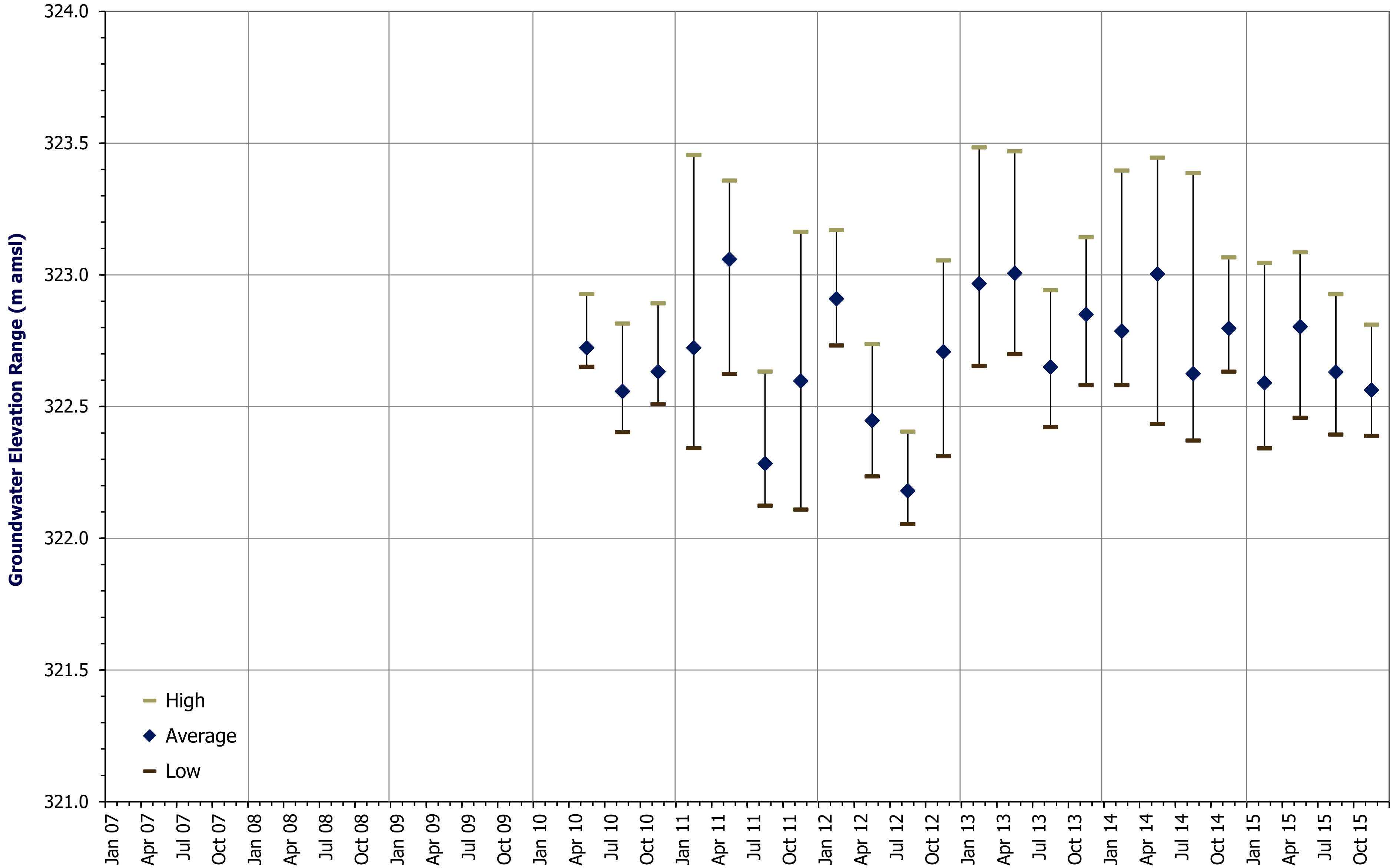
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-2

Quarterly Groundwater Elevation Range - MW103



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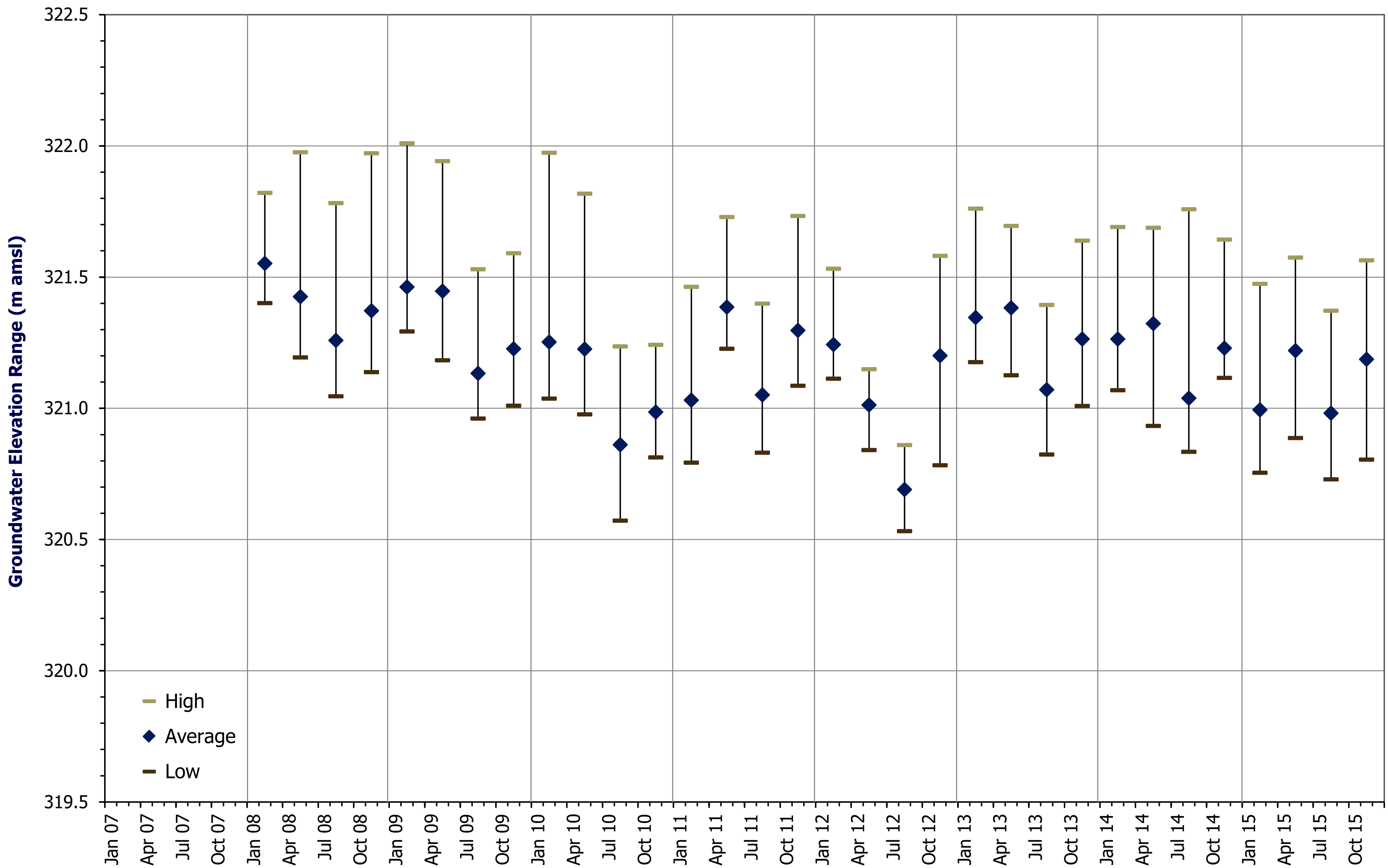
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-3

Quarterly Groundwater Elevation Range - MW104



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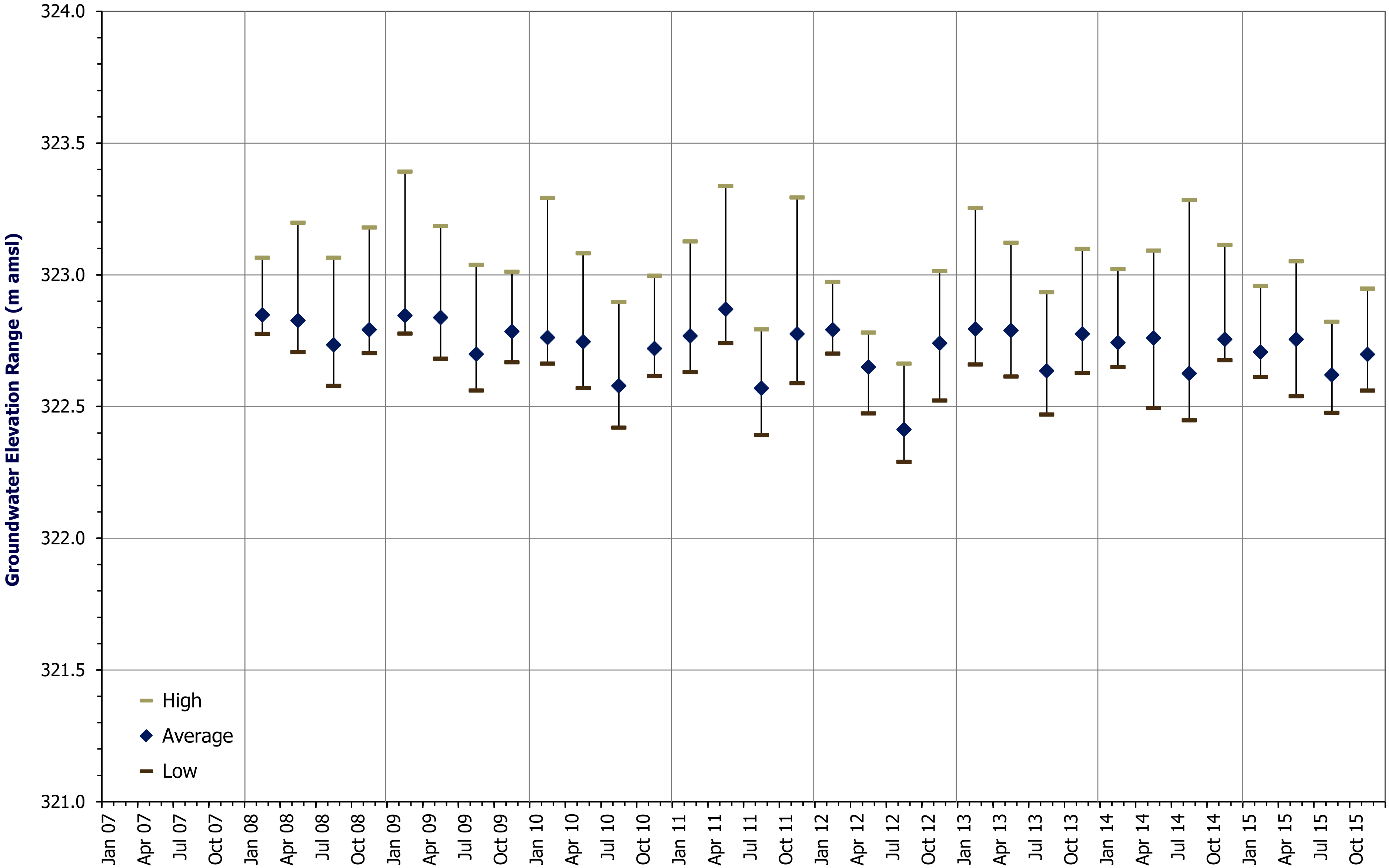
Hanlon Creek Business Park - Groundwater Monitoring Program

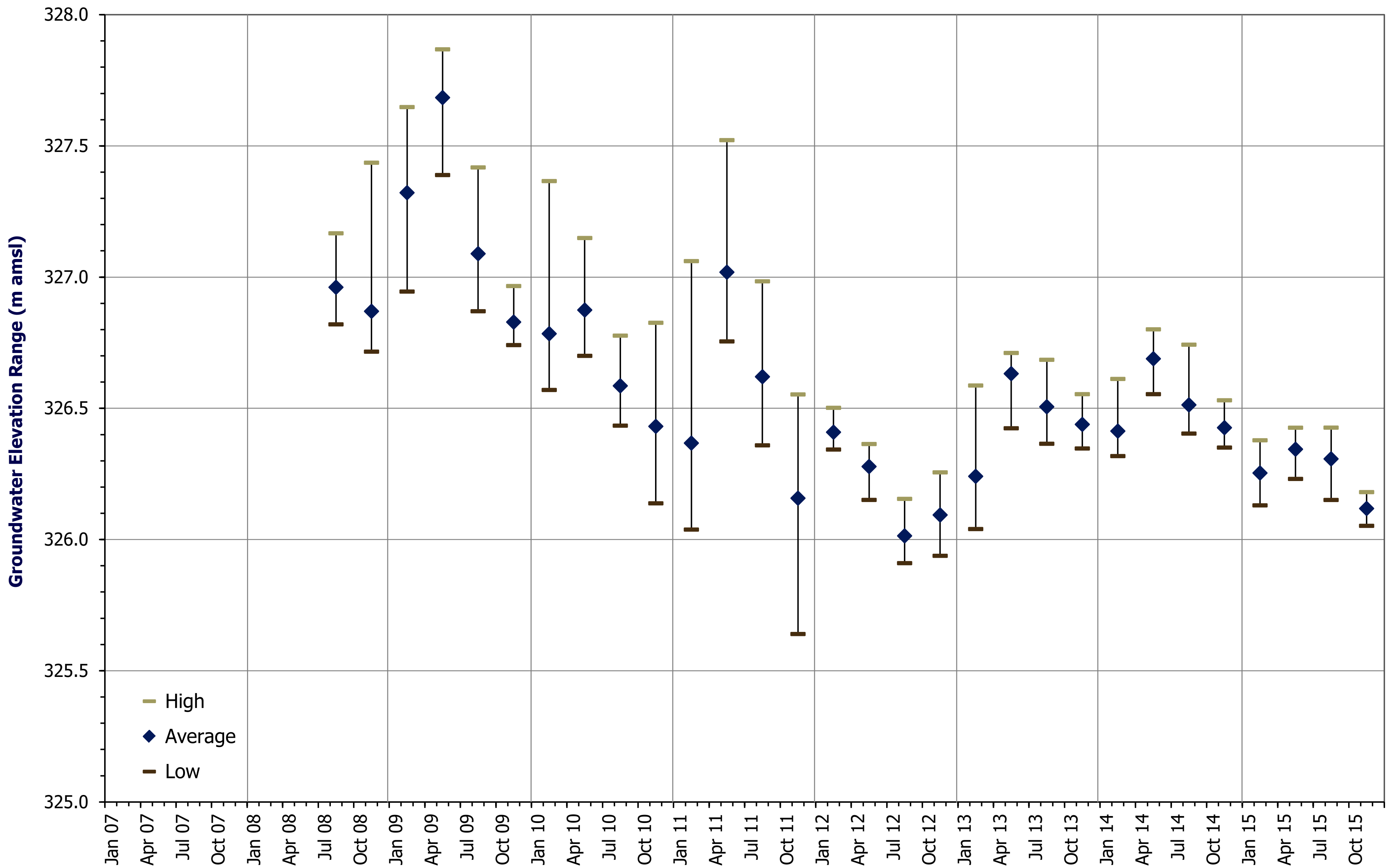
December 2015

Graph I-4

Quarterly Groundwater Elevation Range - MW105



Quarterly Groundwater Elevation Range - MW107



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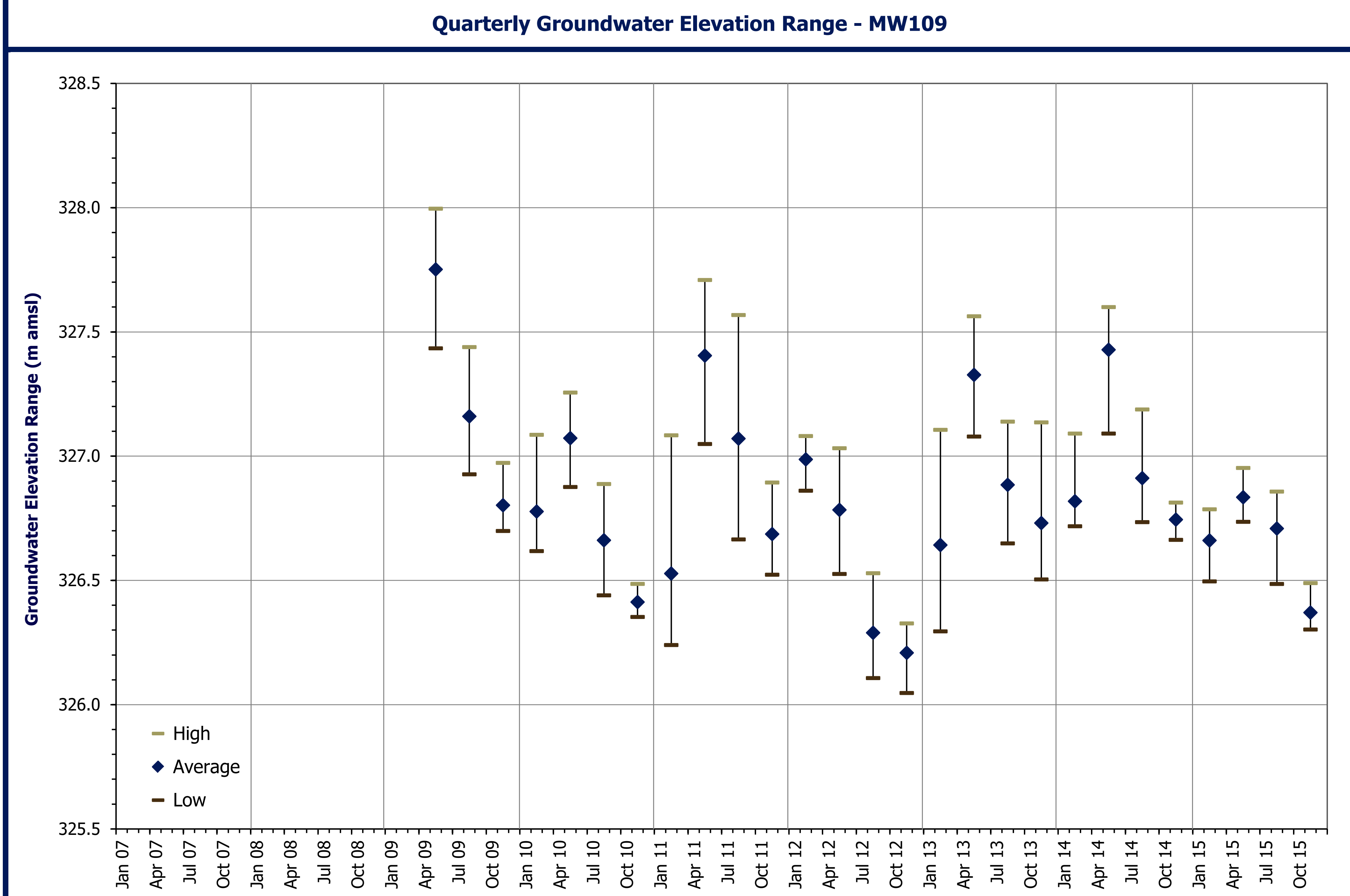
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Graph I-6**



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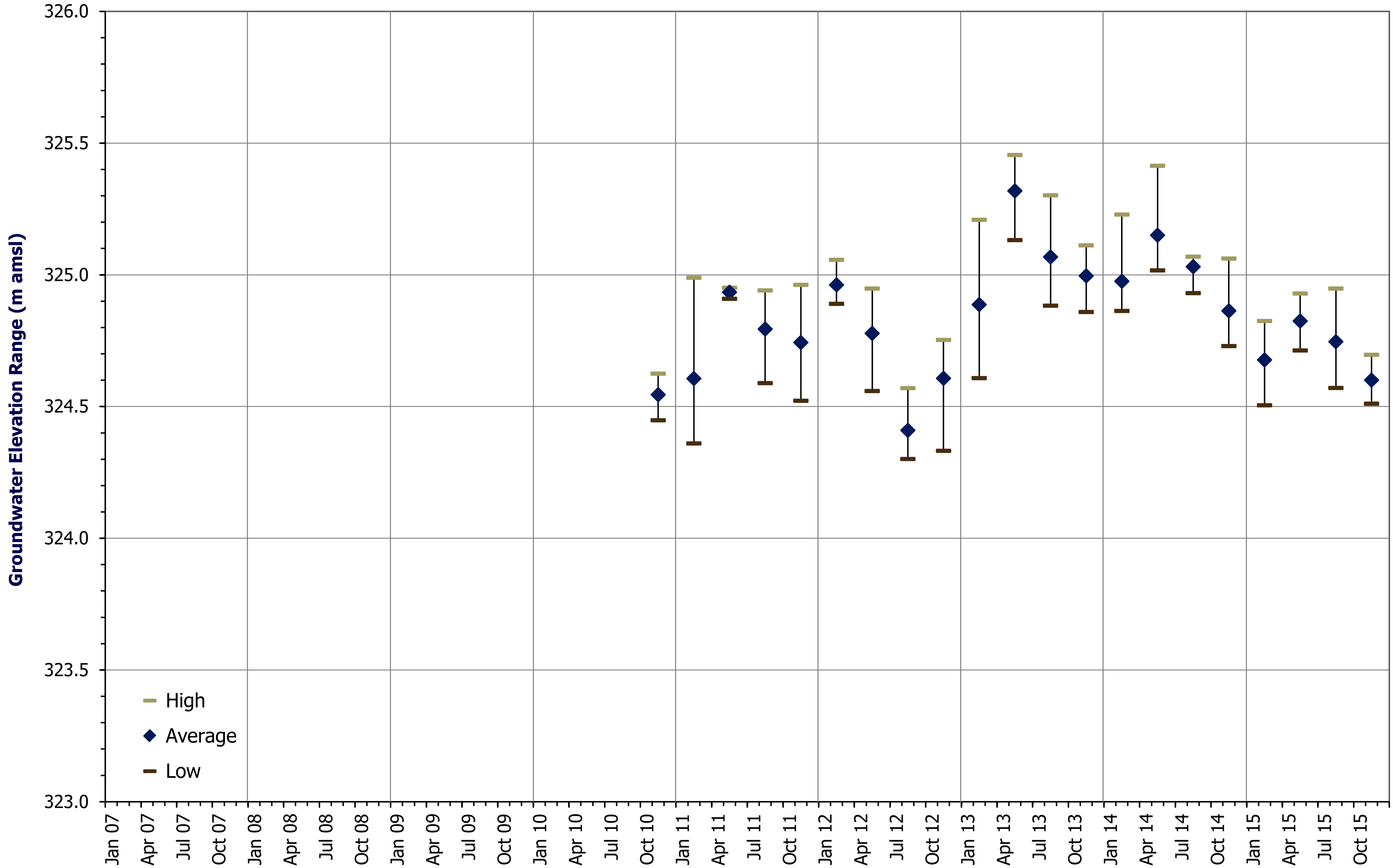
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-7

Quarterly Groundwater Elevation Range - MW111



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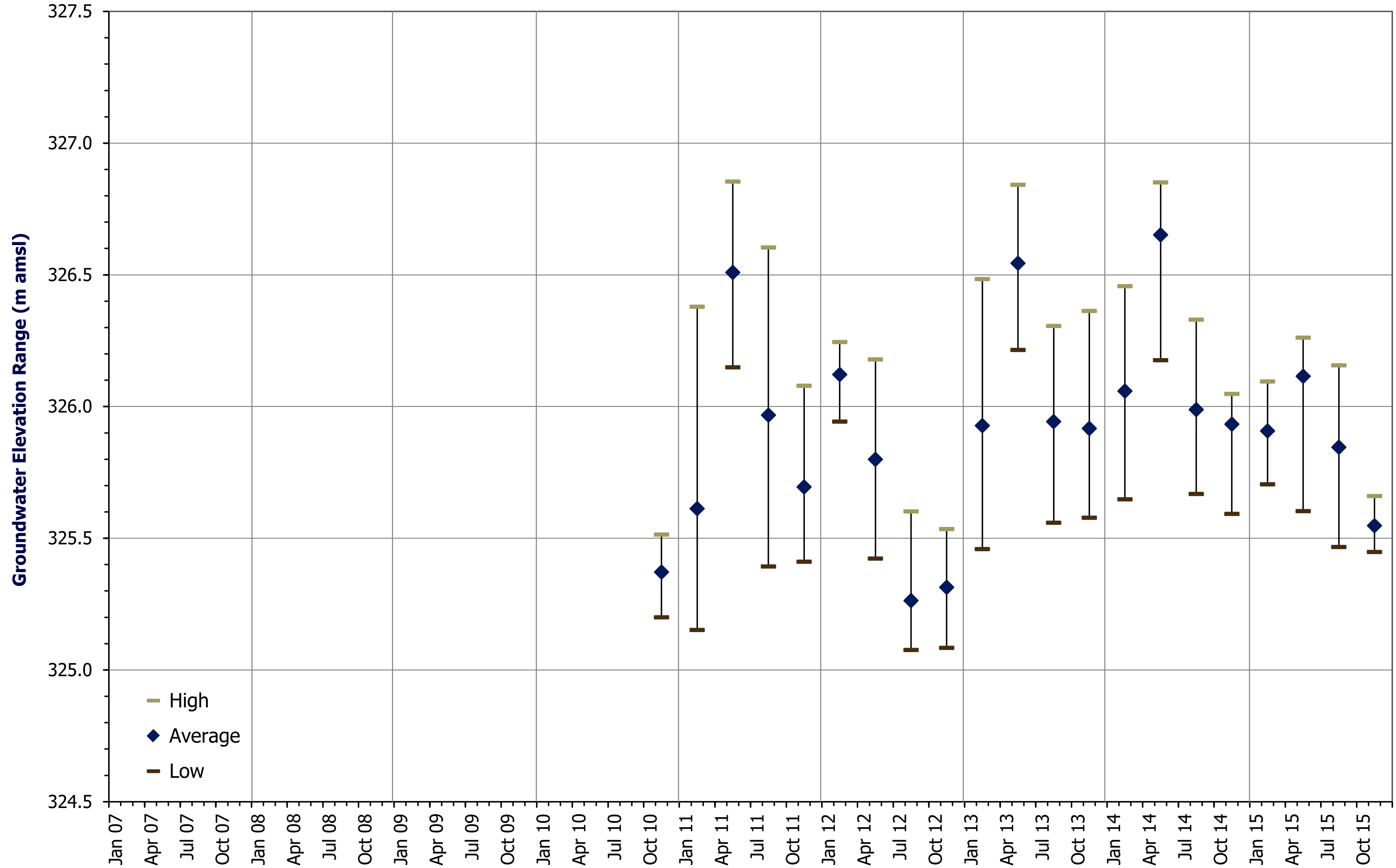
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-8

Quarterly Groundwater Elevation Range - MW112



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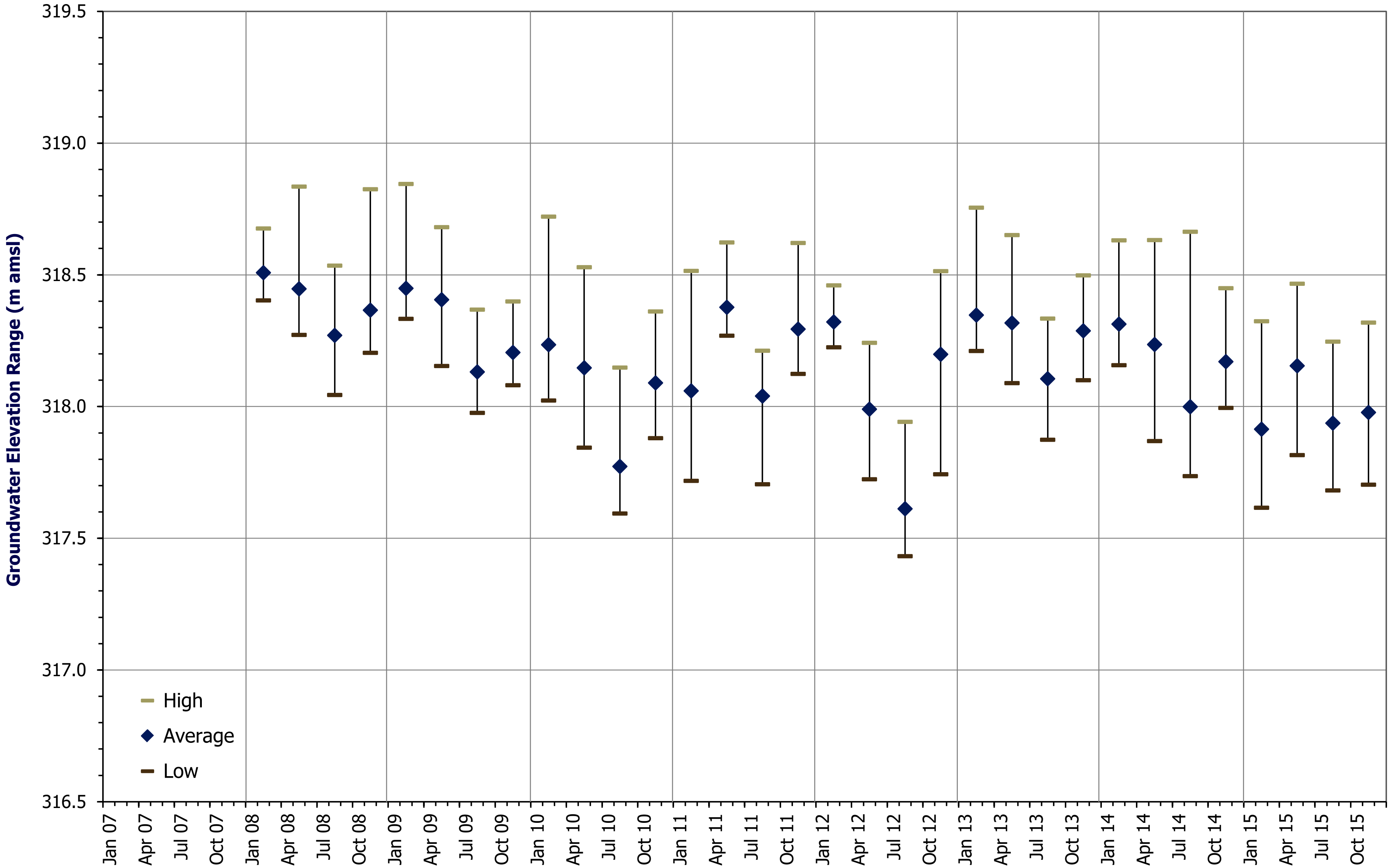
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015 **Graph I-9**

Quarterly Groundwater Elevation Range - MW116A



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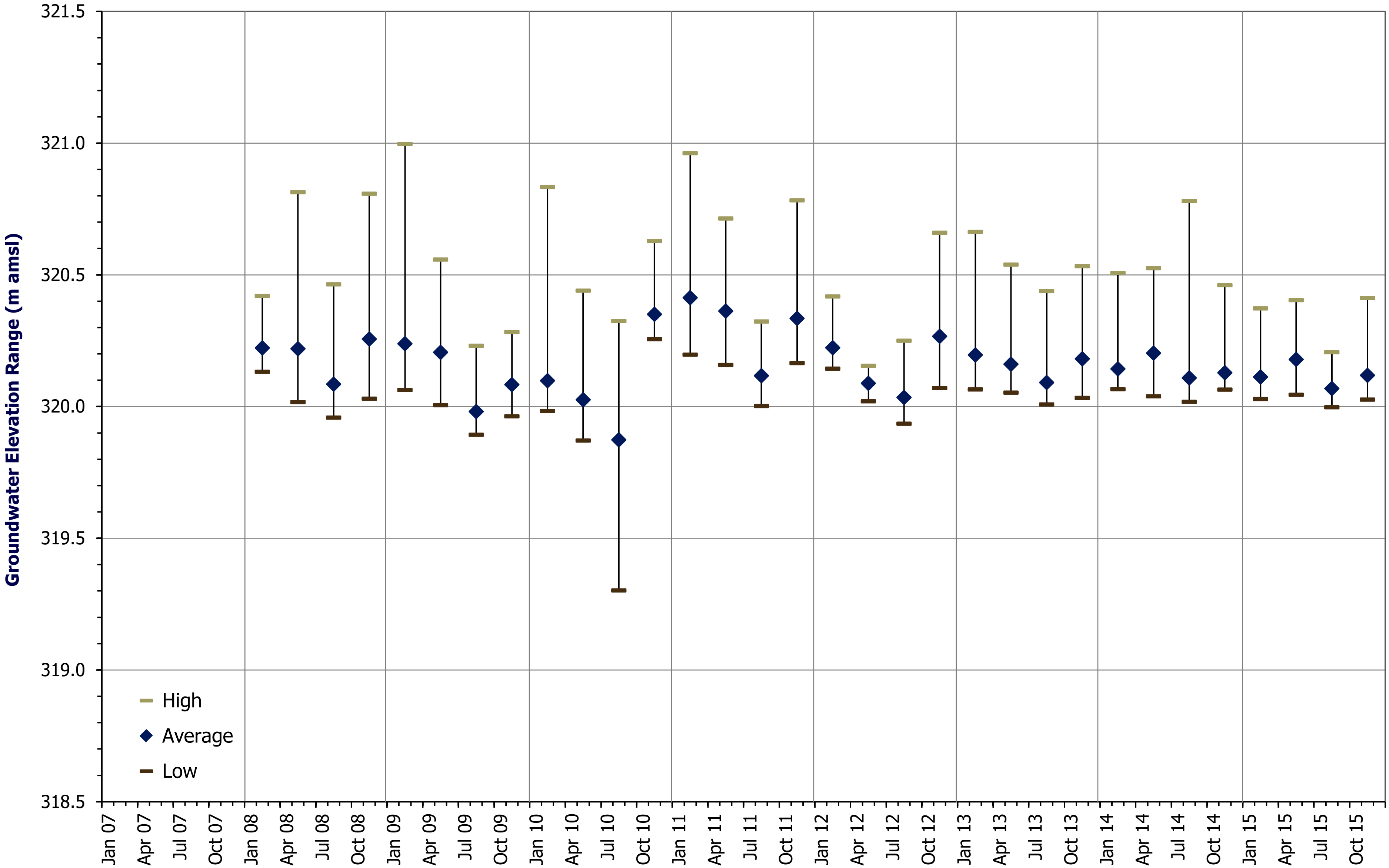
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-10

Quarterly Groundwater Elevation Range - MW117A



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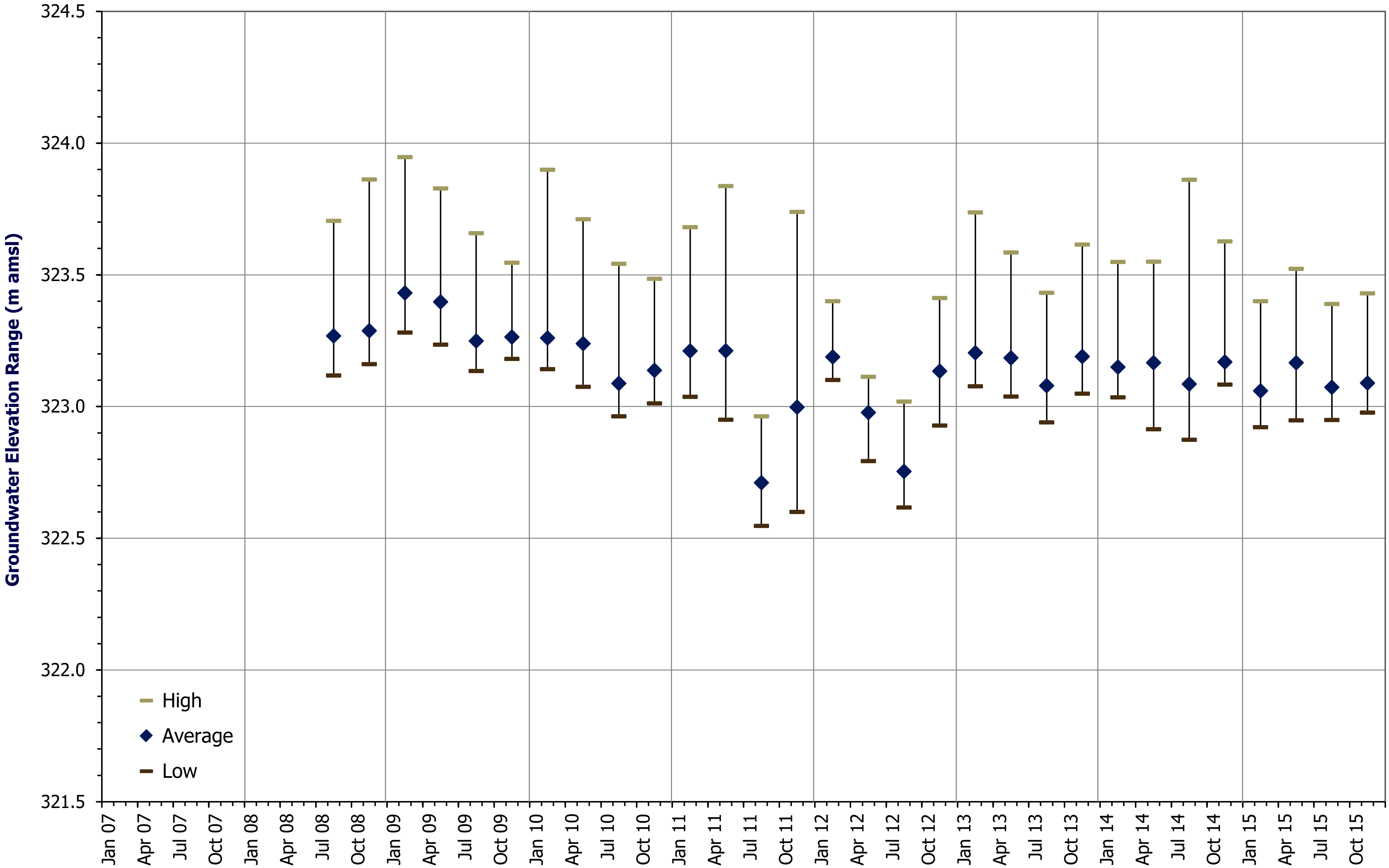
Hanlon Creek Business Park - Groundwater Monitoring Program

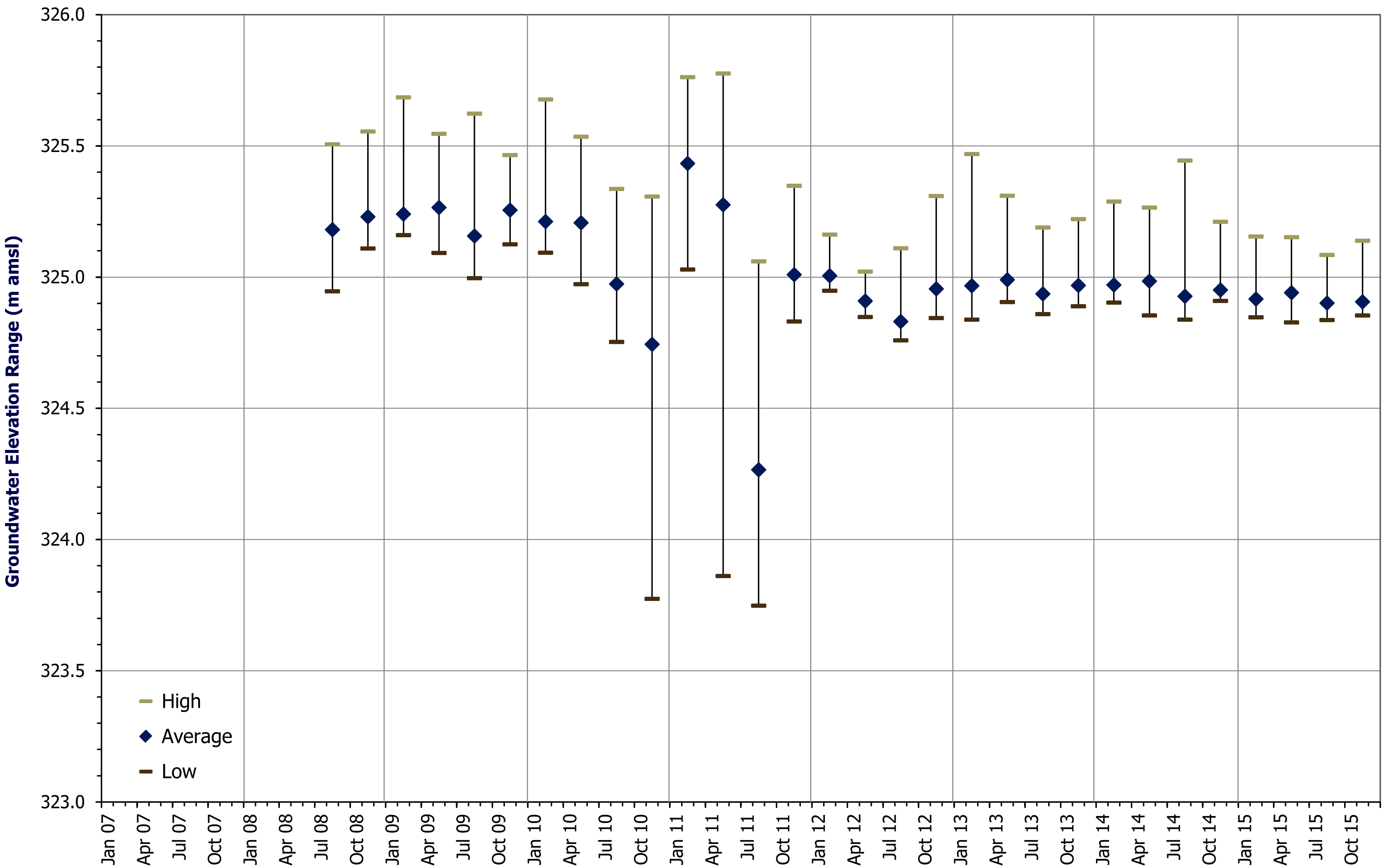
December 2015

Graph I-11

Quarterly Groundwater Elevation Range - MW118A



Quarterly Groundwater Elevation Range - MW119A



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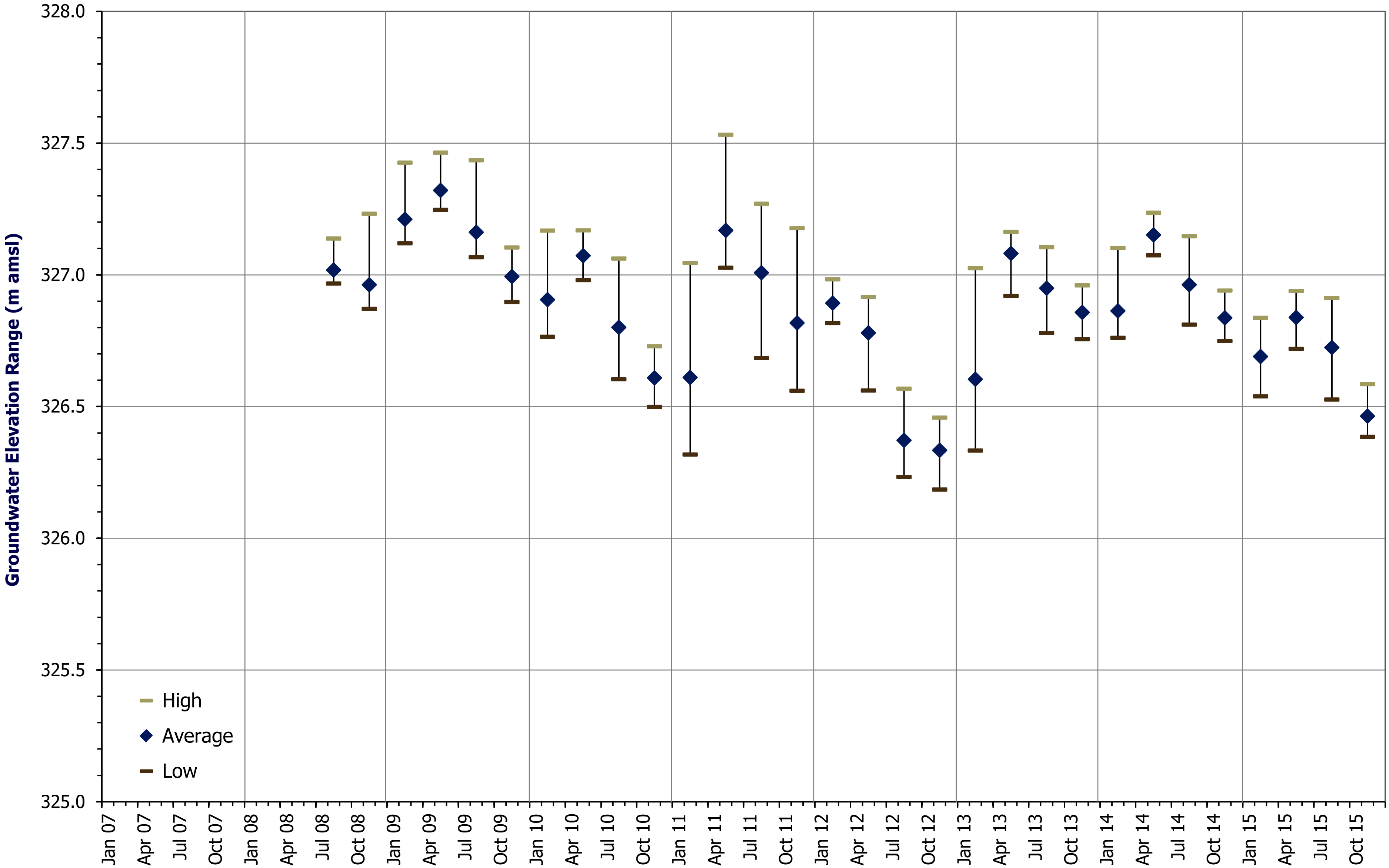
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2015

Graph I-13

Quarterly Groundwater Elevation Range - MW121A



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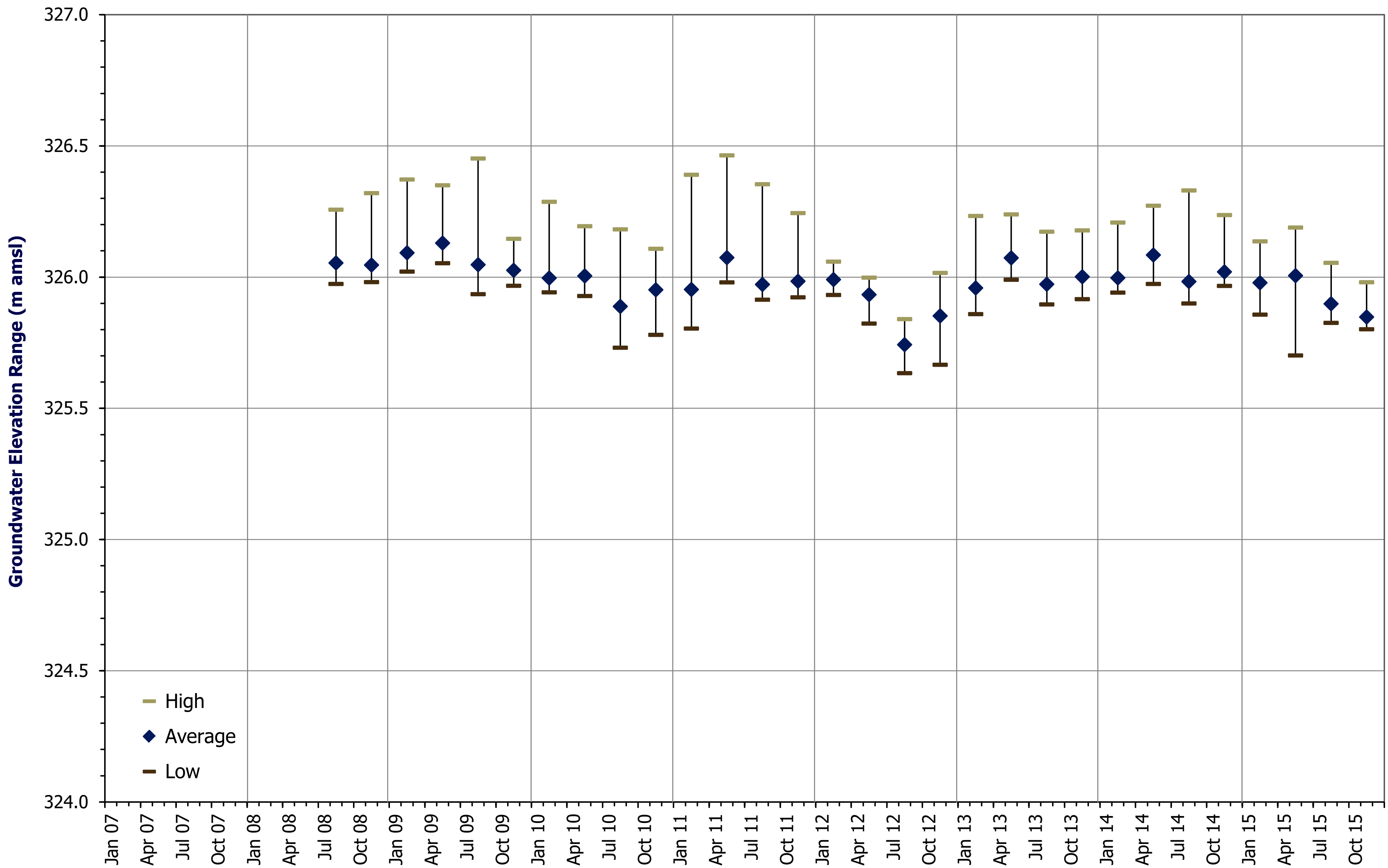
Graph I-14

Quarterly Groundwater Elevation Range - MW122A



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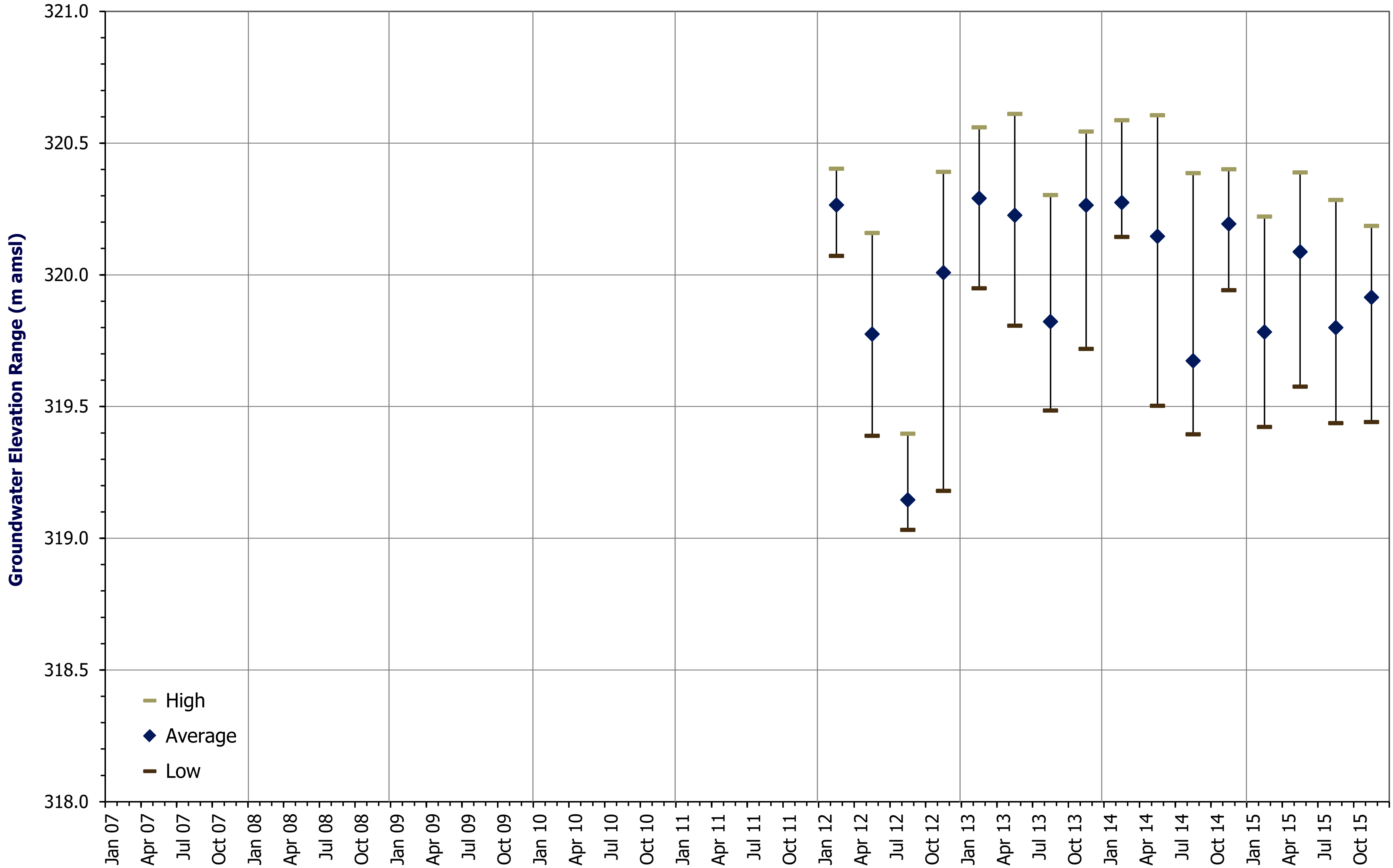
Graph I-15

Quarterly Groundwater Elevation Range - MW124



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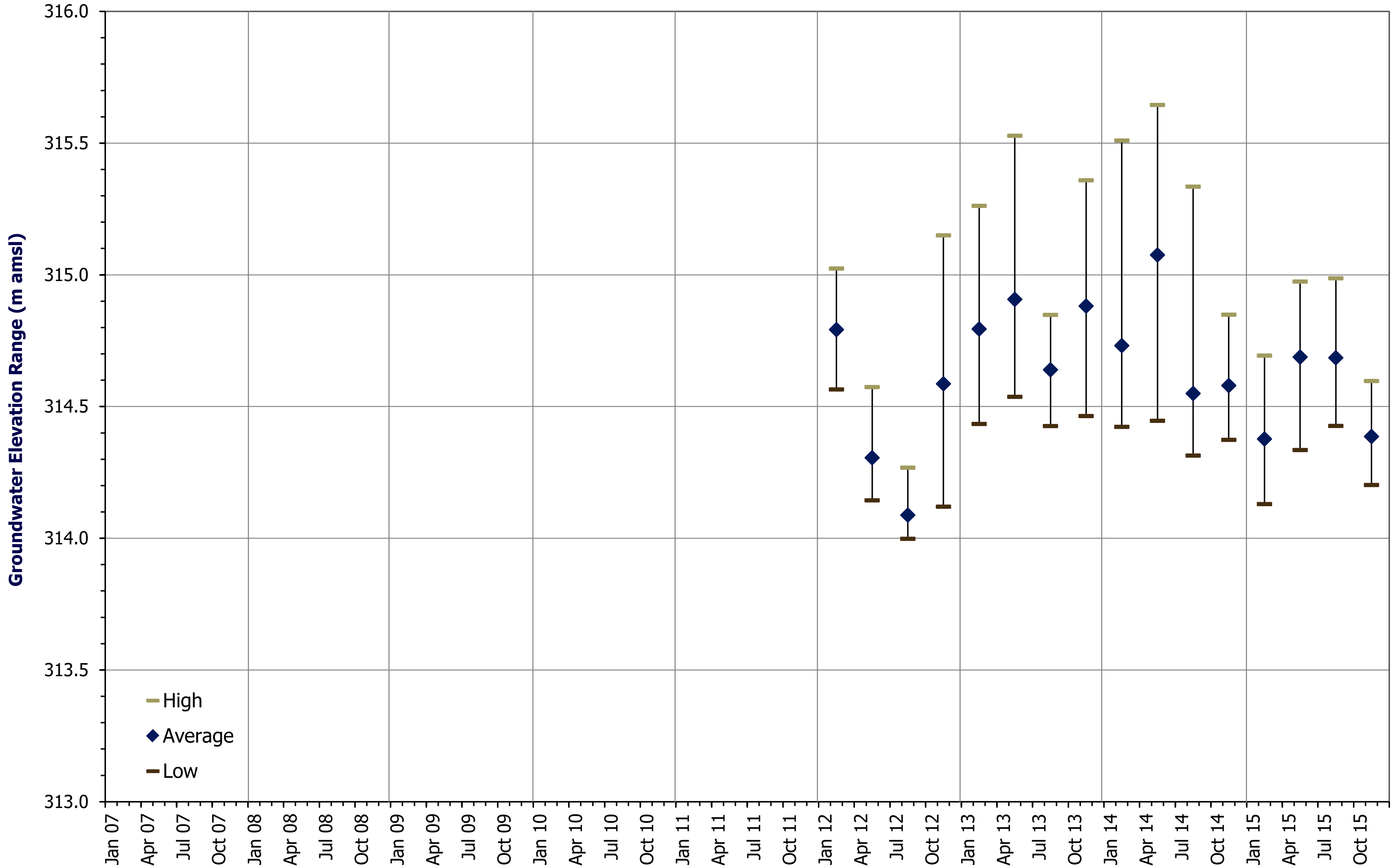
Graph I-16

Quarterly Groundwater Elevation Range - MW125



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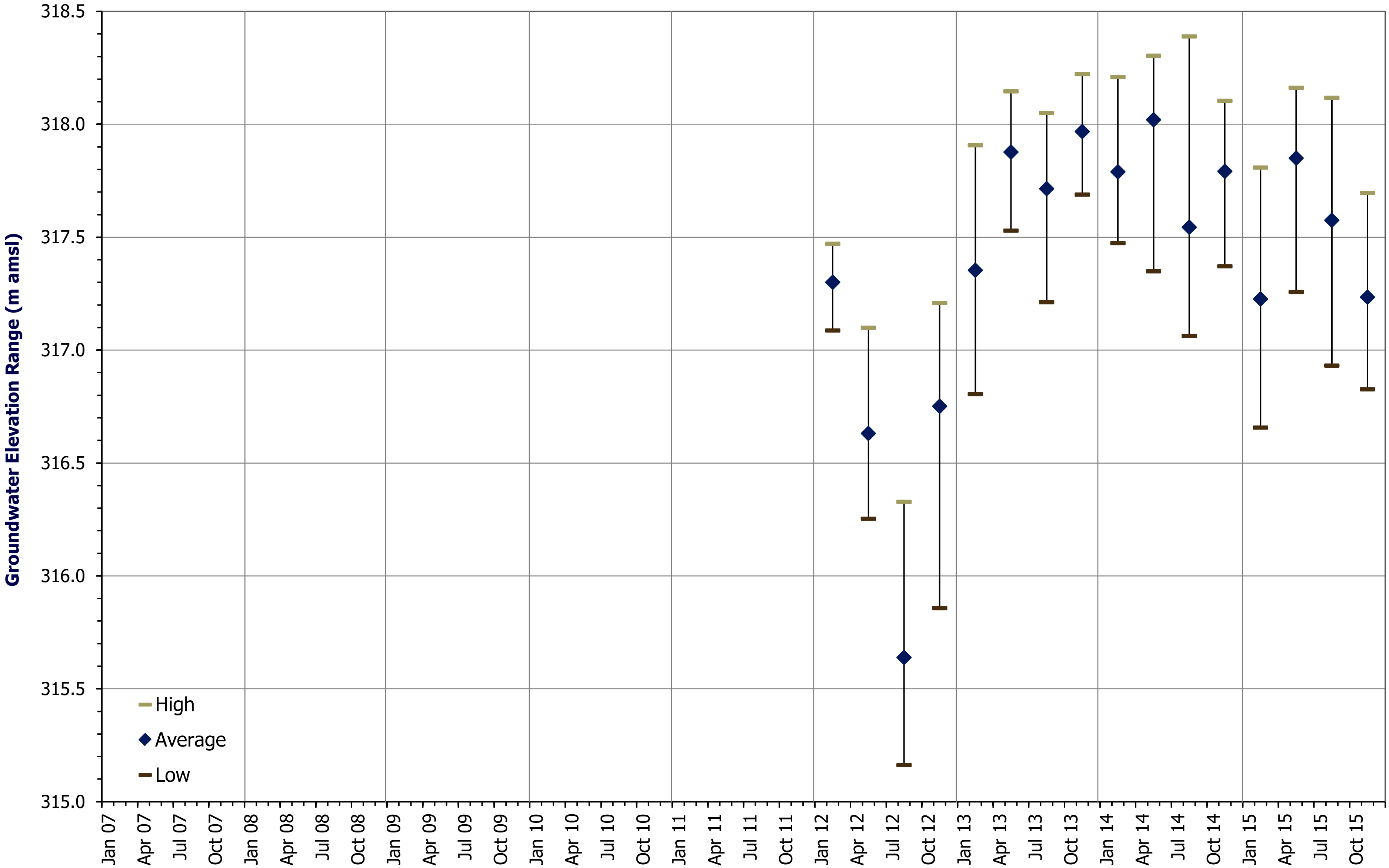
Graph I-17

Quarterly Groundwater Elevation Range - MW126



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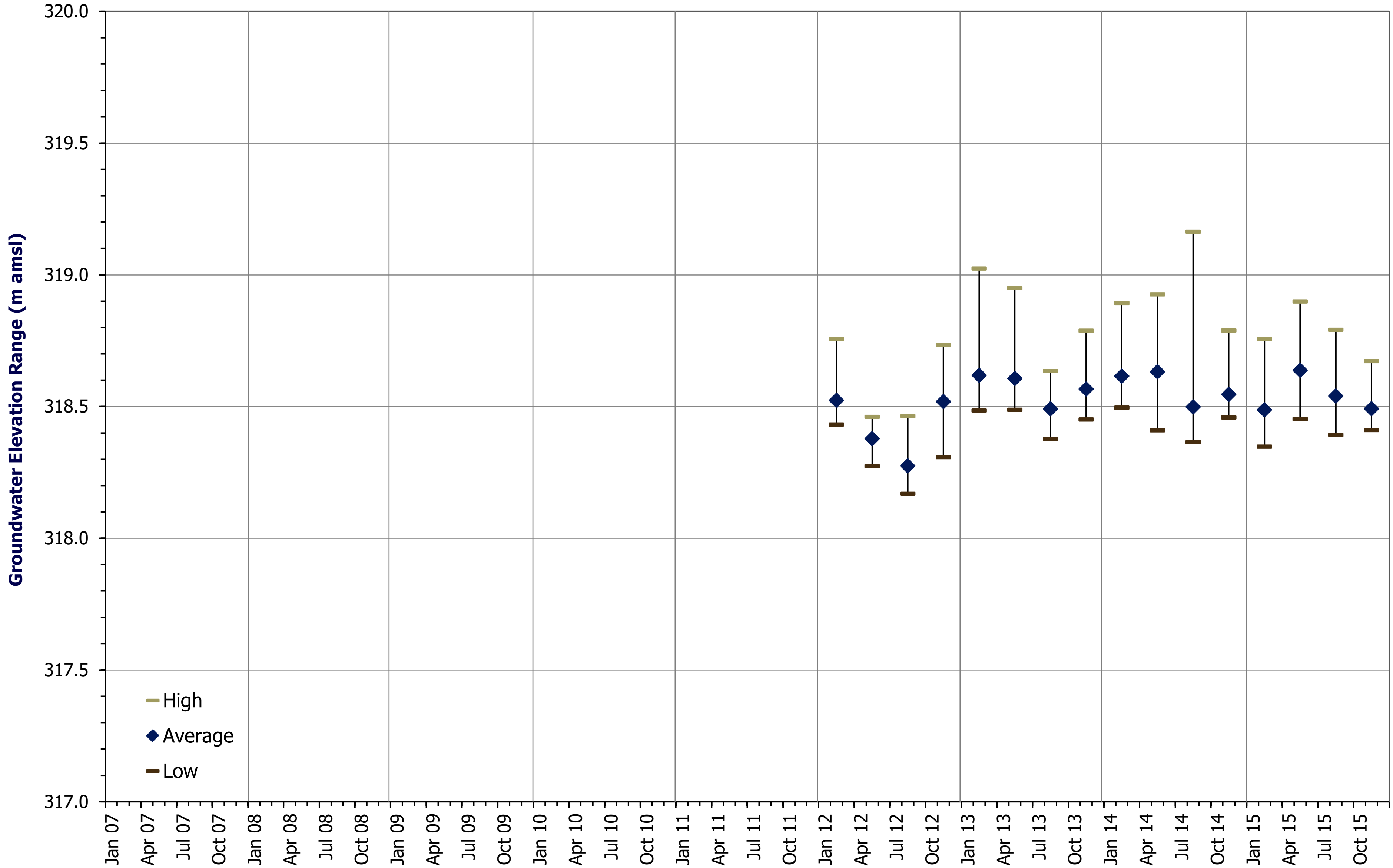
Graph I-18

Quarterly Groundwater Elevation Range - MW127



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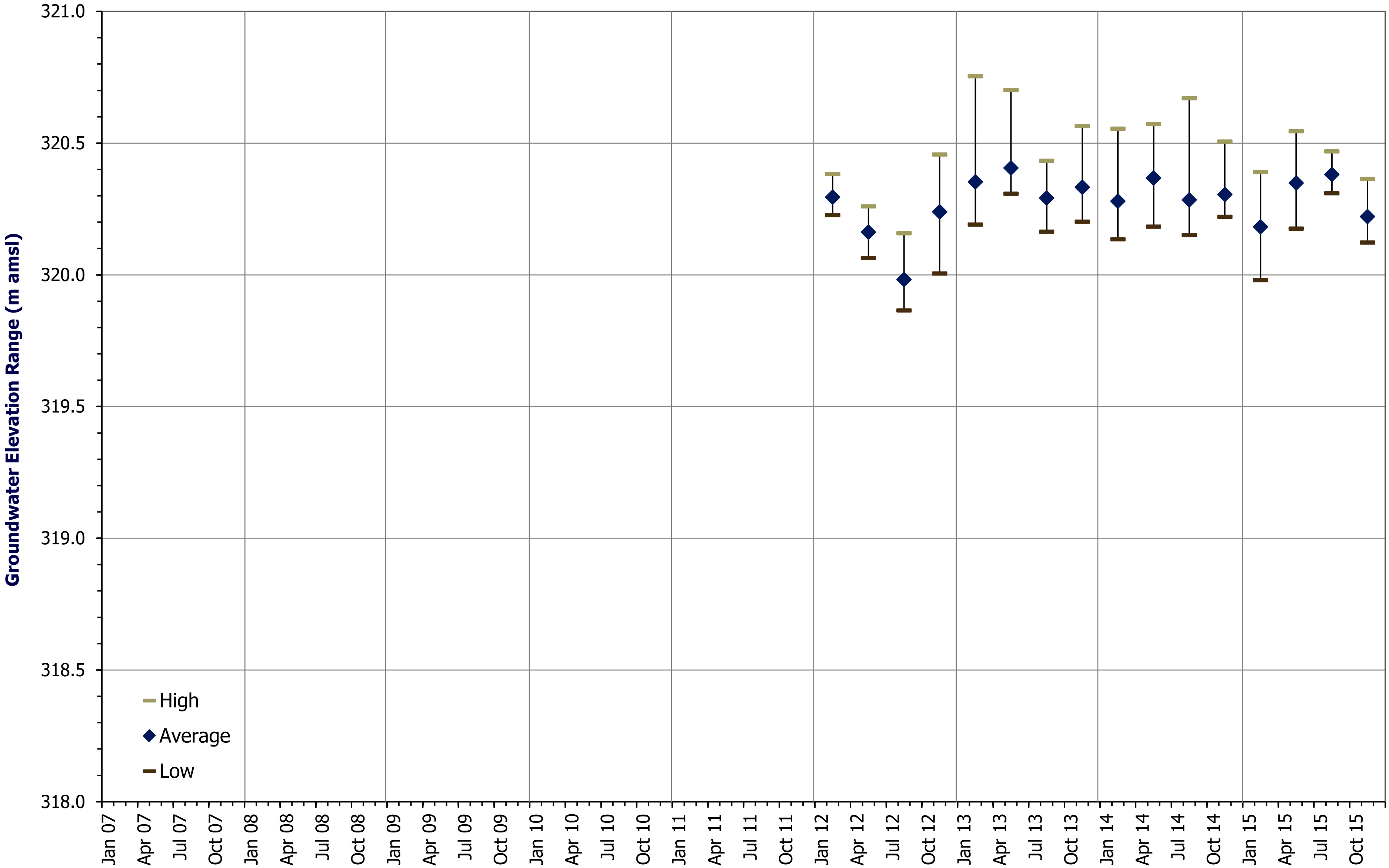
Graph I-19

Quarterly Groundwater Elevation Range - MW128



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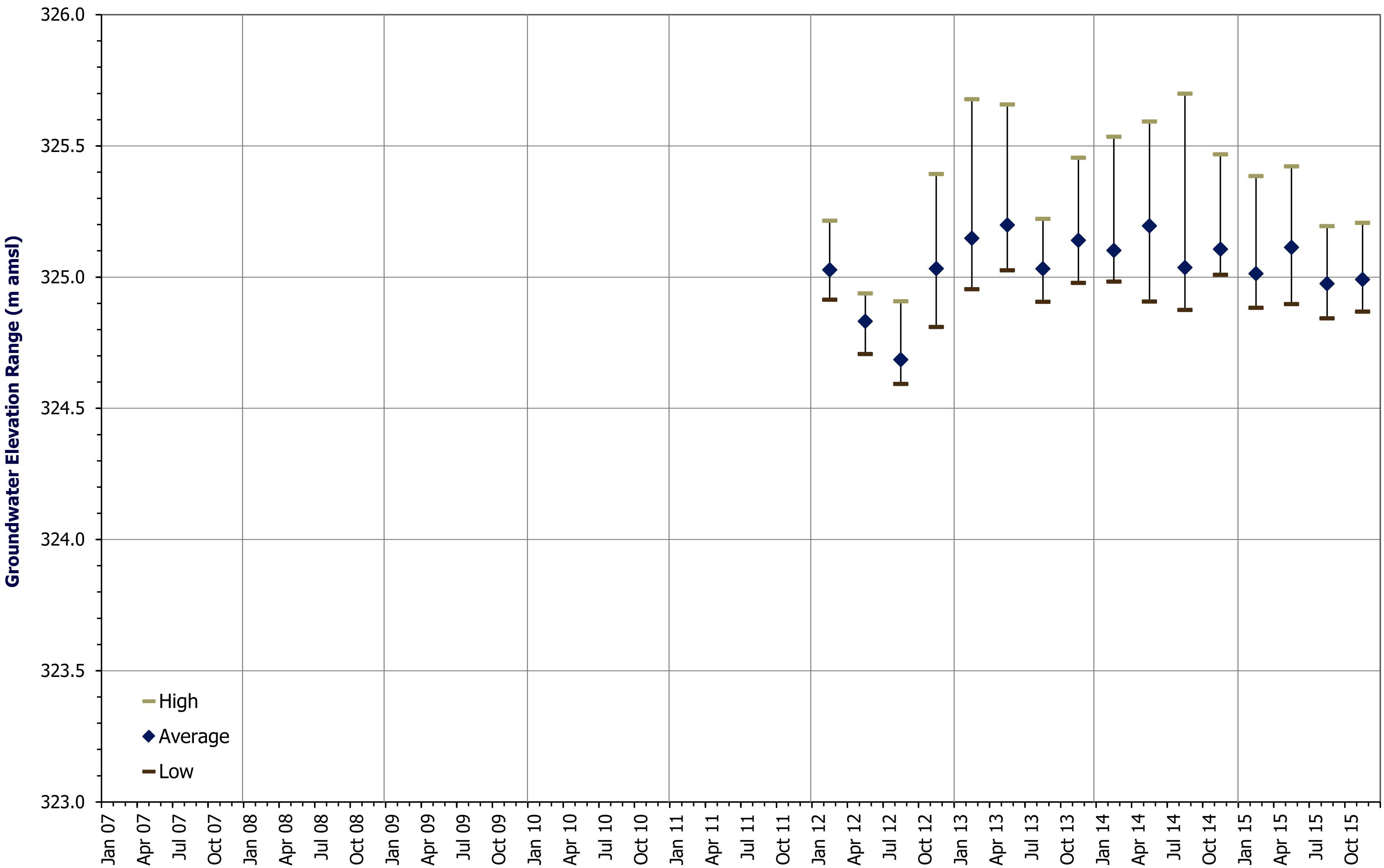
December 2015 **Graph I-20**

Quarterly Groundwater Elevation Range - MW129



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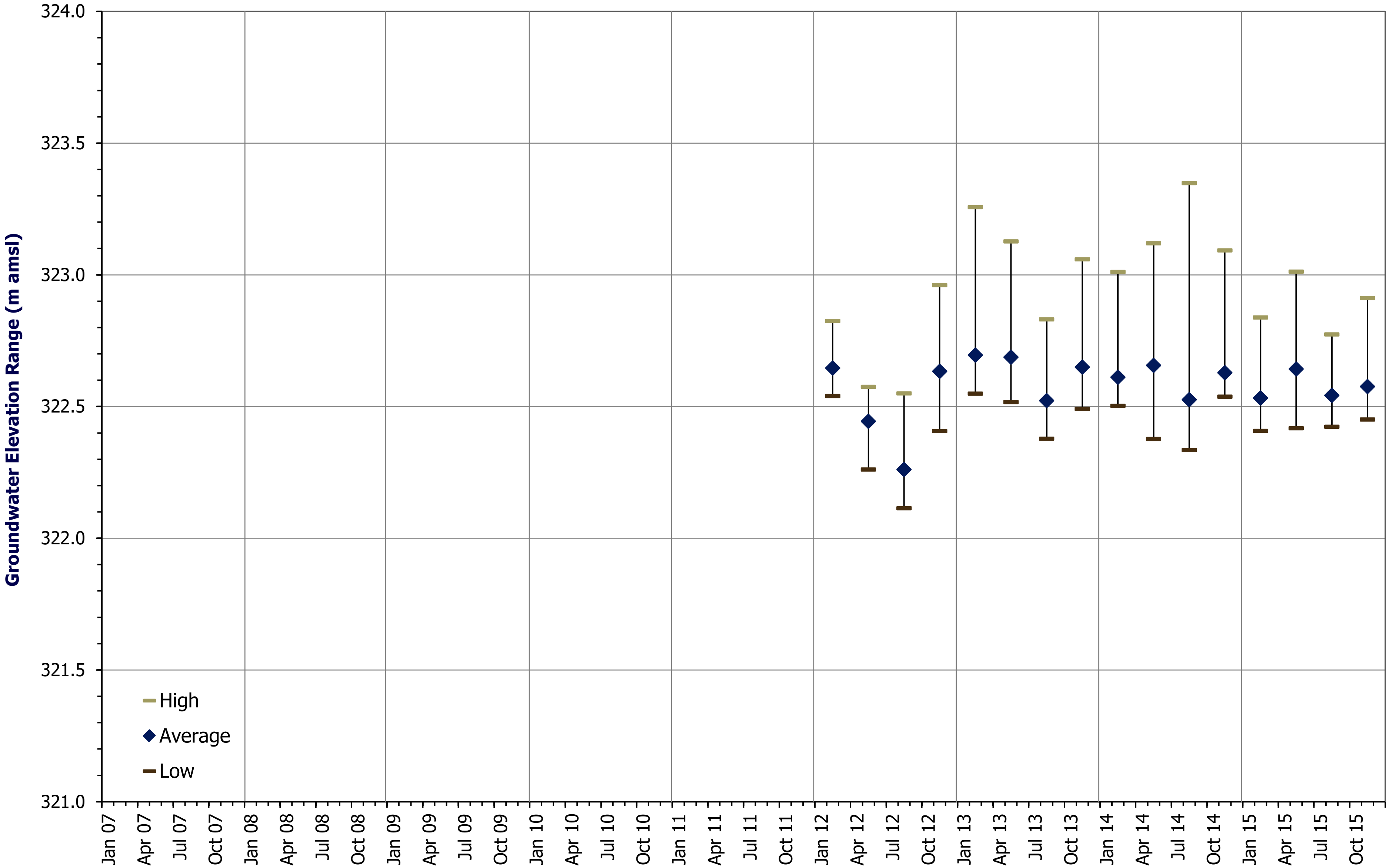
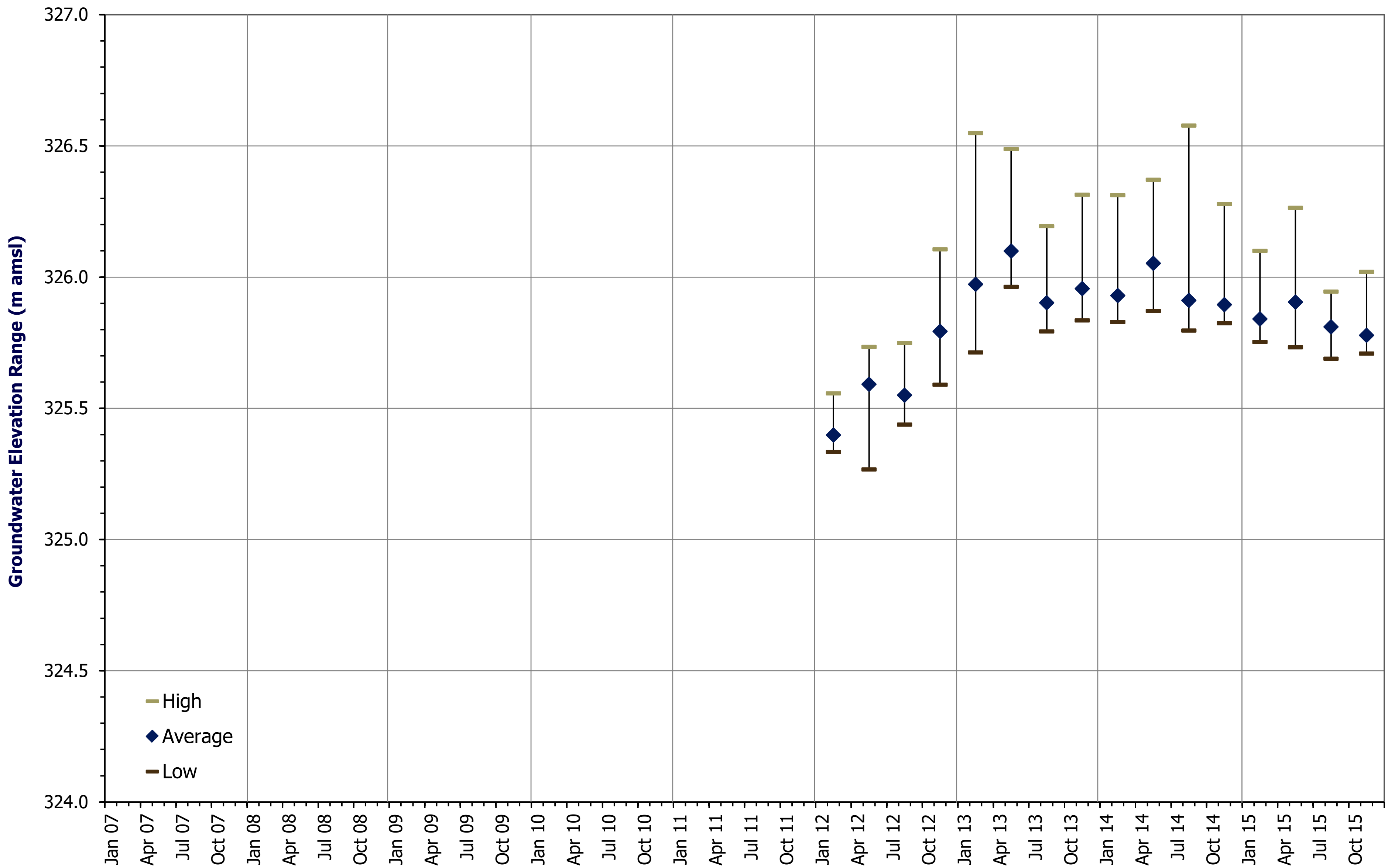
December 2015 **Graph I-21**

Quarterly Groundwater Elevation Range - MW130A



Quarterly Groundwater Elevation Range - MW131



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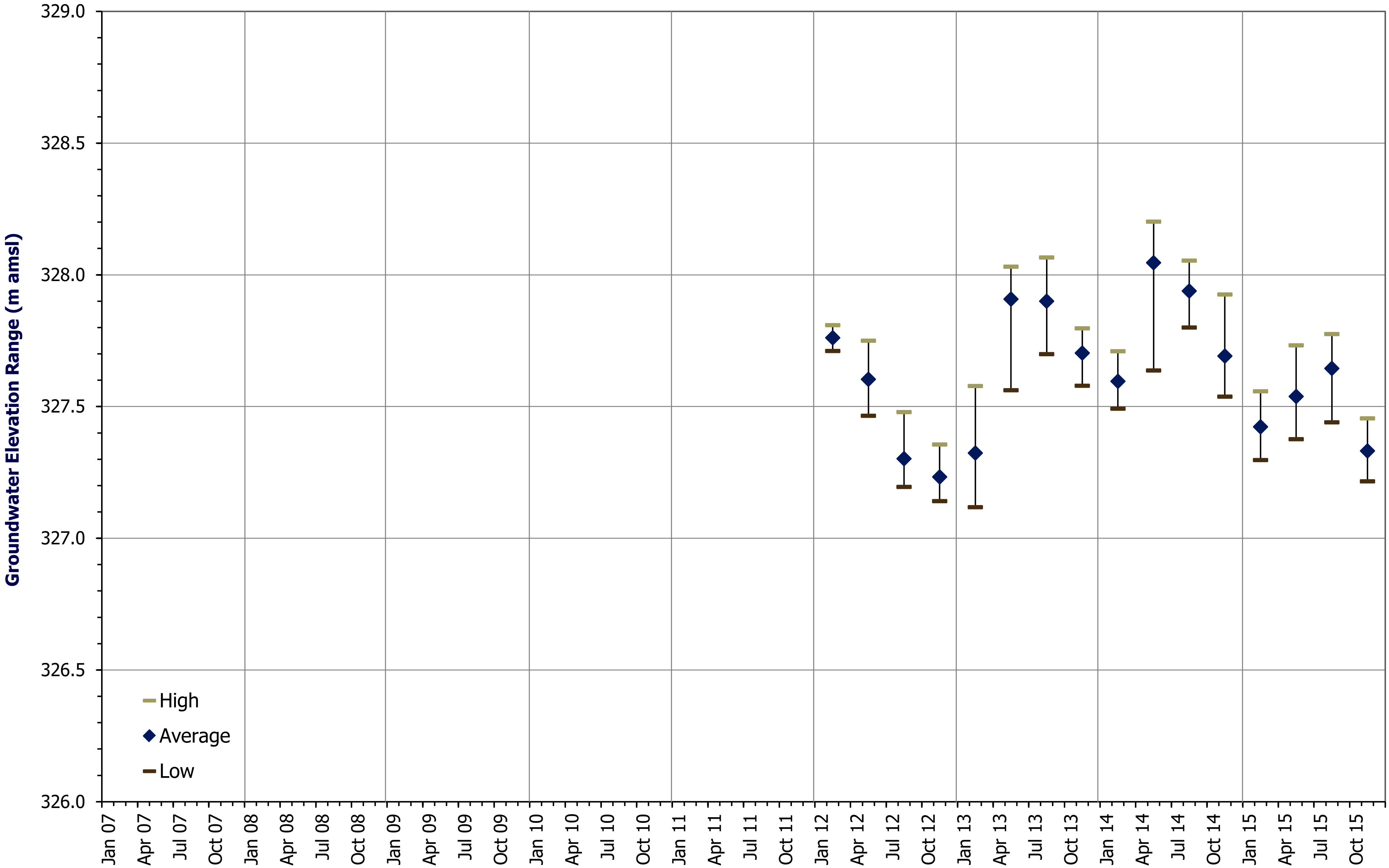
December 2015 **Graph I-23**

Quarterly Groundwater Elevation Range - MW132



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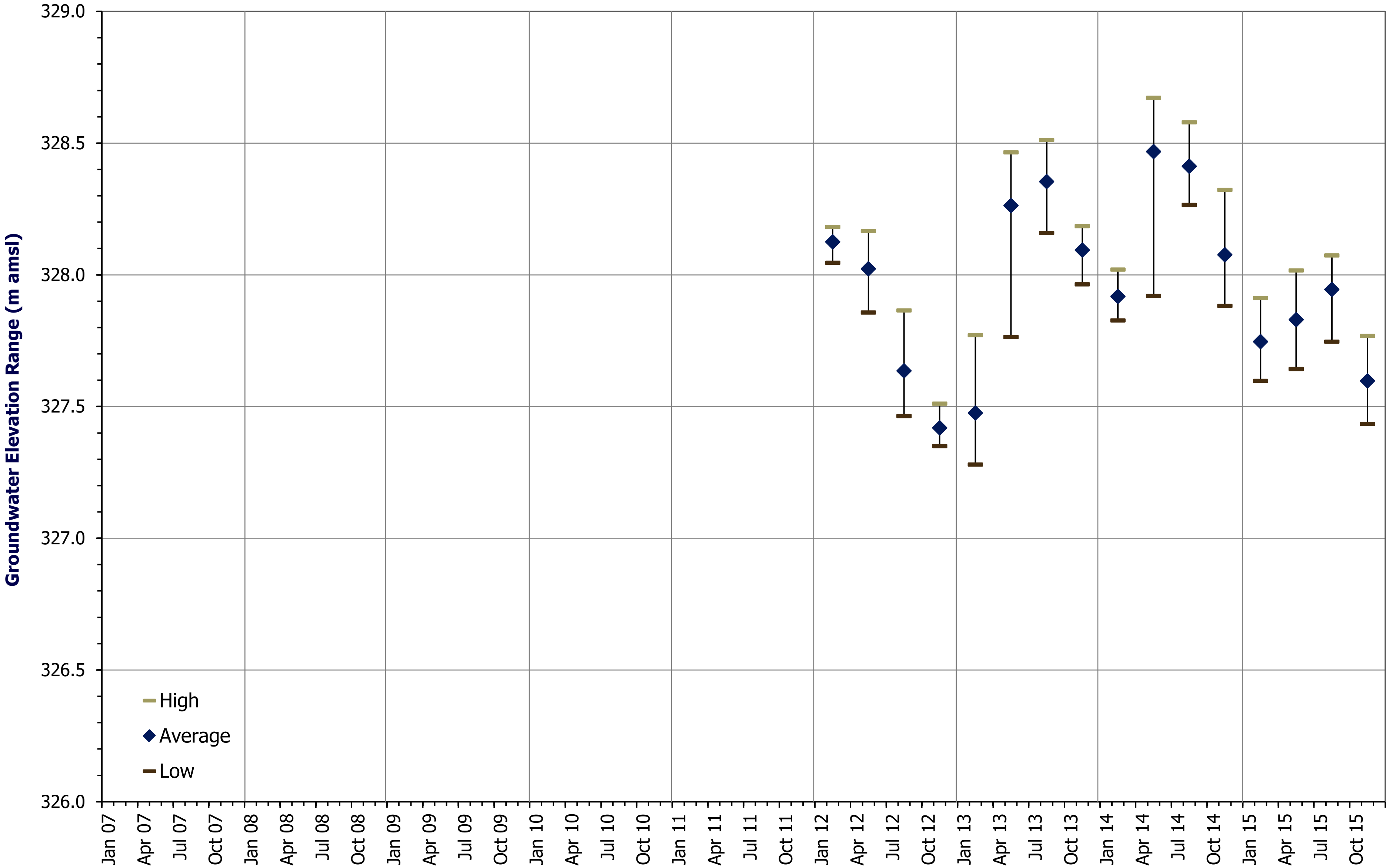
December 2015 **Graph I-24**

Quarterly Groundwater Elevation Range - MW133



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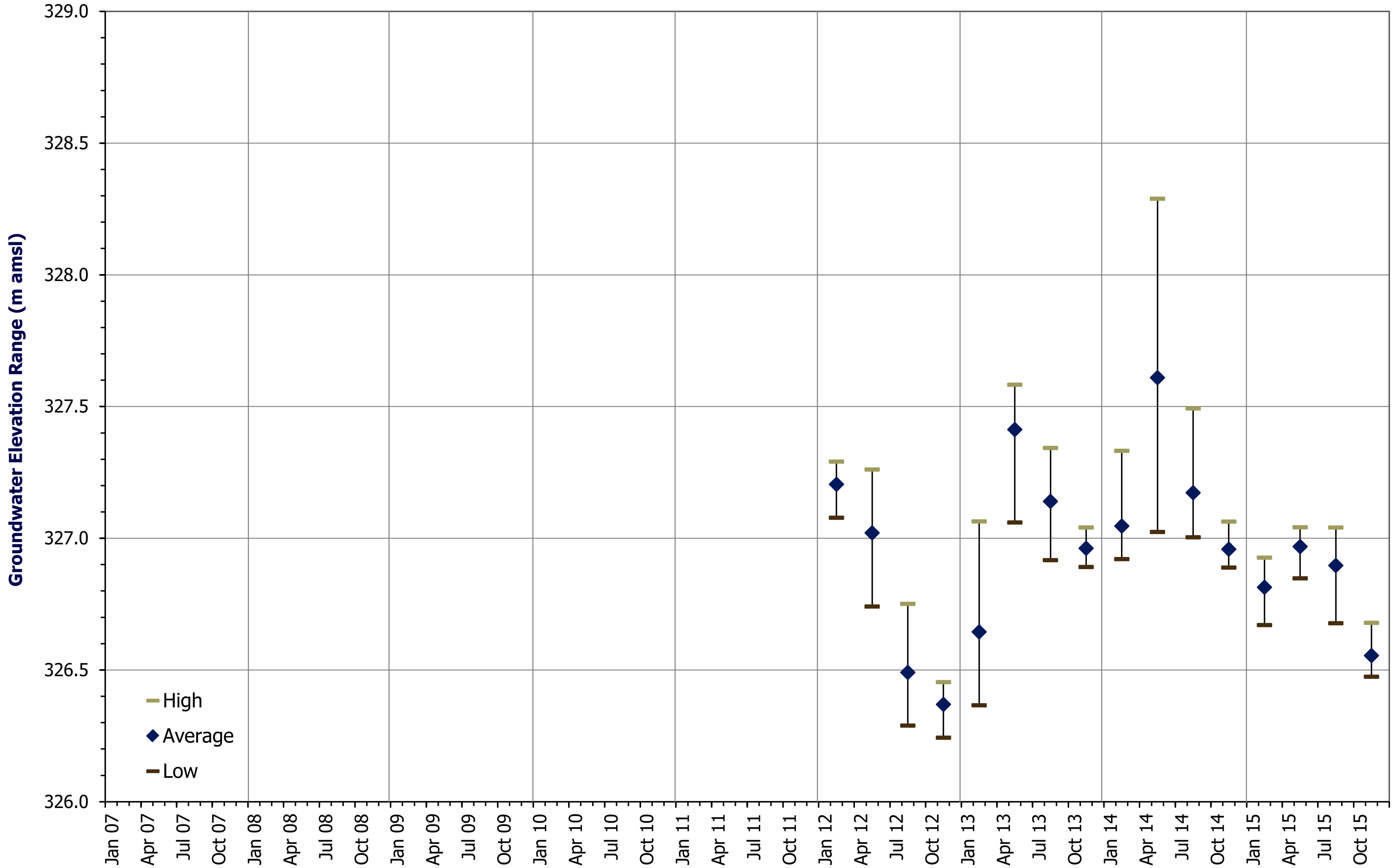
Graph I-25

Quarterly Groundwater Elevation Range - MW134



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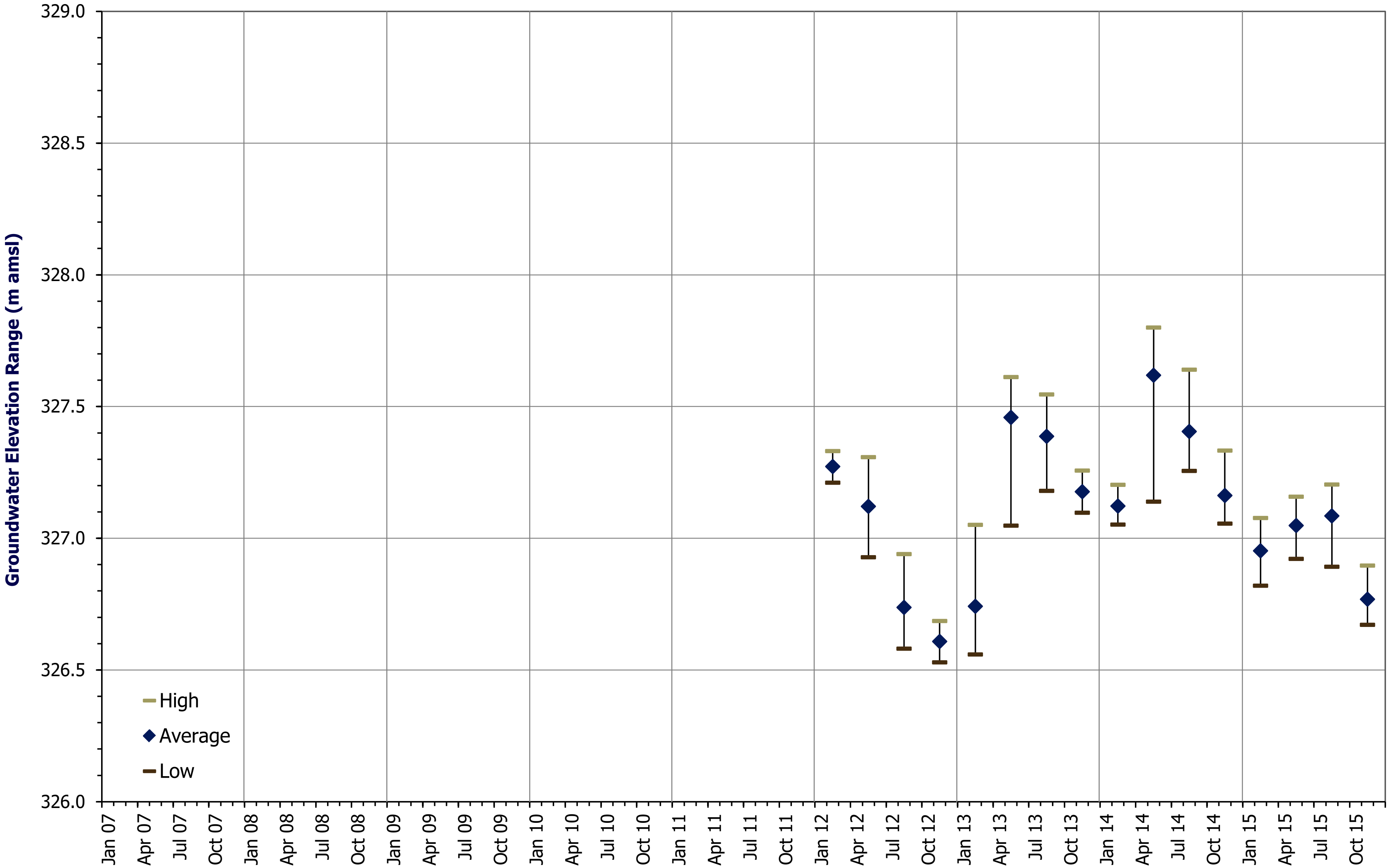
Graph I-26

Quarterly Groundwater Elevation Range - MW135



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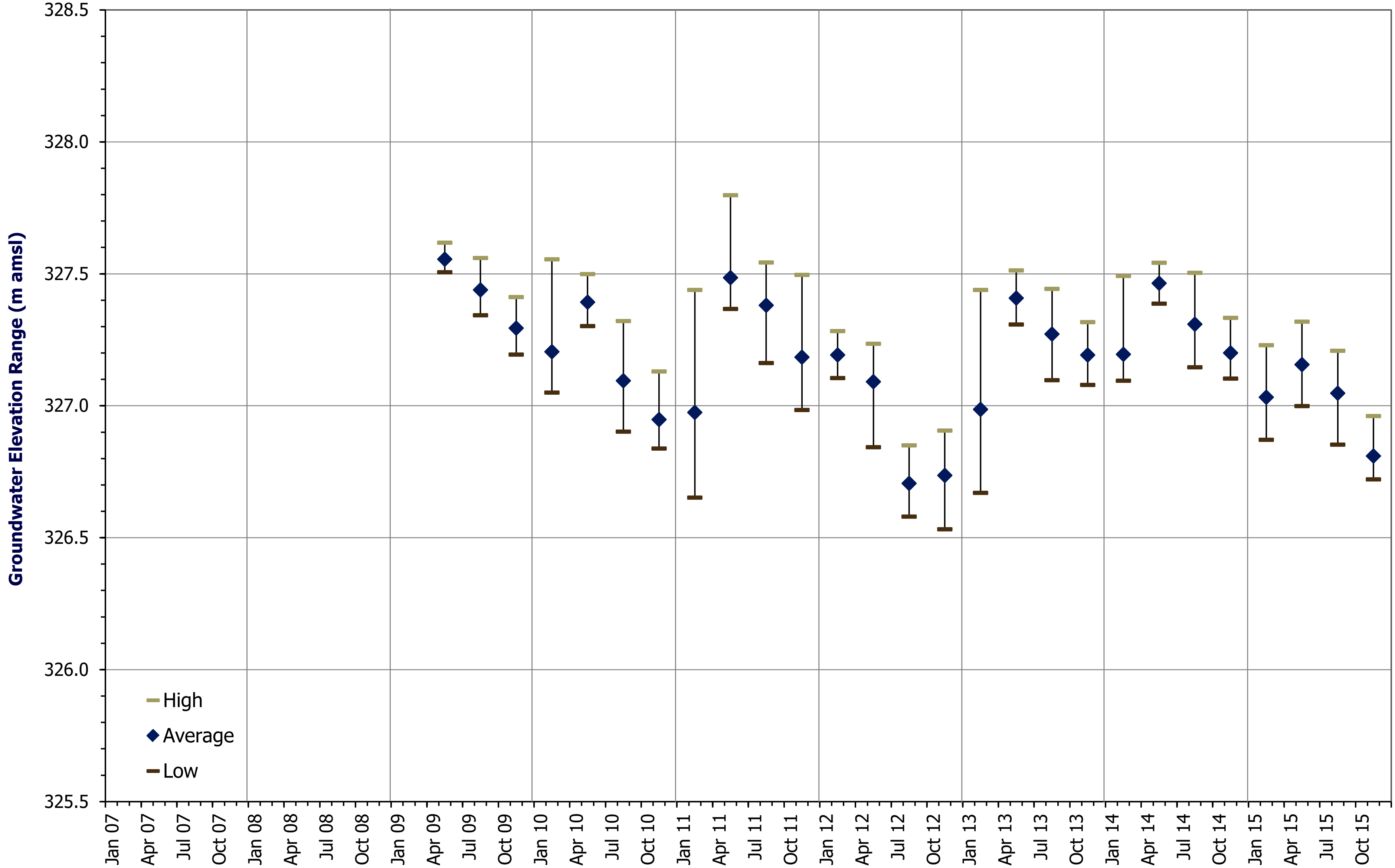
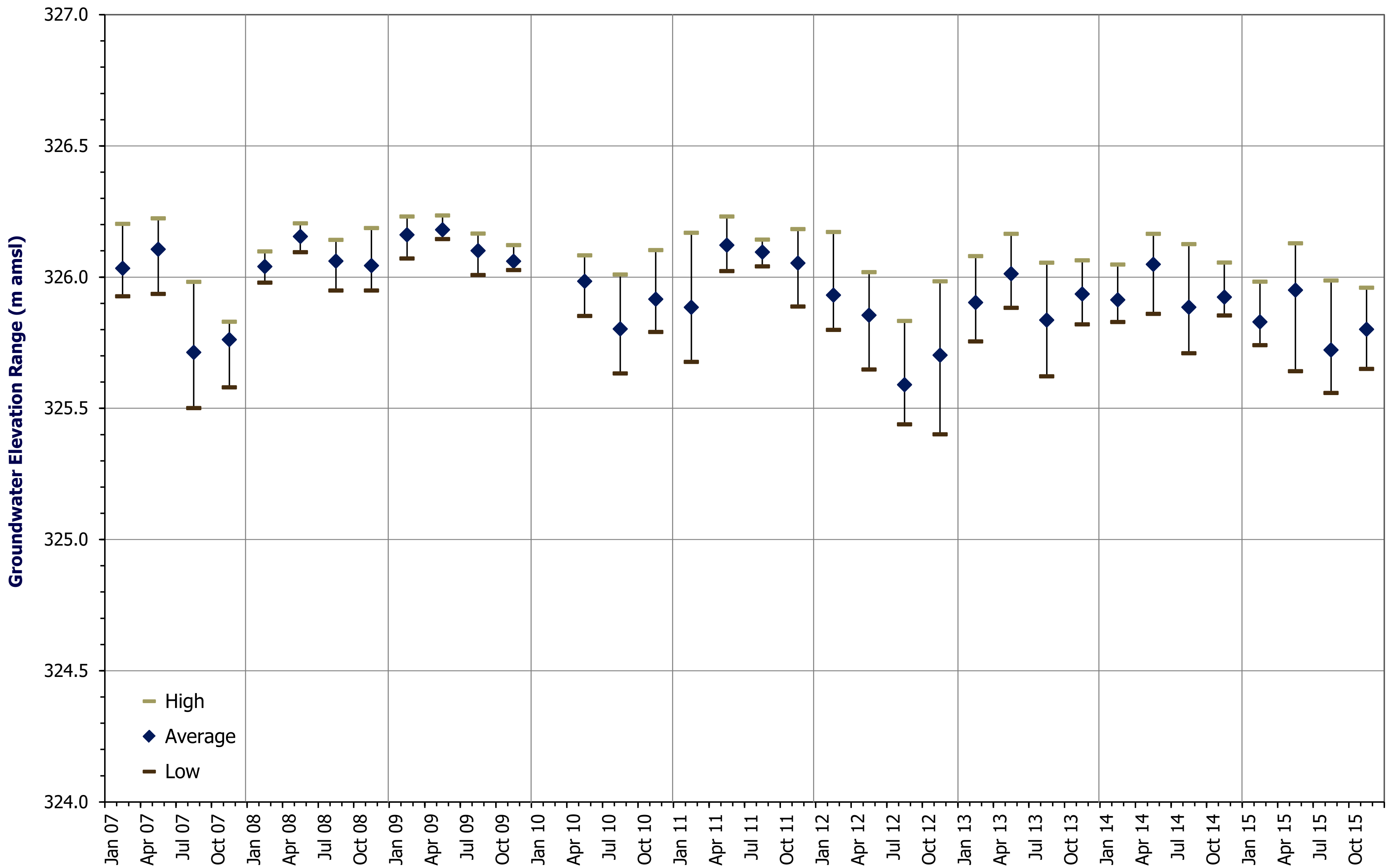
Graph I-27

Quarterly Groundwater Elevation Range - PZ-1D



Quarterly Groundwater Elevation Range - PZ-2D



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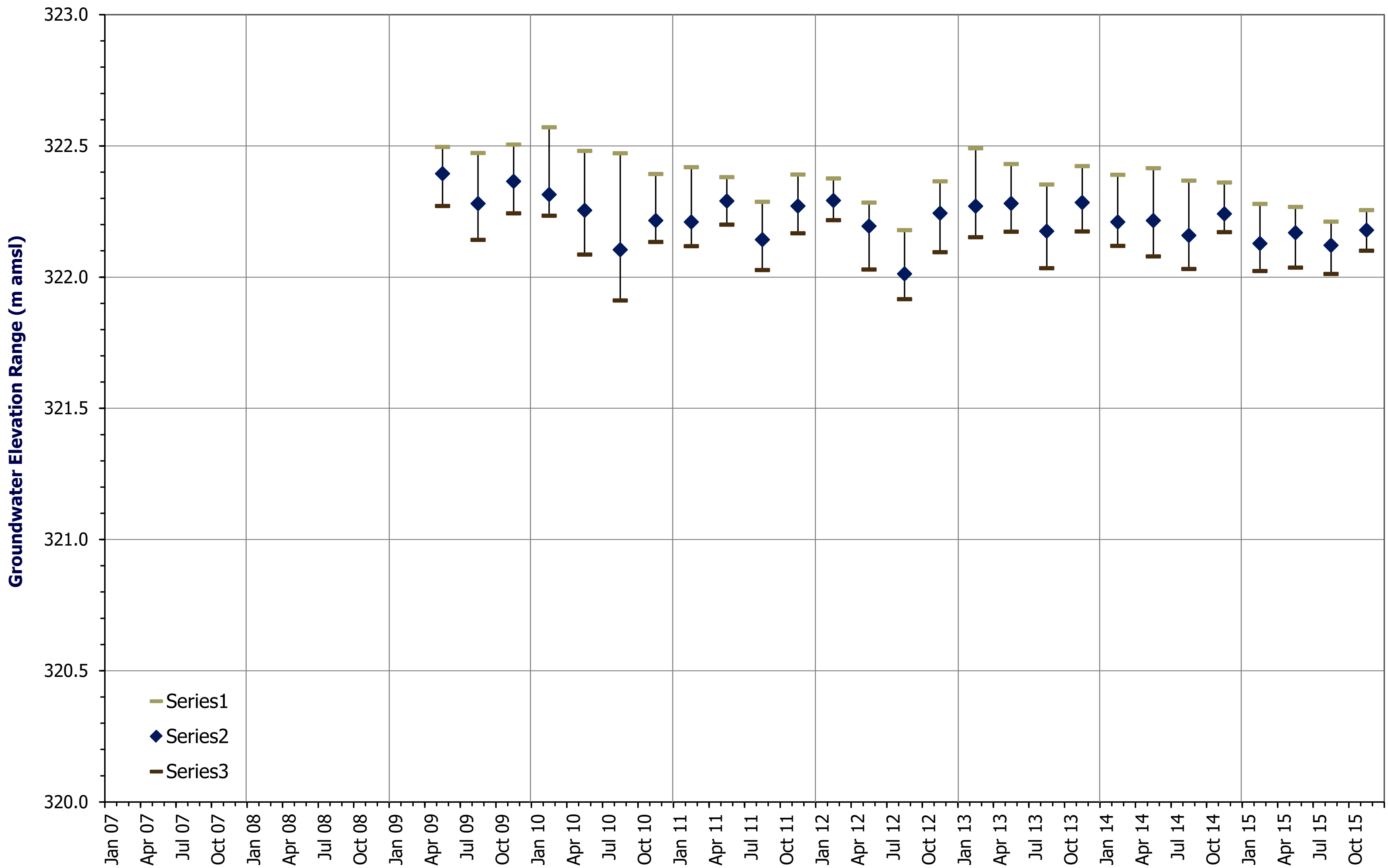
Quarterly Groundwater Elevation Range - PZ-4D



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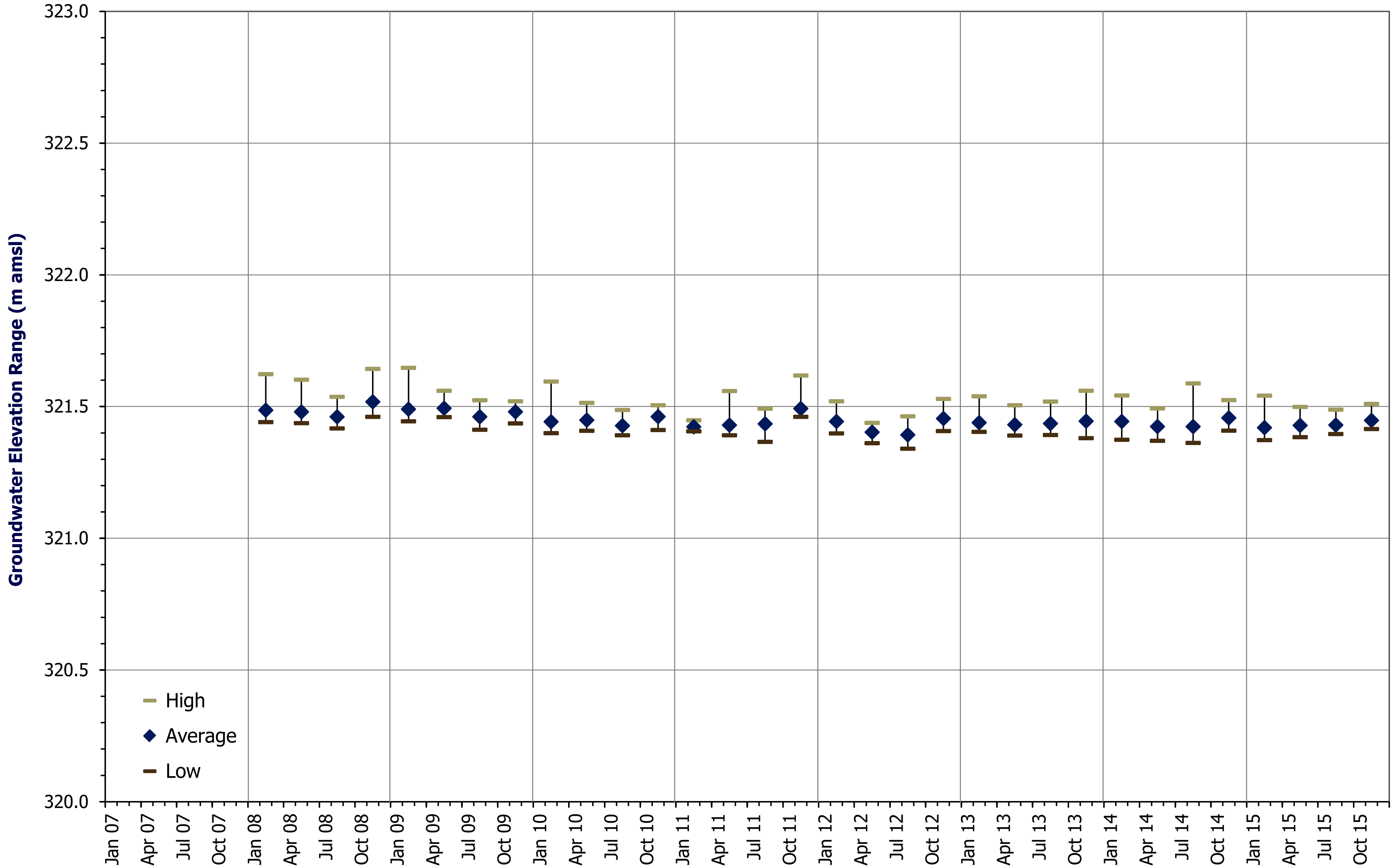
Graph I-30

Quarterly Groundwater Elevation Range - PZ-7D



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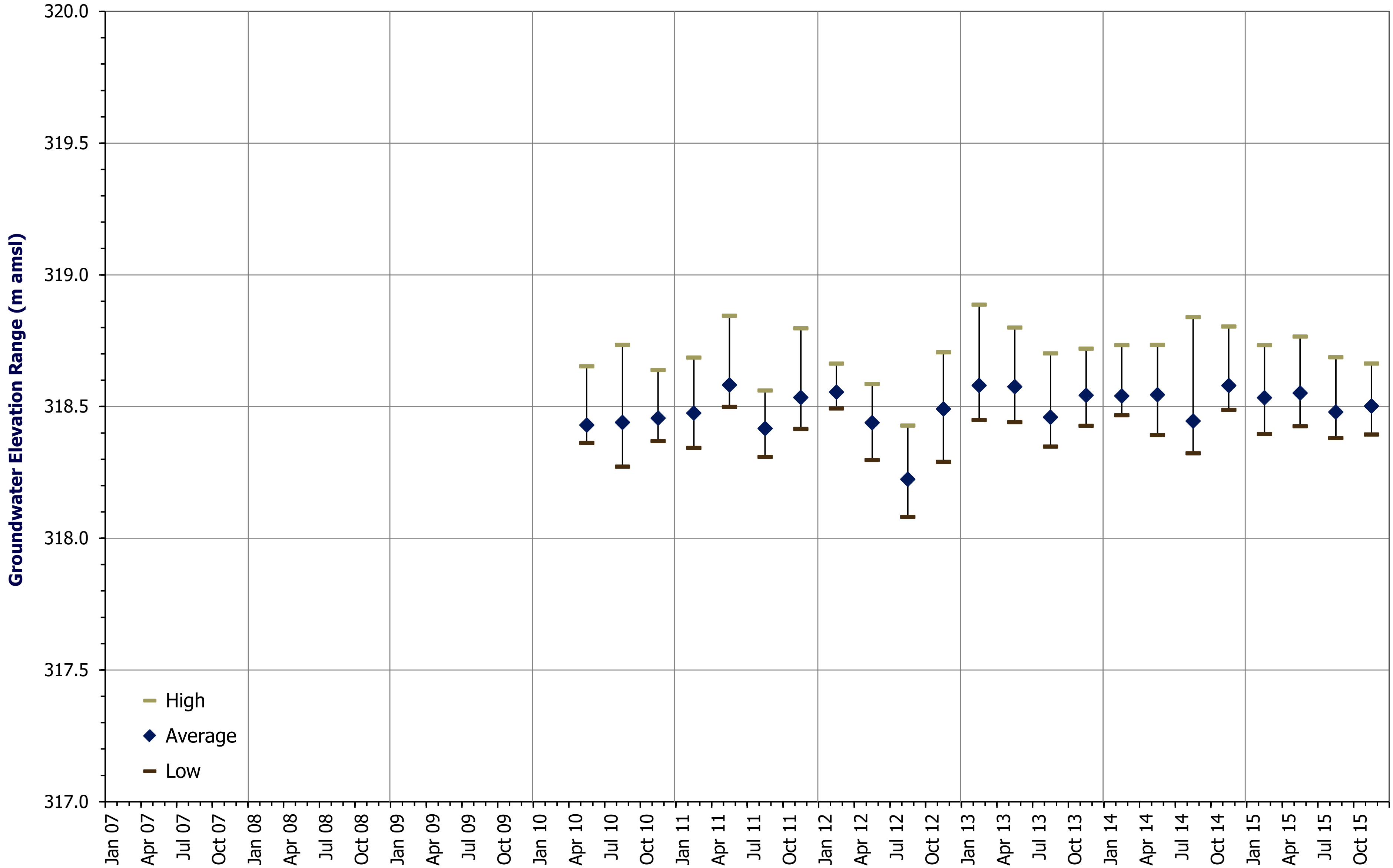
Graph I-31

Quarterly Groundwater Elevation Range - PZ-8D



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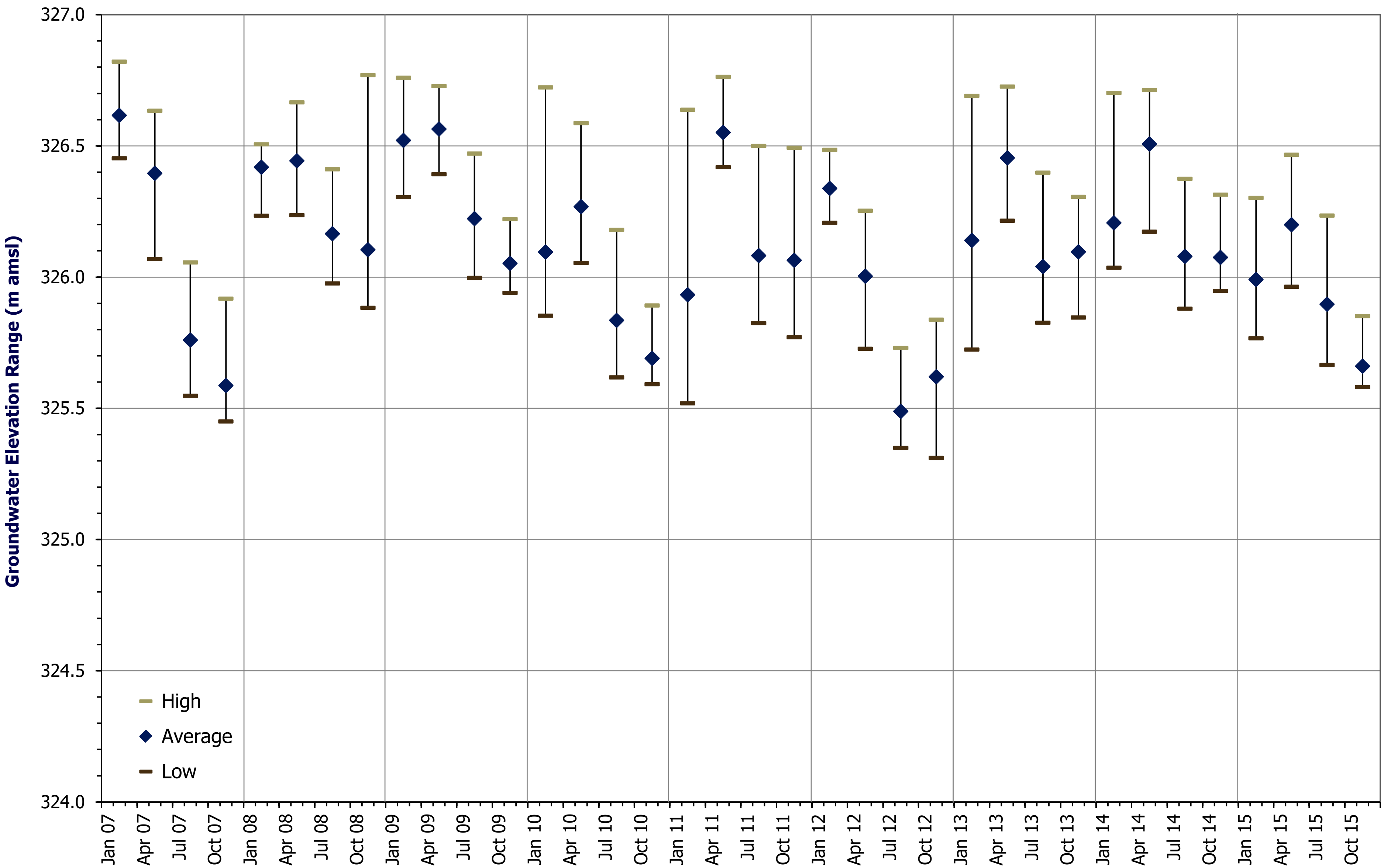
Graph I-32

Quarterly Groundwater Elevation Range - PZ-9D



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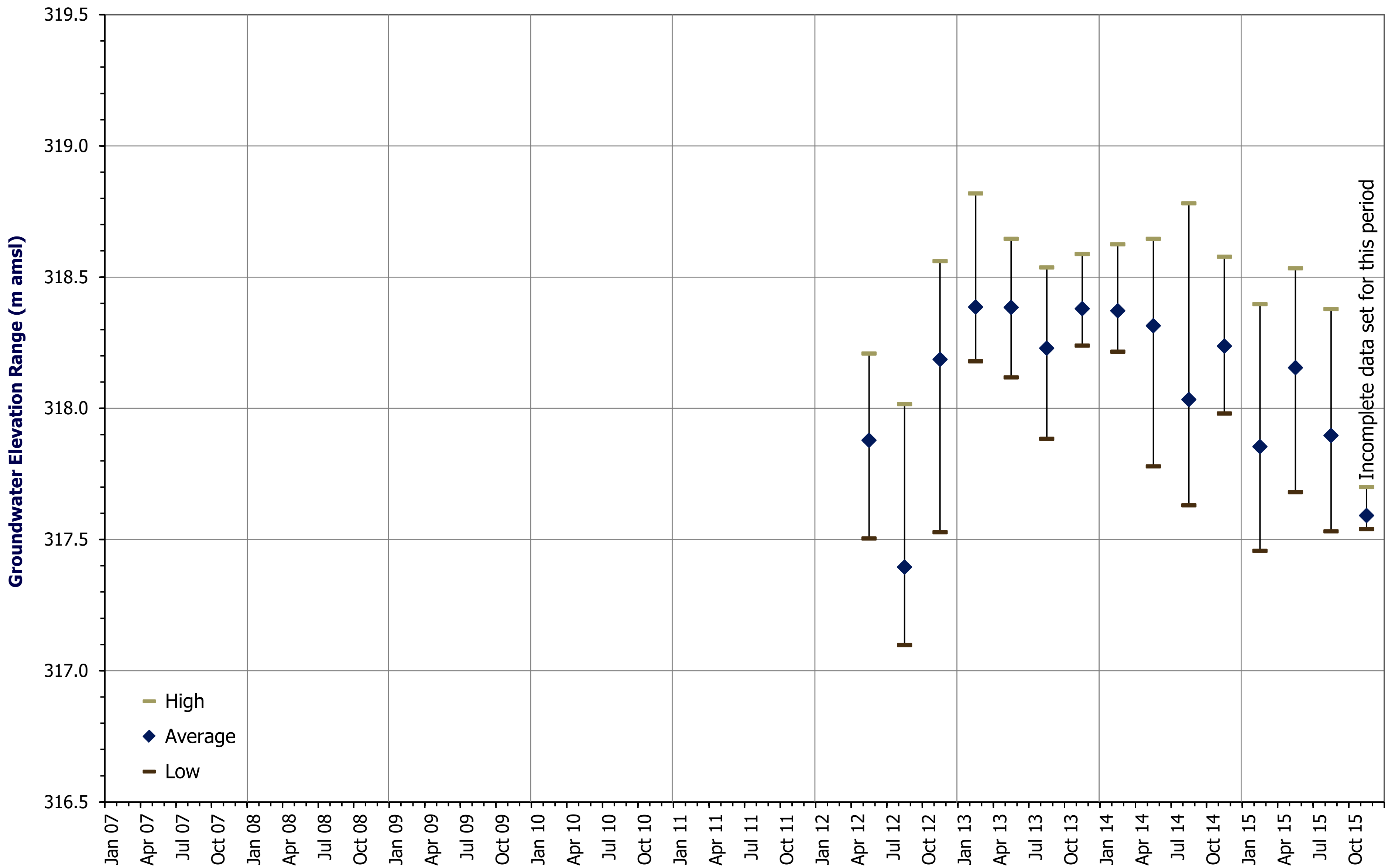
Graph I-33

Quarterly Groundwater Elevation Range - PZ-10D



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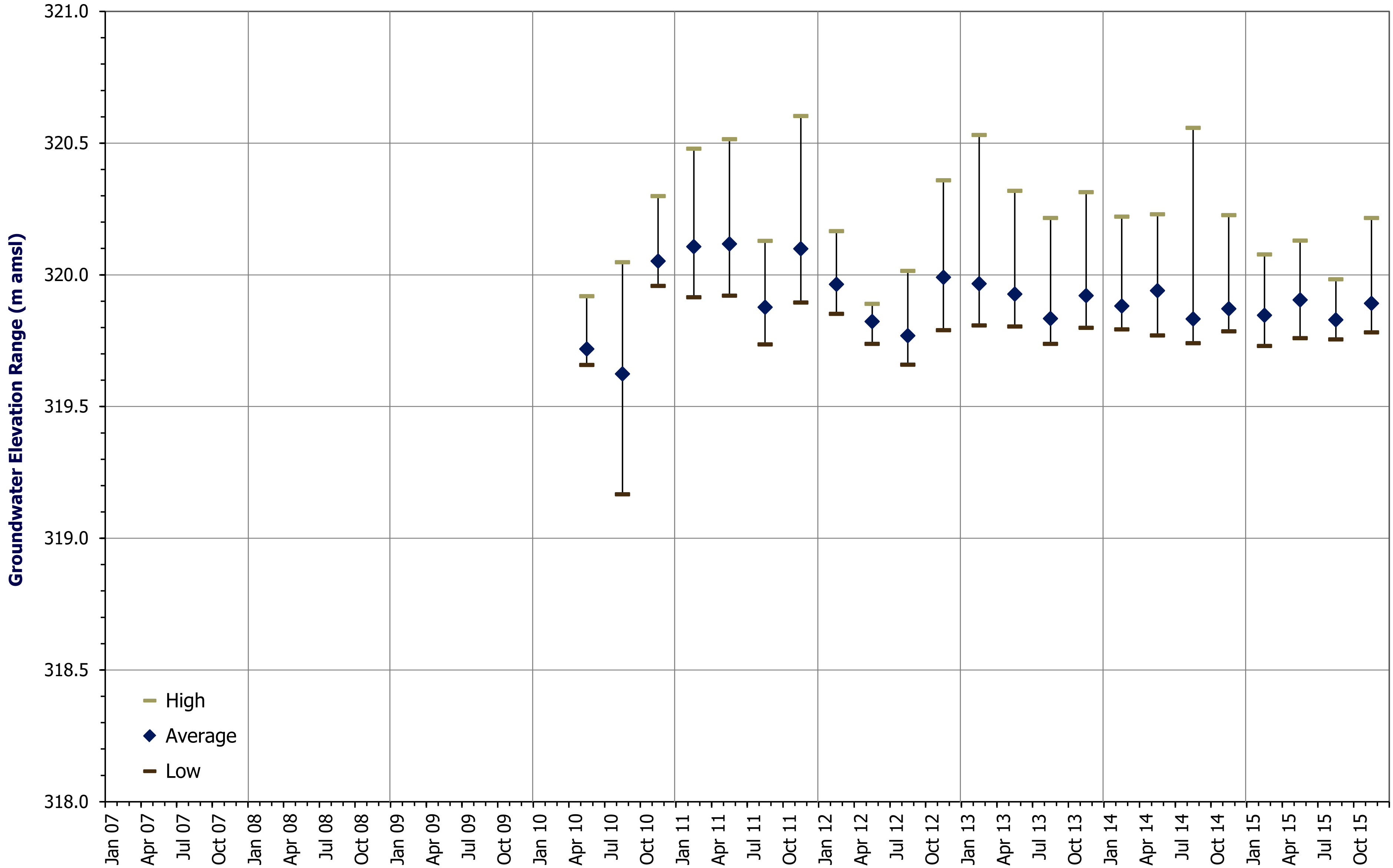
Graph I-34

Quarterly Groundwater Elevation Range - PZ-11D



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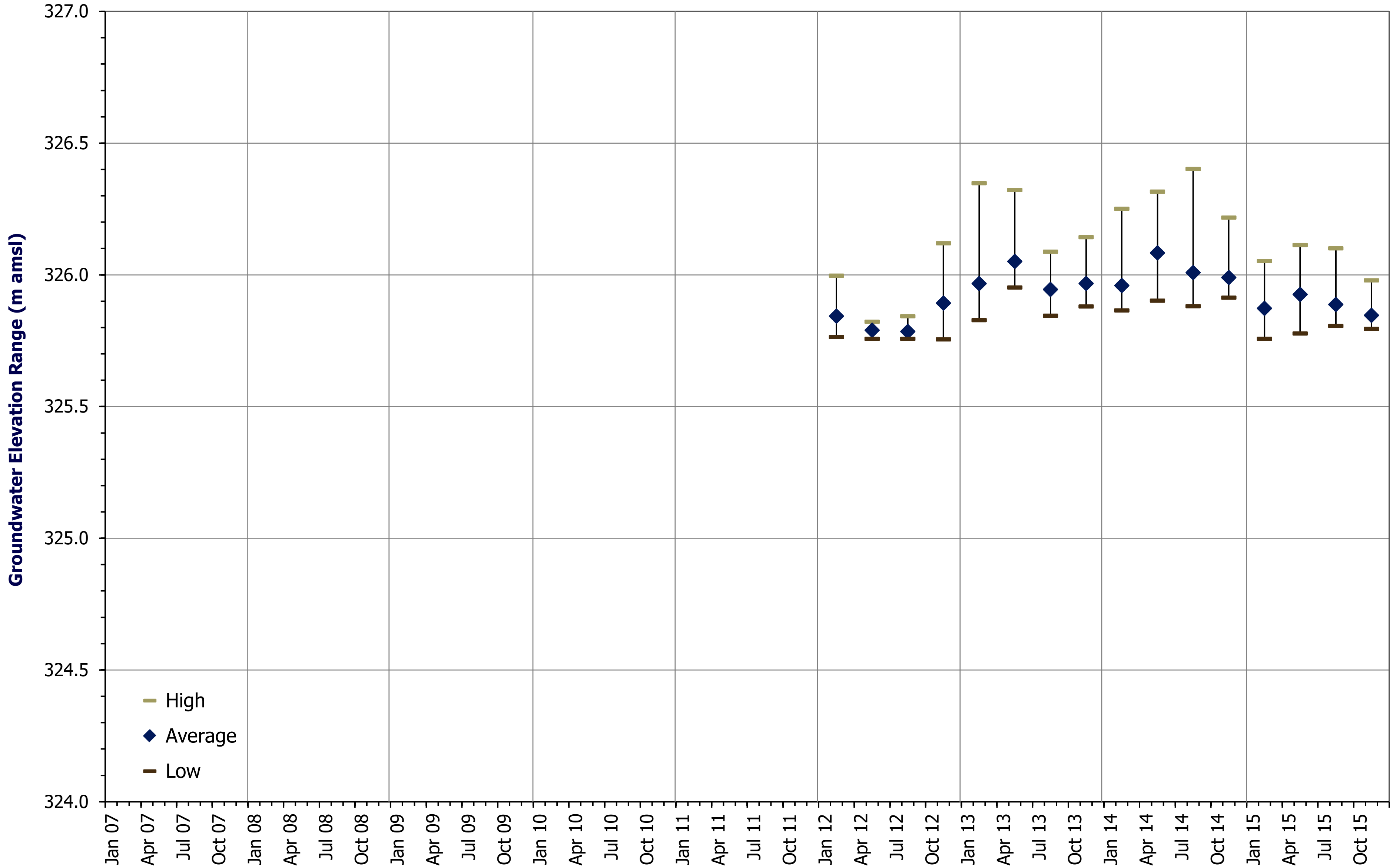
Graph I-35

Quarterly Groundwater Elevation Range - PZ-12D



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Graph I-36

Appendix J

Groundwater Quality Monitoring Data
2003 – 2015

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 001					003									004								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	221	245	311	300	ns	37.6	37.4	38.8	39.5	36.9	38.6	40.5	41.7	63.0	48.9	55.3	48.5	59.7	64.1	64.5	61.8	60.8
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.08	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.50	<0.25	<0.10	0.08	<0.05	0.07	<0.05	<0.05	<0.25	<1.25	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	4.88	3.93	3.09	3.36	ns	11.9	7.79	5.66	4.73	5.80	5.34	6.44	4.57	19.0	10.7	12	9.6	7.85	9.43	13.3	13.7	10.7
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.50	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<1.00	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	28.4	24	24.2	23.7	ns	18.0	16.3	14.3	16.9	14.4	14.2	13.5	10	25.0	20.3	21.4	18.9	18.2	18.8	17.9	20.4	19.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	0.063	<0.004	<0.004	0.009	ns	2.56	<0.004	<0.004	0.018	0.006	0.004	<0.004	<0.004	<0.01	0.648	0.009	<0.004	0.008	0.005	0.008	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	ns	0.010	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.627	0.108	0.142	0.12	ns	0.312	0.057	0.052	0.049	0.056	0.046	0.053	0.048	0.15	0.371	0.126	0.116	0.087	0.115	0.098	0.113	0.121
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.015	0.012	0.015	0.01	ns	0.016	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.05	0.016	0.013	0.011	0.01	0.012	<0.010	0.012	0.012
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.006	<0.002	<0.002	<0.002	ns	0.010	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.0001	0.011	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	ns	86.2	95.7	115	97.8	ns	87.2	86.6	87	80.5	74.8	83.6	75.4	82	130	92.5	119	103	93.7	98.5	110	111	104
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.016	0.004	<0.003	<0.003	ns	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	0.004	0.004	<0.003	<0.003	0.004	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.008	<0.001	<0.001	<0.001	ns	0.027	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.004	<0.003	<0.003	<0.003	ns	0.082	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	0.002	0.009	0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	0.63	<0.010	<0.010	<0.010	ns	3.20	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.13	0.592	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	<0.001	<0.002	<0.002	<0.002	ns	0.325	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	27.3	28.9	34.7	29.4	ns	24.3	27.3	24.8	22.4	21.1	23.5	22.1	22.4	36	25	32.2	29.1	26.9	27.2	30.5	31.2	28.6
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	4.87	<0.002	<0.002	<0.002	ns	3.53	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.012	3.38	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	0.028	<0.003	0.005	<0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	0.13	<0.05	<0.05	<0.05	ns	0.97	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	3.07	1.73	2.06	1.85	ns	2.24	1.79	1.67	1.57	1.51	1.77	1.58	1.57	15	10.3	13.4	12	6.33	10.4	8.32	17.4	16.9
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	ns	0.006	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.0001	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	127	105	162	167	ns	14	17.4	15.4	13.7	14.8	14.9	15.5	17.3	24	18.6	22.3	20.7	19.5	25	25.6	27.8	27.8
	Strontium (mg/L)		0.001	0.005	0.005	ns	1.91	0.113	0.155	0.128	ns	0.994	0.094	0.096	0.106	0.109	0.091	0.095	0.092	0.16	1.98	0.138	0.132	0.131	0.129	0.128	0.123	0.129
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.0003	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.0004	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.005	<0.002	<0.002	<0.002	ns	0.016	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.002	<0.002	0.003	<0.002	ns	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.309	0.023	0.016	0.012	ns	1.19	0.011	0.015	0.033	0.02	0.014	0.011	0.009	0.018	0.835	0.042	0.032	0.027	0.031	0.032	0.026	0.026
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	299	275	297	298	ns	252	262	272	248	259	254	243	252	320	293	326	305	303	330	297	338	319
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	299	275	297	298	ns	252	262	272	248	259	254	243	252	319	293	326	305	303	330	297	338	319
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	5	<5	ns	<5	<5	7	<5	<5	<5	<5	<5	27	<5	<5	7	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	36.6	1.4	1.8	1.5	ns	2.6	4.2	1.6	1	6.4	2	2.4	2	na	1.0	2	1.8	1.2	4.9	2.4	2	1.4
	DOC (mg/L)	5	0.7	0.5	0.5	ns	1.4	1.5	1.8	1.5	ns	2.6	1.9	1.6	0.9	2	1	2.2	2.1	1.3	1.0	2	1.6	1	1.8	1.5	2.1	1.3
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	328	358	430	365	ns	318	329	319	293	274	306	279	297	473	334	430	377	345	358	400	406	377
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	0.15	<0.02	ns	<0.02	<0.02	<0.02	0.59	<0.02	<0.02	0.03	<0.02	<0.05	0.17	<0.02	<0.02	<0.02	0.03	<0.02	0.04	<0.02
	Conductivity (us/cm)		3	2	2	ns	1160	1290	1450	1360	ns	658	667	617	623	616	666	622	679	950	739	897	762	785	859	936	965	933
	pH	8.5	0.1	N/A	N/A	ns	7.84	8.18	8.11	7.76	ns	8.14	7.90	8.05	7.98	7.94	8.23	8.07	7.97	7.3	8.11	7.83	8.05	7.72	7.99	7.87	8.04	7.87
Calculated Values	Anion sum (meq/L)		0.01			ns	12.2	13.2	14.5	15.2	ns	7.33	7.19	6.34	6.76	6.93	6.85	6.74	6.75	10.1	8.43		7.55	8.68	9.47	9.08	9.91	9.26
	Cation sum (meq/L)		0.01			ns	12.1	11.8	15.7	14.6	ns	7.02	7.37	7.1	6.54	6.15	6.8	6.3	6.73	10.9	7.76		8.74	7.9	8.51	9.33	9.76	9.19
	% Difference (%)		0.01	0.1	0.1	ns	0.1	5.7	0.8	1.8	ns	2.1	1.2	1	1.7	6	0.3	3.4	0.2	7.93	4.1	2.7	1.1	4.7	5.4	1.3	0.7	0.4
	Langelier Index		0.0001			ns	0.94	1.28	1.32	0.91	ns	1.18	0.98	1.13	0.98	0.93	1.26	1.04	0.98	-0.17	1.24	1.28	1.25	0.85	1.17	1.09	1.29	1.06
	Saturation pH (pH units)		0.01			ns	6.9	6.9	6.79	6.85	ns	6.96	6.92	6.92	7	7.01	6.97	7.03	6.99	7.47	6.87	6.55	6.8	6.87	6.82	6.78	6.75	6.81
	Silica (mg/L)			0.05	0.05 - 0.10	ns	10.6	3.79	9.4	8.49	ns	8.30	3.60	8.11	6.62	6.89	7.5	6.59	6.61	20.2	9.64	4.37	9.09	9.27	9.27	10.2	9.32	9.13

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, PWQO: Provincial Water Quality Objective, RDL: Reported Detection Limit, ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program
Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 005-I				006				101				102			
			2003	2008-10	2011-15	2003	2008	2009	2010	2003	2008	2009	2010	2003	2008	2009	2010	2003	2008	2009	2010
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	190	163	182	233	ns	22.9	36.8	45.3	ns	82.5	101	85.0	ns	46.3	39.9	41.9
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.10	<0.05	<0.05	<0.05	ns	0.06	<0.05	<0.05	ns	0.10	0.08	0.07	ns	0.09	<0.05	0.05
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	6.80	6.95	4.71	3.72	ns	2.36	5.83	3.38	ns	2.57	2.03	1.72	ns	<0.05	0.05	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.30	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	20.0	18.4	17.2	18.2	ns	9.85	13.8	11.6	ns	23.2	22.3	21.1	ns	38.7	25.6	32.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	1.09	<0.004	<0.004	ns	0.067	<0.004	<0.004	ns	0.048	<0.004	<0.004	ns	0.037	0.022	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	<0.003	<0.003	<0.003	ns	0.005	<0.003	<0.003	ns	<0.003	<0.003	<0.003	ns	0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.10	0.366	0.095	0.11	ns	0.480	0.043	0.047	ns	0.558	0.043	0.042	ns	0.332	0.056	0.062
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.015	<0.010	<0.010	ns	0.016	<0.010	<0.010	ns	0.012	0.011	0.012	ns	0.012	0.011	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.020	<0.002	<0.002	ns	0.008	<0.002	<0.002	ns	0.001	<0.002	<0.002	ns	0.0012	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	110	83.6	103	99.6	ns	67.5	78.3	78.4	ns	76.2	83.5	84.4	ns	83.7	85.1	82.4
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.004	0.012	0.006	<0.003	ns	<0.003	<0.003	<0.003	ns	0.013	<0.003	<0.003	ns	0.013	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.028	<0.001	<0.001	ns	0.008	<0.001	<0.001	ns	0.006	<0.001	<0.001	ns	0.015	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.005	0.058	<0.003	<0.003	ns	<0.003	<0.003	<0.003	ns	<0.003	<0.003	<0.003	ns	0.005	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.12	<0.010	<0.010	<0.010	ns	<0.010	<0.010	<0.010	ns	0.40	<0.010	<0.010	ns	4.65	0.684	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.082	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.001	<0.002	<0.002	ns	<0.001	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	44	27	31.9	30.9	ns	22.4	24.5	23.7	ns	24.4	27	27.2	ns	24.9	26.9	25.9
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.046	3.74	<0.002	<0.002	ns	2.50	<0.002	<0.002	ns	4.13	<0.002	<0.002	ns	4.26	0.152	0.076
	Molybdenum (mg/L)		0.001	0.002	0.001	0.004	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	0.003	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	0.004	0.022	<0.003	0.009	ns	<0.003	<0.003	<0.003	ns	0.009	<0.003	0.004	ns	0.022	<0.003	0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.18	<0.05	<0.05	ns	<0.05	<0.05	<0.05	ns	0.03	<0.05	<0.05	ns	1.07	0.02	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	3.4	2.26	1.48	1.57	ns	1.11	0.81	0.79	ns	2.46	1.41	1.32	ns	2.12	1.01	1.64
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.0001	<0.002	<0.002	ns	<0.0001	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	73	84.6	87.5	123	ns	16	24.9	32.5	ns	53.9	53.5	55.4	ns	39.5	35	37.9
	Strontium (mg/L)		0.001	0.005	0.005	0.19	1.69	0.117	0.126	ns	2.13	0.073	0.089	ns	1.79	0.11	0.132	ns	1.89	0.13	0.127
	Thallium (mg/L)		0.0003	0.006	0.006	0.0008	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	ns	<0.0003	<0.006	<0.006	ns	<0.0003	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.005	<0.002	<0.002	ns	0.004	<0.002	<0.002	ns	0.004	<0.002	<0.002	ns	0.003	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	0.003	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.013	1.32	0.02	0.024	ns	0.498	0.008	0.009	ns	0.015	0.01	0.006	ns	0.08	0.042	0.009
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	290	306	261	278	ns	264	251	266	ns	275	285	284	ns	307	300	300
	Bicarbonate (CaCO3) (mg/L)		10	5	5	289	306	261	278	ns	264	251	266	ns	275	285	284	ns	307	300	300
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	ns	<5	<5	<5	ns	<5	<5	<5	ns	<5	<5	<5
	Colour (TCU)	5	1	5	5	16	<5	<5	6	ns	<5	<5	5	ns	<5	<5	<5	ns	<5	<5	5
	Total Organic Carbon (mg/L)			0.5	0.5	na	9.9	5.4	1.4	ns	1.2	1.6	1.5	ns	12.4	5.4	2.1	ns	19.7	3	2.6
	DOC (mg/L)	5	0.7	0.5	0.5	<0.7	0.8	3.9	1.5	ns	1.2	1.5	1.3	ns	1.5	4.8	1.6	ns	2.9	3	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	456	320	389	376	ns	261	296	293	ns	291	320	323	ns	312	323	312
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	<0.02	ns	1.05	<0.02	<0.02	ns	<0.02	<0.02	0.31	ns	<0.02	<0.02	0.05
	Conductivity (us/cm)		3	2	2	1100	1050	1110	1200	ns	547	642	623	ns	775	823	774	ns	695	728	669
	pH	8.5	0.1	N/A	N/A	7.5	7.82	8.01	8.07	ns	8.13	8.18	8.20	ns	7.89	8.13	8.17	ns	8.01	8.19	8.03
Calculated Values	Anion sum (meq/L)		0.01			12.1	11.6		11.9	ns	6.3	6.76	6.21	ns	7.6	9.16	7.71	ns	7.25		6.87
	Cation sum (meq/L)		0.01			12.4	10.1		12.9	ns	6.01	7.03	7.3	ns	8.22	8.75	8.91	ns	8		7.94
	% Difference (%)		0.01	0.1	0.1	2.62	6.8	2.5	0.5	ns	2.4	1.9	1.5	ns	3.9	2.3	1.5	ns	4.9	2.2	0.5
	Langelier Index		0.0001			-0.10	0.92	1.59	1.2	ns	1.14	1.19	1.23	ns	0.93	1.23	1.27	ns	1.13	1.32	1.14
	Saturation pH (pH units)		0.01			7.60	6.9	6.42	6.87	ns	6.99	6.99	6.97	ns	6.96	6.9	6.9	ns	6.88	6.87	6.89
	Silica (mg/L)			0.05	0.05 - 0.10	12.9	11.4	8.94	10.2	ns	8.53	3.56	8.81	ns	11.0	4.33	10.1	ns	9.93	3.82	8.44

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 103									104								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	143	173	237	246	212	289	301	342	ns	49.9	47.1	48.7	46.7	65.4	79.7	123	104
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.16	<0.05	0.11	<0.05	<0.05	<0.5	<1.25	<0.25	ns	0.19	<0.05	0.09	<0.05	<0.05	<0.10	<1.25	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	0.27	0.14	0.23	0.2	0.26	<0.5	<1.25	<0.25	ns	<0.05	<0.05	0.06	<0.05	<0.05	<0.10	<1.25	<0.25
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<1.25	<0.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<1.25	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<1.0	<2.50	<0.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<2.50	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	37.0	18.5	19.5	23.9	41.6	60	27.4	24.6	ns	89.4	20.7	25.5	22	15.9	14.9	9.78	4.86
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	3.29	0.009	0.006	0.012	0.024	0.006	<0.004	0.004	ns	0.630	0.005	0.005	0.072	0.008	0.007	0.005	0.005
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.028	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.232	0.097	0.112	0.094	0.094	0.09	0.126	0.123	ns	0.368	0.095	0.116	0.077	0.067	0.082	0.091	0.083
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.012	0.014	0.012	<0.010	0.01	0.011	0.013	0.011	ns	0.016	<0.010	<0.010	<0.010	<0.010	0.014	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.0015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	ns	0.0049	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	ns	91.2	109	124	103	110	110	109	128	ns	97.8	91.4	99.1	83	76.1	77.7	83.3	94.8
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.025	0.003	<0.003	<0.003	0.005	<0.003	<0.003	<0.003	ns	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.013	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	0.022	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.097	0.005	0.005	0.005	0.004	<0.003	0.004	0.003	ns	0.167	<0.003	0.014	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	11.0	0.109	0.275	0.272	0.247	0.271	0.27	0.566	ns	12.2	1.12	0.061	0.738	0.771	1.45	1.42	2.62
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.149	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.014	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	27.4	34.2	38.8	32.9	34	34.3	35.2	39.8	ns	30.4	28.8	31	26.4	25.2	24.2	27.7	30.5
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	1.52	0.103	0.151	0.122	0.121	0.110	0.139	0.151	ns	3.25	0.196	0.358	0.339	0.203	0.414	0.358	0.484
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	0.020	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	0.004	ns	0.036	<0.003	0.009	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	2.43	0.02	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ns	2.11	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.96	1.18	1.4	1.13	1.3	1.19	1.24	1.32	ns	1.72	0.67	1.02	0.67	0.88	0.87	1	1.03
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	90.4	98.4	121	121	118	134	139	170	ns	18.9	19.6	22.1	19.4	34.9	37	46.8	43.1
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.741	0.126	0.168	0.152	0.145	0.17	0.174	0.17	ns	1.6	0.117	0.171	0.117	0.09	0.115	0.131	0.127
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	ns	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.046	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.003	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.047	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.983	0.013	0.02	0.013	0.035	0.009	0.014	0.01	ns	0.46	0.016	0.503	0.005	0.006	<0.005	0.006	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	325	381	360	327	332	305	339	334	ns	259	297	320	275	268	242	279	308
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	325	381	360	327	332	305	339	334	ns	259	297	320	275	268	242	279	308
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	20	34	25	29	37	13	29	41	ns	10	27	19	42	44	6	33	23
	Total Organic Carbon (mg/L)			0.5	0.5	ns	22.2	7.8	6.3	5	6.4	5	6.6	8.5	ns	22.6	11.9	11.3	5.2	6.9	6.7	6	7.1
	DOC (mg/L)	5	0.7	0.5	0.5	ns	9.0	7.5	6.6	5	4.8	3.9	6.5	8.1	ns	6.9	11.1	5.4	4.8	4.8	5.5	5.9	6.4
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	341	413	469	393	415	416	417	484	ns	369	347	375	316	294	294	322	362
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	0.05	0.04	ns	<0.02	0.09	0.03	0.06	0.08	0.07	0.17	0.2
	Conductivity (us/cm)		3	2	2	ns	1010	1240	1300	1260	1230	1520	1570	1690	ns	731	717	711	642	675	778	898	875
	pH	8.5	0.1	N/A	N/A	ns	7.61	7.83	7.92	7.65	8.17	7.99	7.82	7.56	ns	7.67	7.97	8.02	7.71	8.1	7.85	7.87	7.62
Calculated Values	Anion sum (meq/L)		0.01			ns	10.3		13.1	14	13.5	15.5	15.8	16.8	ns	7.61		7.26	7.28	7.54	7.4	9.25	9.19
	Cation sum (meq/L)		0.01			ns	10.8		14.7	13.1	13.5	14.2	14.4	17.1	ns	8.25		8.49	7.18	7.42	7.5	8.51	9.15
	% Difference (%)		0.01	0.1	0.1	ns	2.5	1.3	1.3	3.1	0.2	4.5	4.7	0.7	ns	4	0.7	1	0.7	0.8	0.7	4.2	0.2
	Langelier Index		0.0001			ns	0.79	1.14	1.26	0.87	1.42	1.19	1.07	0.87	ns	0.76	1.12	1.24	0.79	1.14	0.84	0.96	0.81
	Saturation pH (pH units)		0.01			ns	6.82	6.69	6.66	6.78	6.75	6.8	6.75	6.69	ns	6.91	6.85	6.78	6.92	6.96	7.01	6.91	6.81
	Silica (mg/L)			0.05	0.05 - 0.10	ns	9.87	4.31	11.6	10.1	4.56	10.2	10.3	10.9	ns	12.0	4.65	13.3	10.7	4.16	10.3	10.2	12

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

						Monitoring Wells																					
	Parameter (units)	**ODWQS**		**RDL**		**105**									**106**				**107**								
			2003	**2008-10**	**2011-15**	**2003**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2003**	**2008**	**2009**	**2010**	**2003**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	25.6	39.6	51.0	70.4	56.1	50.6	41.7	58.3	ns	182	288	241	ns	63.4	69.1	85.3	80.9	117	174	166	144
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.26	0.22	0.18	<0.05	<0.05	<0.25	<0.25	<0.25	ns	0.05	<0.05	0.1	ns	0.06	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.25	ns	5.20	1.94	3.6	ns	2.42	1.43	5.1	3.11	3.25	2.82	2.71	2.18
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.25	ns	<0.05	1.0	<0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.50	<0.50	ns	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.20
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	17.5	20.3	20.2	17.5	19.1	19.1	16.6	21.1	ns	26.5	24.4	31.1	ns	18.2	11	15.1	17.4	16.9	18.6	17.7	15.9
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	1.31	0.013	<0.004	0.007	0.007	0.005	<0.004	<0.004	ns	1.90	<0.004	<0.004	ns	1.16	0.108	<0.004	0.007	0.013	0.006	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.011	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.009	<0.003	<0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.173	0.088	0.084	0.087	0.078	0.065	0.063	0.077	ns	0.275	0.091	0.091	ns	0.429	0.081	0.082	0.054	0.075	0.064	0.075	0.074
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ns	0.021	0.013	0.012	ns	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	ns	0.008	<0.002	<0.002	ns	0.0039	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	ns	69.7	84.5	83.4	81.3	75.4	72.6	68.9	79.3	ns	85.4	85.3	83.1	ns	76.4	84.5	93.3	71.9	80.9	86	89.7	86.4
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.004	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	ns	0.009	0.003	<0.003	ns	0.012	<0.003	<0.003	<0.003	0.005	<0.003	0.006	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	0.027	<0.001	<0.001	ns	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.028	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.060	<0.003	<0.003	ns	0.075	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	4.09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ns	3.92	<0.010	<0.010	ns	2.58	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.066	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.126	<0.002	<0.002	ns	0.091	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	25.2	29.2	30	29.5	29.3	26.7	26.3	29.1	ns	24.4	24.6	24.5	ns	23.4	26.7	29.8	22.6	26.4	26.2	28.5	26.8
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	1.47	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	5.00	0.006	<0.002	ns	1.50	0.067	0.038	<0.002	0.005	0.003	0.004	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.025	<0.003	<0.003	ns	0.056	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	1.41	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ns	3.94	<0.05	<0.05	ns	0.54	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.11	0.74	0.81	0.78	0.89	0.69	0.67	0.86	ns	2.44	1.63	1.52	ns	1.76	1.33	1.08	0.81	1.22	1.3	1.41	1.27
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	18.9	21.8	23.3	22.5	26.7	30	27.7	28.1	ns	99.9	151	158	ns	35.1	36.2	40.2	32	61.3	73.1	77.9	87.4
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.653	0.129	0.142	0.172	0.157	0.131	0.117	0.147	ns	1.26	0.117	0.134	ns	0.247	0.091	0.113	0.095	0.106	0.123	0.105	0.096
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	ns	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.021	<0.002	<0.002	ns	0.073	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.006	<0.002	0.002	ns	0.01	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.201	0.028	<0.005	<0.005	0.007	0.007	<0.005	<0.005	ns	1.06	0.014	0.019	ns	0.669	0.231	0.021	0.008	0.029	0.016	0.011	0.011
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	281	290	285	277	278	279	286	274	ns	263	277	293	ns	262	279	297	219	273	250	275	272
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	267	290	285	277	278	279	286	274	ns	263	277	293	ns	262	279	297	219	266	283	275	272
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	14	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5	ns	<5	<5	<5	<5	8	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5	ns	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	1.1	1.9	1.2	1	3	1	1.7	1	ns	1.4	1.3	1.4	ns	5.4	2.7	1.4	0.9	3.7	2	3.2	0.8
	DOC (mg/L)	5	0.7	0.5	0.5	ns	1.1	2.2	1.2	0.9	2.9	1	1.6	0.9	ns	1.4	1.3	1.5	ns	2.6	2.8	1.4	1.1	0.9	1.8	1.8	1
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	278	331	332	324	309	291	280	318	ns	314	314	308	ns	287	321	356	273	311	323	341	326
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.04	<0.02	ns	<0.02	<0.02	<0.02	ns	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02
	Conductivity (us/cm)		3	2	2	ns	585	684	651	724	668	716	664	705	ns	1070	1380	1260	ns	671	733	790	685	849	1100	1050	1040
	pH	8.5	0.1	N/A	N/A	ns	8.31	8.06	8.00	7.68	8.25	8.15	8.02	7.82	ns	7.99	8.13	8.13	ns	7.89	8.15	8.11	7.66	8.34	8.05	8.12	7.95
Calculated Values	Anion sum (meq/L)		0.01			ns	6.71	7.34	6.63	7.89	7.54	7.4	7.24	7.56	ns	11.3	14.4	12.6	ns	6.72	7.86	8.05	7.25	9.34	10.5	10.7	9.99
	Cation sum (meq/L)		0.01			ns	6.4	7.59	7.66	7.48	7.36	7.14	6.83	7.59	ns	10.7	12.9	13.1	ns	7.31	8.02	8.88	6.86	8.91	9.66	10.2	10.3
	% Difference (%)		0.01	0.1	0.1	ns	2.3	1.6	0.6	2.7	1.2	1.8	3	0.2	ns	2.9	5.5	1.9	ns	4.2	1	0.8	2.7	2.4	4.2	2.4	1.8
	Langelier Index		0.0001			ns	1.34	1.18	1.12	0.77	1.32	1.2	1.06	0.9	ns	1.02	1.18	1.2	ns	0.91	1.24	1.27	0.58	1.38	1.07	1.2	1.01
	Saturation pH (pH units)		0.01			ns	6.97	6.88	6.88	6.91	6.93	6.95	6.96	6.92	ns	6.97	6.95	6.93	ns	6.98	6.91	6.84	7.08	6.96	6.98	6.92	6.94
	Silica (mg/L)			0.05	0.05 - 0.10	ns	14.3	5.14	12.9	11.9	5.19	12.1	10.9	11.1	ns	10.5	3.69	8.51	ns	10.6	3.15	8.49	6.39	3.91	9.66	8.61	8.8

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 109									110				111								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	86.6	113	82.1	92.7	120	93.5	105	97.2	91.0	75.8	78.3	86.5	3.00	1.27	1.23	1.32	2.77	5.79	5.07	4.16	5.85
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.06	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	0.10	0.06	<0.05	<0.05	0.71	1.08	1.22	0.97	1.08	0.9	0.87	1.07	1.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	5.69	5.53	4.41	4.42	4.05	4.18	3.72	3.76	7.70	7.48	5.38	4.91	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	0.56	<0.30	<0.10	<0.10	<0.10	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	21.8	22.5	20.6	18.4	19.1	18.8	18.4	17.7	27.0	19.5	18.5	16.8	27.0	21.1	21	22	25.6	29.5	28.6	23	24.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	1.65	<0.004	<0.004	0.008	<0.004	<0.004	<0.004	<0.004	<0.01	0.981	<0.004	<0.004	0.210	0.614	<0.004	<0.004	0.007	0.087	0.005	0.011	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.007	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	0.004	0.004	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.309	0.094	0.095	0.085	0.086	0.089	0.083	0.091	0.10	0.126	0.086	0.084	0.08	0.093	0.067	0.064	0.071	0.089	0.072	0.056	0.06
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.016	0.011	0.011	0.012	<0.010	0.01	0.013	0.012	0.10	0.010	<0.010	<0.010	0.06	0.016	0.019	0.015	0.016	0.011	0.013	0.019	0.017
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.014	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	ns	94.8	112	94.4	91.3	101	81.4	95.5	97.3	91.0	81.6	91.5	93.6	53.0	43.3	57.8	55.8	53.3	56.5	56	54.4	55.2
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.006	0.004	<0.003	<0.003	0.003	<0.003	0.005	<0.003	0.003	0.008	0.004	<0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.034	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.017	<0.001	<0.001	<0.0008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.058	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.026	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	2.12	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.06	3.71	<0.010	<0.010	0.27	1.55	0.023	0.02	0.122	0.071	0.28	0.054	0.266
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.21	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.129	<0.002	<0.002	<0.001	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	27.2	32.4	27.7	27.8	30	23.6	27.7	27	29	25.7	28.3	29.2	23	20.8	25.1	25.2	24	25.9	25.7	24.4	24.8
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	3.74	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.075	0.843	<0.002	<0.002	0.024	0.051	0.006	0.005	0.010	0.018	0.011	0.006	0.005
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.010	<0.003	0.017	<0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	1.69	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.36	<0.05	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	2.36	1.61	1.73	1.8	1.81	1.42	1.99	1.65	2.7	2.87	1.92	2.12	1.2	0.84	1.41	1.37	1.33	1.31	1.46	1.34	1.31
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	30.9	39.0	35.2	37.8	48.9	36.4	46.9	42.6	27	34.4	34.4	37.4	5.2	10.2	3.80	4.51	3.9	4.79	5.17	5.27	6.24
	Strontium (mg/L)		0.001	0.005	0.005	ns	1.12	0.123	0.123	0.119	0.11	0.117	0.111	0.121	0.19	0.234	0.115	0.107	0.16	0.205	0.134	0.146	0.172	0.161	0.144	0.132	0.161
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.019	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.067	<0.002	<0.002	0.009	0.034	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.005	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.008	0.004	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	1.15	0.019	0.017	0.016	0.016	0.02	0.019	0.022	0.011	0.521	0.021	0.024	0.008	0.015	<0.005	<0.005	<0.005	0.106	0.007	<0.005	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	279	279	278	266	295	284	301	298	270	277	266	277	240	225	218	219	216	225	219	218	212
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	279	279	278	266	295	284	301	298	269	277	266	277	239	225	213	219	216	225	219	218	212
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<10	<5	5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	<5	65	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	1.2	3.2	0.9	0.7	1.4	0.9	4	1.3	na	2.9	1.3	1.7	na	1.5	0.7	0.7	0.6	3.5	11	0.9	0.6
	DOC (mg/L)	5	0.7	0.5	0.5	ns	1.2	2.4	0.9	0.6	1	0.7	3.6	1.2	<0.7	1.0	1.1	1.6	540	0.8	0.6	0.9	0.6	0.9	11	0.9	<0.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	349	413	350	342	376	300	353	354	347	310	345	354	227	194	248	243	232	248	246	236	240
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	0.15	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.05	<0.02	<0.02	<0.02	0.08	<0.02	<0.02	<0.02	<0.02	<0.02	0.08	0.03	0.03
	Conductivity (us/cm)		3	2	2	ns	579	899	771	770	901	862	939	950	860	758	817	771	450	416	437	415	441	451	483	469	464
	pH	8.5	0.1	N/A	N/A	ns	8.03	7.83	8.09	7.74	8.25	8.16	8.07	8.17	7.7	7.93	7.89	8.08	7.8	8.09	8.34	8.14	7.87	8.17	8.19	8.03	8.09
Calculated Values	Anion sum (meq/L)		0.01			ns	8.88		7.71	8.63	9.97	9.01	9.63	9.34	9.08	8.62		7.77	5.49	4.97	4.83	4.21	4.99	5.32	5.16	5.01	4.98
	Cation sum (meq/L)		0.01			ns	8.38		8.57	8.53	9.68	7.62	9.14	8.97	8.17	7.76		8.75	4.80	4.33	5.15	5.09	4.84	5.19	5.17	4.99	5.1
	% Difference (%)		0.01	0.1	0.1	ns	2.9	1.8	0.3	0.6	1.5	8.3	2.6	2	-10.55	5.3	0.8	0.4	-13.41	6.9	3.2	1.6	1.5	1.3	0.1	0.3	1.2
	Langelier Index		0.0001			ns	1.16	1.19	1.22	0.84	1.4	1.23	1.24	1.33	0.02	1	1.15	1.21	-0.10	0.90	1.24	1.04	0.74	1.09	1.09	0.91	0.97
	Saturation pH (pH units)		0.01			ns	6.87	6.64	6.87	6.9	6.85	6.93	6.83	6.84	7.68	6.93	6.74	6.87	7.90	7.19	7.1	7.1	7.13	7.08	7.1	7.12	7.12
	Silica (mg/L)			0.05	0.05 - 0.10	ns	11.3	4.6	10.1	9.96	4.21	10.8	10.1	9.92	11.3	11.5	4.65	12.1	18.4	18.4	7.86	16.8	17.1	6.93	19.1	15.9	17.4

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 112									113				114			
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2003	2008	2009	2010
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	<2.0	1.88	1.92	1.66	2.57	2.93	3.1	3.1	3.43	2.30	0.88	0.82	0.71	5.40	0.55	0.42	0.58
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.67	0.73	0.8	0.67	0.7	0.82	0.61	0.68	0.52	0.68	1.33	1.4	1.14	0.82	0.77	0.81	0.7
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10	<0.05	<0.05	<0.05	0.13	<0.05	<0.05	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	0.16	<0.10	<0.50	<0.20	<0.30	<0.10	0.37	<0.10	<0.30	<0.10	0.64	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	15.0	16.4	18.1	12.2	20.6	22.5	21.9	22.7	20.9	34.0	19.5	20.3	20.3	70.0	4.54	4.73	5.48
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.041	0.005	<0.004	0.007	0.006	0.007	<0.004	<0.004	<0.01	0.145	0.011	<0.004	<0.01	0.046	0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.005	<0.006	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.003	0.004	0.005	0.004	0.005	0.005	0.004	0.004	0.004	0.005	<0.003	<0.003	<0.003	0.001	0.008	0.008	0.007
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.01	0.038	0.041	0.041	0.038	0.036	0.037	0.033	0.036	0.09	0.082	0.082	0.082	0.08	0.050	0.056	0.064
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.037	0.039	0.043	0.043	0.039	0.038	0.042	0.039	<0.05	<0.010	<0.010	<0.010	<0.05	0.016	0.017	0.015
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	28.0	22.9	32	27	28.7	28.7	31.8	31	31.8	59.0	51.6	59.9	62	25.0	40.8	49.5	53.9
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0018	<0.001	<0.001	<0.001	0.0016	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	0.149	0.120	0.073	0.117	0.118	0.077	0.098	0.077	0.07	0.400	0.162	0.184	0.06	1.32	1.09	1.27
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.035	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	22	22.7	27.9	25.1	25.2	25	26.9	26.7	25.7	22	21	23.6	24.6	18	20.3	23.1	25.3
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.034	0.039	0.031	0.029	0.031	0.032	0.030	0.03	0.031	0.029	0.028	0.004	0.002	0.097	0.004	0.003	0.003
	Molybdenum (mg/L)		0.001	0.002	0.001	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.001	<0.002	<0.002	<0.002	0.016	0.002	0.002	0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.06	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	0.05	0.06	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	0.9	0.96	0.81	0.91	0.84	0.72	0.8	0.78	0.87	1.0	1.06	0.94	0.98	1.0	1	0.83	0.95
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	11	12.1	12.5	14.5	11.5	11.9	12.1	12.7	13.2	4.2	3.64	3.00	3.47	34	6.55	5.08	4.83
	Strontium (mg/L)		0.001	0.005	0.005	0.38	0.426	0.361	0.41	0.436	0.373	0.395	0.363	0.386	0.30	0.193	0.172	0.169	16	0.361	0.289	0.325
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	<0.002	0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.004	0.015	0.009	0.01	0.01	0.013	0.01	0.008	0.009	0.006	0.008	0.019	<0.005	0.007	0.014	0.007	0.013
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	200	185	193	180	181	189	186	186	181	240	228	234	228	220	226	222	226
	Bicarbonate (CaCO3) (mg/L)		10	5	5	199	185	193	180	181	189	186	186	181	239	228	234	228	220	226	222	226
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<10	<5	<5	<5
	Colour (TCU)	5	1	5	5	79	<5	<5	6	<5	<5	<5	<5	<5	4	<5	<5	<5	85	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	0.6	0.7	1.1	0.6	4	1.1	0.7	0.7	na	0.7	0.6	0.9	na	1.2	1.1	2
	DOC (mg/L)	5	0.7	0.5	0.5	46.0	0.5	0.7	1	0.6	1.7	0.7	0.7	0.7	56.0	0.6	0.7	0.8	51.0	1.2	1.2	1.6
	Hardness (CaCO3) (mg/L)	100	10	10	10	161	151	195	171	175	175	190	187	185	238	215	247	256	137	185	219	239
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.33	0.37	0.07	0.13	0.2	0.13	0.16	0.3	0.29	0.06	<0.02	<0.02	0.02	0.15	0.67	0.45	0.24
	Conductivity (us/cm)		3	2	2	380	358	379	335	374	374	416	403	401	480	402	450	426	530	383	413	390
	pH	8.5	0.1	N/A	N/A	7.7	8.13	8.21	8.26	8.15	8.11	8.12	8.11	8.09	7.8	8.05	8.12	8.14	7.2	8.07	8.10	8.21
Calculated Values	Anion sum (meq/L)		0.01			4.41	4.09		3.35	4.16	4.37	4.3	4.32	4.18	5.62	4.99		4.31	6.06	4.63		3.95
	Cation sum (meq/L)		0.01			3.73	3.58		4.07	4.04	4.03	4.35	4.33	4.31	4.97	4.49		5.29	4.24	4.06		5.02
	% Difference (%)		0.01	0.1	0.1	-16.71	6.7	1.9	1.7	1.5	4.1	0.7	0.2	1.6	-12.28	5.3	0.4	2.2	-35.34	6.5	1	3.4
	Langelier Index		0.0001			-0.54	0.75	1.09	0.92	0.82	0.8	0.84	0.82	0.79	-0.06	0.91	1.18	1.08	-1.07	0.86	1.09	1.11
	Saturation pH (pH units)		0.01			8.24	7.38	7.12	7.34	7.33	7.31	7.28	7.29	7.3	7.86	7.14	6.94	7.06	8.27	7.21	7.01	7.1
	Silica (mg/L)			0.05	0.05 - 0.10	12.8	14.7	6.56	12.8	14.2	13.5	16	13.2	13.8	18.0	18.5	7.96	17.2	11.3	17.3	7.38	9.31

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 115									115A								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	6.80	2.33	2.42	2.72	3.23	3.27	2.96	2.95	3.44	150	237	156	72.4	135	137	223	199	264
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.34	0.38	0.38	0.3	0.34	0.31	0.3	0.28	0.23	<0.10	0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	0.14	9.10	2.12	1.3	1.28	0.88	1.96	0.5	<1.25	0.53
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	45.0	30.9	32.1	31.8	33.3	34.4	32.5	32.7	34.1	29.0	22.7	14.8	11.9	13.7	24.8	18.8	15.6	13.7
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.031	0.004	0.006	0.077	0.006	0.007	<0.004	<0.004	<0.01	2.41	0.012	<0.004	0.01	0.022	0.005	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	0.013	0.005	0.004	0.006	0.005	0.004	0.004	0.004	<0.001	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.12	0.957	0.113	0.09	0.093	0.084	0.084	0.069	0.08	0.08	0.191	0.057	0.043	0.05	0.045	0.053	0.047	0.059
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.11	0.020	0.012	0.01	0.013	0.011	0.011	0.013	0.012	<0.05	0.018	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	63.0	52.7	57.4	57.2	56.1	55.9	56.5	53.9	56.8	110	109	93.4	83.1	95.9	77.9	98.9	83.2	89.3
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	0.010	0.003	<0.003	<0.003	0.006	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.023	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.082	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	3.25	0.176	0.246	0.51	0.397	0.314	0.347	0.347	0.08	3.68	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.208	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	21	22.6	24.2	24.2	24	24.1	23.5	23.4	23.2	28	29.8	26.5	22.5	27.4	21.9	27.5	24.1	23.4
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.047	4.94	0.01	0.011	0.031	0.012	0.012	0.011	0.012	<0.001	3.19	0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.1	<0.05	<0.050	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	9.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.2	2.04	1.17	1.15	1.04	1.09	1.04	0.9	1.05	1.4	1.68	0.94	0.99	0.83	0.78	0.95	0.89	0.97
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	7.6	4.56	4.54	5.4	4.69	4.68	4.44	4.76	4.86	53	79.7	111	77.3	77.1	82.4	92.1	147	192
	Strontium (mg/L)		0.001	0.005	0.005	0.25	2.41	0.123	0.13	0.164	0.14	0.128	0.119	0.131	0.16	1.16	0.114	0.11	0.14	0.115	0.145	0.112	0.134
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.003	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	0.019	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.011	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.025	0.055	0.005	0.007	0.007	<0.005	<0.005	<0.005	<0.005	0.011	0.49	0.007	0.008	<0.005	0.028	<0.005	<0.005	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	230	214	206	205	213	212	208	210	205	270	251	351	359	335	278	303	358	363
	Bicarbonate (CaCO3) (mg/L)		10	5	5	229	200	206	205	213	212	208	210	205	269	251	351	359	335	278	303	358	363
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	14	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	15	<5	<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	0.8	12.9	2.1	2.6	25	2	1.5	1.2	na	3.8	2	2.3	1.1	3.9	2	1.6	1.6
	DOC (mg/L)	5	0.7	0.5	0.5	2.2	0.8	12.3	1.2	2.6	3	2	1.5	1.2	1.3	3.8	2	2.1	1	2.9	2	1.6	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	244	225	243	242	239	239	238	231	237	390	395	342	300	352	285	360	307	319
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.07	<0.02	<0.02	0.02	0.06	0.04	0.08	0.06	0.06	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Conductivity (us/cm)		3	2	2	470	425	441	412	419	427	464	460	454	1000	1160	1130	807	963	910	1280	1310	1510
	pH	8.5	0.1	N/A	N/A	7.7	8.32	8.21	8.16	7.95	8.21	8.04	8.07	8.01	7.5	8.27	8.02	8.08	7.71	8.01	8.12	8.2	7.93
Calculated Values	Anion sum (meq/L)		0.01			5.75	4.99	4.86	4.18	5.06	5.06	4.94	4.98	4.93	10.9	12.3	11.8	8.38	10.9	10.1	12.8	13.1	15
	Cation sum (meq/L)		0.01			5.26	4.74	5.08	5.11	5.01	5	4.98	4.85	4.98	10.1	11.4	11.7	9.39	10.4	9.29	11.2	12.5	14.8
	% Difference (%)		0.01	0.1	0.1	-8.90	2.6	2.3	2.6	0.5	0.6	0.4	1.3	0.6	-7.13	3.9	0.5	0.9	2.1	4.1	6.5	2.1	0.9
	Langelier Index		0.0001			-0.15	1.17	1.08	1.03	0.83	1.08	0.9	0.93	0.87	-0.13	1.38	1.21	1.25	0.89	1.05	1.27	1.35	1.1
	Saturation pH (pH units)		0.01			7.85	7.15	7.13	7.13	7.12	7.13	7.14	7.14	7.14	7.63	6.89	6.81	6.83	6.82	6.96	6.85	6.85	6.83
	Silica (mg/L)			0.05	0.05 - 0.10	6.67	17.6	8.38	17.5	18.3	7.45	20.4	17.5	18.4	10.6	6.41	3.25	8.72	7.06	2.94	7.44	6.83	6.38

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells																	
						116									116A								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	68.0	27.2	31.3	29.3	35.6	36.9	46.4	56.8	55.1	15.0	13.1	9.23	13.9	13	33.2	44.8	43.9	83.6
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.15	0.11	0.12	<0.05	0.17	<0.25	<1.25	<0.25	<0.10	0.12	<0.05	0.08	0.12	0.09	<0.25	<1.25	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	2.30	0.12	0.08	<0.05	0.1	<0.05	<0.25	<1.25	<0.25	0.54	0.10	<0.05	<0.05	0.06	0.33	0.36	<1.25	<0.25
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.45	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	57.0	33.6	24.1	23.5	16.9	21.5	20.7	20.4	17.1	57.0	25.4	8.82	10.2	15.7	16.9	14.6	7.92	9.46
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	3.20	0.006	<0.004	0.007	0.03	0.004	<0.004	<0.004	<0.01	1.84	<0.004	0.016	0.008	0.007	<0.004	0.189	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.001	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.007	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.06	0.170	0.039	0.052	0.037	0.047	0.068	0.043	0.056	0.04	0.122	0.031	0.041	0.044	0.044	0.036	0.041	0.053
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.09	0.011	0.013	<0.010	<0.010	0.011	<0.010	0.013	0.011	<0.05	0.011	<0.010	<0.010	0.019	<0.010	<0.010	0.011	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0027	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.0001	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	94.0	81.1	90.6	82.2	88.8	85.2	97.1	94.7	98.2	84.0	74.6	84.8	94.9	66.3	94.7	98.4	93	107
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.015	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	0.003	0.012	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	0.0008	0.012	<0.001	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.0008	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	0.057	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.136	<0.003	0.003	<0.003	<0.003	<0.003	0.005	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.06	7.45	<0.010	<0.010	1.62	<0.010	<0.010	<0.010	<0.010	0.05	5.07	0.265	<0.010	<0.010	0.038	0.300	1.35	0.308
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.114	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.154	<0.002	<0.002	<0.002	<0.002	<0.002	0.007	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	34	25.7	27.5	26.4	29.1	27.4	30.7	31.1	30.7	22	22.5	24.7	28.4	19	31.3	32.1	29.9	32.1
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.14	1.66	0.002	0.386	0.069	0.042	1.97	0.148	0.023	0.021	1.11	0.078	0.046	0.044	0.055	0.062	0.127	0.158
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	0.002	0.017	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	0.003	<0.002	0.030	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.97	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.7	1.58	1.57	1.2	0.74	1.28	1.42	1.18	1.48	1.0	0.9	0.69	0.81	1.87	0.75	0.76	0.7	0.83
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	25	13	16.5	16.4	11.8	14.1	17.2	22.0	24.0	5.8	7.69	7.97	8.20	10.30	16.00	20.70	30.2	44.1
	Strontium (mg/L)		0.001	0.005	0.005	0.21	0.419	0.106	0.16	0.12	0.117	0.158	0.115	0.128	0.12	0.467	0.095	0.118	0.11	0.134	0.141	0.125	0.141
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.081	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.059	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.002	<0.002	<0.002	<0.002	0.002	<0.002	0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	0.023	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.008	0.021	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.019	0.649	0.020	0.038	<0.005	0.021	0.02	0.025	0.02	0.031	0.467	0.012	0.052	0.008	0.009	0.017	0.032	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	280	276	298	280	307	292	295	314	317	250	262	268	336	228	341	323	356	367
	Bicarbonate (CaCO3) (mg/L)		10	5	5	279	276	268	280	307	292	295	314	317	249	262	268	336	228	341	323	356	367
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	18	<5	<5	5	<5	<5	<5	<5	<5	11	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	6.3	7.5	5	1.6	14.4	2.9	2.2	2.4	na	8.2	3.1	9.2	2.3	22.2	3.2	3.7	2.4
	DOC (mg/L)	5	0.7	0.5	0.5	6.6	2.4	4.4	2	1.5	7	2.5	2.1	2.3	1.9	3.0	3.1	2.5	2.3	2.2	1.9	2.5	2.4
	Hardness (CaCO3) (mg/L)	100	10	10	10	375	308	339	314	342	326	369	365	372	300	279	313	354	244	365	378	355	399
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	0.56	<0.02	0.02	<0.02	0.03	0.03	<0.05	<0.02	<0.02	0.09	<0.02	<0.02	<0.02	0.06	<0.02
	Conductivity (us/cm)		3	2	2	830	604	624	589	629	635	726	818	801	600	526	524	615	471	700	759	826	927
	pH	8.5	0.1	N/A	N/A	7.6	7.66	7.84	8.00	7.68	8.11	8.03	8.12	7.77	7.5	7.63	7.98	7.93	8.05	8.01	8.08	8.01	7.64
Calculated Values	Anion sum (meq/L)		0.01			8.87	6.1	6.76	6	7.5	7.34	7.64	8.31	8.25	6.65	5.29	5.80	6.23	5.26	8.14	8.05	8.52	9.9
	Cation sum (meq/L)		0.01			8.65	6.77	7.54	7.06	7.36	7.15	8.16	8.27	8.51	6.28	5.93	6.63	7.46	5.37	8.02	8.47	8.44	9.92
	% Difference (%)		0.01	0.1	0.1	-2.51	5.2	5.5	1	1	1.3	3.3	0.2	1.5	-5.72	5.7	6.6	0.9	1	0.8	2.5	0.5	0.1
	Langelier Index		0.0001			-0.06	0.73	0.94	1.08	0.84	1.23	1.21	1.32	0.98	-0.21	0.63	1.07	1.15	0.96	1.25	1.31	1.25	0.95
	Saturation pH (pH units)		0.01			7.66	6.93	6.90	6.92	6.84	6.88	6.82	6.8	6.79	7.71	7.0	6.91	6.78	7.09	6.76	6.77	6.76	6.69
	Silica (mg/L)			0.05	0.05 - 0.10	10.5	9.79	3.99	8.88	7.21	3.55	9.31	8.43	8.29	7.90	8.38	3.41	8.06	8.01	3.67	8.45	8.0	7.4

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 117									117A								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	8.10	17.3	17.5	21.2	27.4	27.1	30.5	32.3	36.3	35.0	31.8	41.2	49.4	37.5	19.1	37.8	29.2	66.8
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.13	0.16	<0.05	0.13	<0.05	<0.05	<0.10	<0.10	<0.25	0.12	0.23	<0.05	0.17	0.19	0.27	<0.10	0.21	0.28
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	0.11	<0.05	0.12	<0.05	<0.05	<0.10	<0.10	<0.25	3.30	0.88	0.51	0.22	0.33	<0.05	<0.10	<0.10	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.25	0.23	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	35.0	37.8	34.3	37.7	38.7	38.5	35.3	36.4	37	40.0	20.2	24.3	24.6	16.7	30	25.2	22.8	26.2
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.02	<0.004	<0.004	0.009	0.008	0.005	<0.004	<0.004	<0.01	2.04	<0.004	<0.004	0.007	0.005	0.004	0.008	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.001	<0.003	<0.003	<0.003	<0.003	0.005	<0.003	<0.003	<0.003	<0.001	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.10	0.970	0.114	0.155	0.082	0.139	0.088	0.096	0.096	0.12	0.387	0.092	0.106	0.085	0.073	0.07	0.059	0.078
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.013	0.012	<0.010	<0.010	0.011	<0.010	0.014	<0.010	<0.05	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.0001	0.0025	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	79.0	79.9	79.4	82.8	80.7	83.5	91.5	82.6	90.6	90.0	70.8	78.4	82.4	75.5	71.5	77.8	62.4	80.9
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.014	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	0.018	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.020	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.001	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.070	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	1.61	0.532	<0.010	1.65	0.195	1.3	1.17	1.33	0.06	2.47	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.591	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	24	27.4	28.3	29.8	29.9	30	32.2	28.8	32	27	23.7	27.3	28.2	26.7	25.6	28.6	22.9	30.9
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.097	4.08	0.046	0.356	0.062	0.049	0.054	0.058	0.052	0.013	2.09	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	0.002	0.037	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.023	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.04	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2.03	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	1.5	2.27	0.83	1.38	0.73	1.06	0.84	0.87	0.83	1.2	1.28	0.77	1.06	0.88	0.82	0.86	0.8	0.88
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	5.5	6.27	7.16	4.97	5.09	4.45	4.64	4.5	4.5	18	15.4	18.7	23.6	16.8	12.3	21.7	17.5	26.6
	Strontium (mg/L)		0.001	0.005	0.005	0.17	2.04	0.117	0.213	0.143	0.146	0.13	0.128	0.129	0.15	0.765	0.103	0.149	0.113	0.099	0.108	0.089	0.12
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.022	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.010	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.013	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.004	0.038	0.009	0.01	<0.005	0.006	<0.005	<0.005	<0.005	0.012	0.328	0.016	0.018	0.007	0.009	0.01	0.01	0.01
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	280	271	264	276	259	268	263	275	263	280	243	255	274	263	256	256	232	249
	Bicarbonate (CaCO3) (mg/L)		10	5	5	279	271	264	276	259	268	263	275	263	279	243	255	274	263	256	256	232	249
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	14	<5	<5	7	<5	<5	<5	<5	<5	11	5	<5	5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	34.2	7.9	3.5	1.9	21.9	2.9	50.4	3.3	na	15.7	2.5	4.3	1.4	13	3.2	39.2	2
	DOC (mg/L)	5	0.7	0.5	0.5	2.5	1.6	6.9	1.6	1.7	9.6	2.5	21.7	3.2	1.7	3.0	2.2	1.9	1.4	3.2	1.6	15.6	1.9
	Hardness (CaCO3) (mg/L)	100	10	10	10	296	312	315	329	325	332	361	325	358	336	274	308	322	298	284	312	250	329
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	0.09	0.06	0.07	0.05	0.18	0.17	<0.05	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	0.05	<0.02
	Conductivity (us/cm)		3	2	2	570	563	602	577	596	597	646	642	664	730	551	645	645	592	544	643	565	731
	pH	8.5	0.1	N/A	N/A	7.6	7.83	8.06	8.06	7.89	8.21	8.12	7.88	7.87	7.5	7.78	8.08	7.96	7.71	8.13	7.98	7.9	7.89
Calculated Values	Anion sum (meq/L)		0.01			6.57	5.82		6.01	6.76	6.93	6.86	7.17	7.05	7.66	5.46		6.51	6.7	6.3	6.71	5.95	7.42
	Cation sum (meq/L)		0.01			6.20	6.57		6.84	6.73	6.86	7.44	6.72	7.38	7.53	6.18		7.49	6.72	6.23	7.2	5.78	7.76
	% Difference (%)		0.01	0.1	0.1	-5.79	6.1	1	0.6	0.2	0.5	4.1	3.2	2.3	-1.71	6.3	1.3	0.5	0.1	0.5	3.5	1.4	2.2
	Langelier Index		0.0001			-0.07	0.9	1.12	1.16	0.95	1.3	1.24	0.97	0.98	-0.04	0.74	1.12	1.05	0.74	1.13	1.02	0.83	0.94
	Saturation pH (pH units)		0.01			7.68	6.93	6.94	6.9	6.94	6.91	6.88	6.91	6.89	7.65	7.04	6.96	6.91	6.97	7	6.96	7.07	6.95
	Silica (mg/L)			0.05	0.05 - 0.10	14.2	15.9	7.48	15.7	16.1	6.87	19.1	16.5	17.3	12.5	9.9	3.94	10.6	7.91	3.77	10.6	9.2	10.3

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 118									118A								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	6.40	0.44	12	0.73	0.82	0.98	0.99	1.06	1.18	220	137	217	195	185	285	292	336	396
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.50	0.59	0.53	0.46	0.54	0.58	0.46	0.52	0.4	0.11	0.06	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5	<0.5
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	0.11	0.28	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	11.0	4.02	3.82	3.41	3.03	2.18	1.84	1.48	1.70
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.30	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5	<0.5
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	0.23	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<1.0	<1.0	1.5
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	20.0	12.7	11.2	10.4	10.6	10.3	10.3	10.3	11	23.0	25.8	20.7	18.2	20.7	26.7	39.1	31.4	32.5
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.035	0.344	<0.004	0.009	0.007	0.006	<0.004	0.005	<0.01	1.20	<0.004	<0.004	0.008	0.004	0.008	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.003	0.004	0.006	0.009	0.009	0.01	0.008	0.009	0.007	<0.001	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.15	1.190	0.137	0.142	0.099	0.124	0.115	0.09	0.095	0.10	0.938	0.093	0.113	0.09	0.1	0.087	0.094	0.116
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.018	0.023	0.025	0.027	0.025	0.024	0.026	0.025	<0.05	0.013	0.01	0.011	<0.010	0.011	<0.010	0.014	0.012
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0012	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0154	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	46.0	38.3	47.3	41.5	40	39	40.8	38.2	38.5	100	89.7	102	107	98.1	101	92.5	95.6	99.8
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	0.014	0.003	<0.003	<0.003	0.01	<0.003	<0.003	0.006
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.017	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.115	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	5.6	1.06	0.032	0.283	0.098	0.037	0.182	0.207	0.09	2.35	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.001	0.027	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.032	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	25	25.6	26.2	28.4	27.6	27.2	27.6	25.5	25.1	29	27.2	31	32.6	30.8	31	28.2	29.4	28.2
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.003	4.87	0.191	0.008	0.008	0.016	0.012	0.008	0.009	0.003	3.3	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	0.038	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.066	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.0	1.67	1.04	1.1	0.91	1.08	0.94	0.95	0.89	2.3	2.52	1.67	1.59	1.44	1.82	1.45	1.95	1.77
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	11	6.41	11.9	6.41	6.41	6.41	6.46	6.77	6.31	110	80.7	105	99.7	91.1	160	152	206	224
	Strontium (mg/L)		0.001	0.005	0.005	0.28	1.97	0.265	0.285	0.284	0.245	0.258	0.226	0.241	0.14	0.94	0.11	0.14	0.124	0.113	0.116	0.118	0.13
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.003	0.026	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.010	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.018	0.067	0.114	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.011	2.14	0.086	0.026	0.01	0.012	0.019	0.012	0.012
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	230	237	208	213	216	214	213	207	217	270	296	282	316	305	313	316	329	325
	Bicarbonate (CaCO3) (mg/L)		10	5	5	228	237	203	209	216	214	211	207	217	269	296	282	316	305	313	316	329	325
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	5	5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	14	<5	<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	10	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	6.1	1.8	1.7	1.9	4.1	3	13.8	1.8	na	27.5	5.9	1.3	1	18.3	2	24.7	1.2
	DOC (mg/L)	5	0.7	0.5	0.5	1.8	0.8	1.2	1.3	1.5	2.3	3	9.4	1.7	0.8	4.8	6.0	1.6	0.9	2.7	2	11.3	0.9
	Hardness (CaCO3) (mg/L)	100	10	10	10	218	201	226	221	214	209	216	200	199	369	336	382	401	372	380	347	360	365
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.13	0.26	0.16	<0.02	0.21	0.1	0.33	0.33	0.34	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.03	0.03
	Conductivity (us/cm)		3	2	2	400	388	439	379	383	387	414	412	409	1300	935	1220	1130	1070	1430	1560	1690	1840
	pH	8.5	0.1	N/A	N/A	7.9	8.2	8.35	8.31	8.01	8.09	8.31	8.02	8.17	7.5	7.92	8.04	8.05	7.73	8	8.16	8.1	8.05
Calculated Values	Anion sum (meq/L)		0.01			5.23	4.28	4.75	3.92	4.59	4.55	4.53	4.41	4.62	12.9	9.64	12.5	11.4	12	15	15.5	16.8	18.5
	Cation sum (meq/L)		0.01			4.89	4.35	5.07	4.71	4.58	4.49	4.63	4.34	4.3	12.2	10.3	12.2	12.4	11.4	14.6	13.6	16.2	17.1
	% Difference (%)		0.01	0.1	0.1	-6.72	0.8	3.2	2	0.1	0.7	1.1	0.8	3.6	-5.18	3.2	0.9	0.2	2.3	1.4	6.6	1.9	3.9
	Langelier Index		0.0001			-0.06	1.05	1.19	1.15	0.84	0.91	1.14	0.81	0.98	-0.18	1.03	1.18	1.26	0.89	1.19	1.31	1.27	1.22
	Saturation pH (pH units)		0.01			7.97	7.15	7.16	7.16	7.17	7.18	7.17	7.21	7.19	7.69	6.89	6.86	6.79	6.84	6.81	6.85	6.83	6.83
	Silica (mg/L)			0.05	0.05 - 0.10	15.8	19.4	8.8	18.7	20.6	8.54	23.1	21.8	21.8	10.9	8.08	3.78	9.59	8.84	3.45	9.33	7.99	8.1

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 119									119A									120	120A
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2003
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	32.0	28.7	28.9	29.4	29.8	29.4	82	132	234	30.0	19.3	23.1	27.2	74.4	127	108	165	202	17.0	34.0
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	0.06	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	<0.10
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.25	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	<0.05	<0.05	<0.05	1.95	0.19	<0.25	<0.10	<0.25	0.22	4.40
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.19	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	0.13	<0.10
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.30	<0.30
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	96.0	67.7	61.8	61.7	61.9	53.1	37.9	28.4	25.5	81.0	25.5	15.7	7.83	26.6	43.4	23.8	22.9	15.2	67.0	51.0
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	1.06	0.01	0.006	0.016	0.017	0.01	<0.004	0.005	<0.01	1.74	0.004	0.004	0.014	0.025	0.013	<0.004	<0.004	<0.01	<0.01
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.005
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.002	0.01	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.008	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.001
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.07	0.169	0.048	0.046	0.041	0.043	0.04	0.04	0.081	0.09	0.339	0.06	0.076	0.065	0.071	0.051	0.086	0.106	0.16	0.08
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.11	0.018	0.011	0.01	0.01	<0.010	<0.010	0.01	0.013	<0.05	0.013	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.23	<0.05
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.0001
	Calcium (mg/L)		0.5	0.05	0.05	110	94.4	98.2	103	96.6	100	102	85.6	105	110	89.0	94.1	97.9	70.5	86.6	69	79.6	84.5	72.0	89.0
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.004	<0.003	<0.003	<0.003	0.004	<0.003	0.004	<0.003	0.005	0.004	<0.003	<0.003	<0.003	0.007	<0.003	0.004	<0.003	0.003	0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	0.0009	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	<0.0008
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.007	<0.003	<0.003	0.003	<0.003	0.004	<0.003	<0.003	<0.001	0.001
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.08	10.1	1.02	1.22	1.22	1.14	1.07	0.722	1.18	0.08	8.68	0.259	0.875	0.024	<0.010	<0.010	0.029	0.206	<0.05	0.06
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.044	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001
	Magnesium (mg/L)		0.5	0.05	0.05	31	29.3	30.7	32.5	30.6	31.6	30.6	26.2	32.1	35	26.6	28.6	30	22.8	27.7	21.5	25.6	26.1	22	24
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.16	3.75	0.124	0.154	0.108	0.11	0.12	0.094	0.113	0.20	5.2	0.573	0.536	0.057	0.34	0.369	0.701	0.573	0.063	0.004
	Molybdenum (mg/L)		0.001	0.002	0.001	0.010	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	<0.001
	Nickel (mg/L)		0.002	0.003	0.003	0.005	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	0.005	0.007	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.002
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	1.74	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.21	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	1.9	1.64	0.99	0.99	1.08	1.06	1.02	1.41	1.53	2.5	1.6	1.05	1.01	1.21	1.4	1.33	1.73	1.66	2.8	3.3
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.0001
	Sodium (mg/L)	20	0.5	0.05	0.05	21	8.52	7.79	8.89	9.15	10.7	18.7	52.5	86.2	12	6.23	7.56	9.19	31	52.4	51.3	83.3	101	16	12
	Strontium (mg/L)		0.001	0.005	0.005	0.73	2	0.12	0.145	0.141	0.143	0.133	0.118	0.176	0.21	2.17	0.087	0.104	0.077	0.094	0.078	0.104	0.114	0.13	0.11
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003
	Tin (mg/L)		0.001	0.002	0.002	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.001
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.029	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	0.002	<0.002	<0.002	0.003	<0.002	<0.002	0.002	<0.002	<0.005	<0.005
	Vanadium (mg/L)		0.001	0.002	0.002	0.010	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.008
	Zinc (mg/L)	5	0.003	0.005	0.005	0.011	0.217	0.013	0.006	0.01	0.011	0.007	<0.005	<0.005	0.014	0.519	0.035	0.03	0.015	0.042	0.023	0.017	0.015	0.005	0.007
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	300	296	298	303	289	312	274	226	258	350	312	303	330	210	240	212	236	256	240	250
	Bicarbonate (CaCO3) (mg/L)		10	5	5	299	278	298	303	289	312	274	226	258	349	294	303	330	210	235	212	236	256	239	249
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	18	<5	<5	<5	<5	<5	<5	<5	<10	18	<5	<5	<5	6	<5	<5	<5	<10	<10
	Colour (TCU)	5	1	5	5	19	8	13	14	15	25	<5	6	<5	28	10	10	11	5	6	<5	5	5	35	26
	Total Organic Carbon (mg/L)			0.5	0.5	na	4.9	9.8	6.1	7	7.5	4	4.3	2.3	na	5.1	5.5	6.4	4.4	6.1	6	5.3	3.2	na	na
	DOC (mg/L)	5	0.7	0.5	0.5	3.1	4.9	9.6	5.8	6.4	6	4	3.6	2.2	7.3	5.1	5.4	5.8	3.8	2.8	5	4.5	3	1.3	1.1
	Hardness (CaCO3) (mg/L)	100	10	10	10	402	356	372	391	367	380	381	322	394	419	332	353	368	270	330	261	304	318	270	321
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	0.21	<0.02	0.03	0.05	0.04	0.17	0.12	0.1	<0.05	<0.02	<0.02	<0.02	0.03	<0.02	0.05	0.05	0.03	<0.05	<0.05
	Conductivity (us/cm)		3	2	2	800	676	722	679	671	695	839	899	1220	850	611	646	634	632	853	796	1020	1120	540	700
	pH	8.5	0.1	N/A	N/A	7.4	8.36	7.95	8.02	7.61	8.18	8.05	8.04	7.92	7.4	8.35	8.05	8.23	8.04	8.32	8.14	8.08	7.91	7.7	7.5
Calculated Values	Anion sum (meq/L)		0.01			8.92	8.14	8.06	7.18	7.91	8.17	8.58	8.83	12.3	9.54	7.32	7.04	6.45	6.99	9.3	7.78	9.85	11.1	6.69	7.34
	Cation sum (meq/L)		0.01			9.01	7.55	7.79	8.23	7.77	8.09	8.46	8.75	11.7	8.96	6.94	7.4	7.78	6.77	8.91	7.48	9.75	10.8	6.17	7.03
	% Difference (%)		0.01	0.1	0.1	1.00	3.8	1.7	0.3	0.9	0.5	0.7	0.5	2.6	-6.27	2.6	2.5	1.6	1.6	2.1	2	0.5	1.5	-8.09	-4.31
	Langelier Index		0.0001			-0.17	1.52	1.13	1.23	0.78	1.39	1.21	1.04	1.04	-0.10	1.5	1.22	1.45	0.93	1.36	1.02	1.05	0.93	-0.09	-0.19
	Saturation pH (pH units)		0.01			7.57	6.84	6.82	6.79	6.83	6.79	6.84	7	6.88	7.50	6.85	6.83	6.78	7.11	6.96	7.12	7.03	6.98	7.80	7.70
	Silica (mg/L)			0.05	0.05 - 0.10	11.1	10.3	3.94	9.45	8.42	4.11	9.76	8.69	8.89	11.9	6.42	2.47	6.45	4.31	2.18	4.52	4.48	5.1	11.2	10.0

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 121									121A								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	52.0	45.2	105	54.3	61.2	68.9	60.9	68.3	84	38.0	62.7	48.5	81.1	96.1	89.8	42.8	53.4	63.7
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.08	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.10	0.06	<0.05	0.05	<0.05	<0.05	<0.25	<1.25	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	2.40	3.00	4.45	3.63	3.66	3.34	3.26	3.54	3.51	10.0	4.62	2.85	2.44	1.91	2.53	1.10	1.71	1.37
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	55.0	41.5	15.8	35.4	36.7	28.2	28.3	32	24.3	27.0	16.3	41.6	15	17.5	12.9	8.89	10.4	11.2
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.533	<0.004	<0.004	0.007	0.008	0.006	<0.004	<0.004	<0.01	4.19	1.48	<0.004	0.007	0.011	0.02	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.003	0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.10	0.325	0.064	0.119	0.116	0.086	0.068	0.095	0.10	0.09	0.310	0.163	0.078	0.079	0.061	0.038	0.043	0.053
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.17	0.012	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.05	<0.010	<0.010	0.013	0.013	0.011	<0.010	0.01	0.011
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0043	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.0001	0.0071	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	77.0	84.9	92.9	90.6	86.8	80.6	80.5	88.3	96.9	95.0	83.3	89.3	97.2	91.3	79.7	71	77.9	87
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.010	0.004	<0.003	<0.003	0.006	<0.003	<0.003	<0.003	0.003	0.023	0.011	<0.003	<0.003	0.007	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	0.0011	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.042	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	0.016	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	0.001	0.134	0.017	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	5.16	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.07	11.8	5.44	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.017	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.528	0.079	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	26	28.9	27.4	31.6	31	26.7	26.5	30.8	30.1	25	23.8	31.8	30	30.9	24.5	20.8	22.7	23.7
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.29	2.61	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.003	0.020	3.14	0.721	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.014	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	0.003	0.010	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.036	0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	2.78	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.02	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.2	2.03	1.52	1.34	1.51	1.37	1.25	1.3	1.52	4.3	3.89	1.36	2.45	3.71	1.02	1.19	0.96	1.12
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	24	13.4	38.8	15.4	17.4	24.9	19.6	22.0	28.9	18	30.2	12.1	38.4	41.2	39.5	22.8	30.1	34.2
	Strontium (mg/L)		0.001	0.005	0.005	0.22	1.04	0.108	0.12	0.104	0.091	0.114	0.104	0.112	0.13	0.469	0.318	0.119	0.111	0.105	0.101	0.08	0.093
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.062	0.045	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.008	0.003	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	0.009	0.012	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.010	0.434	0.017	0.031	0.025	0.031	0.034	0.03	0.032	0.028	1.79	0.272	0.017	0.012	0.023	0.018	0.008	0.01
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	250	259	273	261	251	267	261	259	264	280	266	244	305	293	284	274	265	290
	Bicarbonate (CaCO3) (mg/L)		10	5	5	249	259	273	261	251	267	261	259	264	279	266	244	305	293	284	274	265	290
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	22	<5	<5	<5	<5	<5	<5	<5	<5	23	<5	<5	5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	9.4	5.6	1.2	<0.5	2	1	1.2	1.2	na	9.4	2.5	1.6	0.8	1.4	2	1.5	1
	DOC (mg/L)	5	0.7	0.5	0.5	2.1	1.2	1.9	1.3	<0.5	1	1.1	1.1	1.1	1.1	1.9	0.7	1.5	0.8	0.9	2	1.4	1
	Hardness (CaCO3) (mg/L)	100	10	10	10	299	331	345	356	344	311	310	347	366	340	306	354	366	355	300	263	288	315
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	0.15	<0.02	0.02	<0.02	<0.02	<0.02	0.03	0.02	<0.05	0.25	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02
	Conductivity (us/cm)		3	2	2	720	643	845	671	699	736	745	790	847	770	694	684	794	811	789	652	703	774
	pH	8.5	0.1	N/A	N/A	7.6	7.76	7.87	8.16	8.04	8.04	8.13	8.19	7.95	7.5	7.73	7.88	8.07	7.92	8.04	8.11	8.09	7.92
Calculated Values	Anion sum (meq/L)		0.01			7.78	6.69		6.89	7.77	8.11	7.76	8.03	8.41	7.95	6.89		7.88	9.07	8.66	6.95	7.14	7.93
	Cation sum (meq/L)		0.01			7.09	7.26		7.83	7.68	7.34	7.08	7.93	8.61	7.69	7.55		9.05	8.98	7.74	6.28	7.09	7.81
	% Difference (%)		0.01	0.1	0.1	-9.28	4.1	2.6	0.5	0.6	5	4.6	0.6	1.2	-3.32	4.6	2.1	1	0.5	5.6	5.1	0.4	0.8
	Langelier Index		0.0001			-0.17	0.83	1.14	1.27	1.12	1.1	1.18	1.28	1.07	-0.12	0.78	1.12	1.26	1.08	1.11	1.11	1.11	1.02
	Saturation pH (pH units)		0.01			7.77	6.93	6.73	6.89	6.92	6.94	6.95	6.91	6.88	7.62	6.95	6.76	6.81	6.84	6.93	7	6.98	6.9
	Silica (mg/L)			0.05	0.05 - 0.10	10.1	13.4	3.77	12.8	13	11.5	13.4	12.2	12.5	11.0	8.03	5.73	9.03	8.22	8.98	8.27	7.6	7.97

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells: 122									122A								
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2013	2014	2015	2003	2008	2009	2010	2011	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	44.0	63.6	66.1	62.6	66.7	64.4	66.7	67.6	62.7	32.0	48.7	41.9	48.3	51.2	48.9	46.4	38.7	49.1
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.05	<0.05	0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	7.80	11.6	8.71	7.08	6.45	5.41	5.64	4.55	4.00	9.10	4.53	3.79	3.41	2.52	2.24	2.06	1.75	2.23
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	63.0	22.1	22.7	22.2	22.1	19.8	19.1	18.2	16.8	20.0	16.2	16.2	15.1	13.3	13	11.8	10.8	11
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.831	0.004	<0.004	0.008	0.007	<0.004	<0.004	<0.004	<0.01	0.964	0.004	<0.004	0.008	0.004	<0.004	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.09	0.156	0.093	0.099	0.095	0.081	0.089	0.076	0.085	0.07	0.089	0.049	0.058	0.05	0.051	0.047	0.042	0.049
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.05	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.05	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	89.0	85.4	101	95.4	86.7	88.7	81.1	86	86.6	92.0	72.3	79.7	85.2	78.3	78.9	68.4	71.5	83.2
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.006	0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	0.003	0.004	<0.003	<0.003	<0.003	0.006	<0.003	0.004	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.001	0.015	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.036	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.06	2.54	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.07	1.86	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.06	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.091	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	28	26.8	30.6	29.3	26.9	28.1	24.8	25.5	24.6	26	22.6	24.6	26.1	23.8	24.2	20.4	21.5	24
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.14	0.864	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.399	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.86	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.68	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	1.5	1.79	1.29	1.42	1.34	1.39	1.14	1.33	1.27	1.5	1.31	0.9	1.08	1.03	1.03	0.88	0.97	0.96
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	27	19.4	20.6	22.5	21.2	24.3	22.1	25.8	26.5	15	17.9	15.3	19.0	19.8	20.8	19.0	19.5	22.4
	Strontium (mg/L)		0.001	0.005	0.005	0.20	0.407	0.111	0.119	0.109	0.099	0.11	0.096	0.1	0.14	0.222	0.089	0.1	0.087	0.095	0.086	0.083	0.091
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.018	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.010	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.019	0.229	0.037	0.02	0.016	0.019	0.015	0.016	0.014	0.005	0.212	0.007	0.008	<0.005	<0.005	<0.005	<0.005	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	270	267	255	274	258	259	262	268	262	280	247	242	263	244	256	252	265	272
	Bicarbonate (CaCO3) (mg/L)		10	5	5	269	267	255	274	258	259	262	268	262	279	247	242	263	244	251	252	265	272
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	5	<5	<5	<5
	Colour (TCU)	5	1	5	5	27	<5	<5	5	<5	<5	<5	<5	<5	79	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	3.5	5.6	1.2	0.9	1.1	1.2	3.6	0.9	na	8.2	1.4	1.8	0.8	1	1.2	3.9	1
	DOC (mg/L)	5	0.7	0.5	0.5	2.1	0.9	4.9	1.2	0.7	1	0.8	3.1	0.9	0.9	1.7	1.3	1.3	0.7	1.1	1	3.9	0.9
	Hardness (CaCO3) (mg/L)	100	10	10	10	338	324	378	359	327	337	305	320	318	337	274	300	320	294	297	255	267	307
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02
	Conductivity (us/cm)		3	2	2	780	695	773	712	728	701	755	755	780	720	597	637	636	615	619	644	638	723
	pH	8.5	0.1	N/A	N/A	7.7	8.0	7.88	8.14	7.84	8.11	8.18	8.08	8.16	7.5	7.99	8.04	8.18	7.99	8.31	8.22	8.06	8.21
Calculated Values	Anion sum (meq/L)		0.01			8.51	8.42		7.32	7.96	7.8	7.92	7.97	7.64	7.57	6.97		6.32	6.78	6.93	6.74	6.74	7.21
	Cation sum (meq/L)		0.01			7.96	7.36		8.19	7.5	7.83	7.08	7.55	7.53	7.42	6.28		7.25	6.75	6.86	5.94	6.21	7.13
	% Difference (%)		0.01	0.1	0.1	-6.68	6.8	2.6	0.2	3	0.2	5.6	2.7	0.7	-2.00	5.2	0.4	0.5	0.2	0.5	6.3	4.1	0.6
	Langelier Index		0.0001			0.02	1.08	1.16	1.27	0.91	1.19	1.22	1.15	1.22	-0.13	0.96	1.2	1.25	0.99	1.33	1.17	1.05	1.27
	Saturation pH (pH units)		0.01			7.68	6.92	6.72	6.87	6.93	6.92	6.96	6.93	6.94	7.63	7.03	6.84	6.93	7	6.98	7.05	7.01	6.94
	Silica (mg/L)			0.05	0.05 - 0.10	11.4	12.1	4.82	10.6	10.5	4.18	10.7	9.75	10	11.1	8.42	3.29	7.65	6.88	3.44	7.6	6.89	7.19

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 123								124				125				126				127			
			2003	2008-10	2011-15	2003	2008	2009	2010	2011	2012	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	4.22	3.86	3.7	3.94	4.18	4.24	4.3	294	324	290	285	120	4.2	254	262	175	185	229	242	131	163	232	299
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	1.22	1.39	1.1	1.38	1.4	1.28	0.94	<0.05	<0.5	<1.25	<0.25	<0.05	1.18	<0.25	<0.25	<0.05	<0.25	<1.25	<0.25	<0.05	<0.25	<1.25	<0.5
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.05	<0.5	<1.25	<0.25	1.06	<0.05	3.26	0.86	0.18	0.62	<1.25	0.34	1.4	1	<1.25	<0.5
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.05	<0.5	<1.25	<0.25	<0.05	<0.05	<0.25	<0.25	<0.05	<0.25	<1.25	<0.25	<0.05	<0.25	<1.25	<0.5
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.50	<0.10	<1.0	<2.50	<0.50	<0.10	<0.10	<0.50	<0.50	<0.10	<0.50	<2.50	0.62	<0.10	<0.50	<2.50	3.4
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	21.7	22.1	22.1	22.9	23.5	22.4	19.8	46	44.3	39.4	35.3	23.2	22.5	20	21.9	16.4	15.6	16.6	17.2	16.6	16.1	16.7	21.8
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	0.02	0.009	<0.004	0.009	0.007	<0.004	<0.004	0.014	0.012	<0.004	<0.004	0.021	0.005	<0.004	<0.004	0.012	0.004	<0.004	0.041	0.019	0.005	<0.004	0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.009	0.005	0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.067	0.076	0.07	0.07	0.075	0.063	0.074	0.163	0.107	0.113	0.129	0.065	0.065	0.062	0.054	0.054	0.046	0.053	0.046	0.057	0.043	0.054	0.057
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.02	0.017	0.015	0.019	0.02	0.016	0.017	0.014	<0.010	0.012	<0.010	0.017	0.015	0.03	0.013	0.014	<0.010	0.012	0.011	0.013	<0.010	0.011	0.01
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.001	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	ns	45.9	56.6	56.8	50.5	50	53.2	55.5	139	157	148	148	92	54	110	104	64.9	73.9	59.5	60.6	87.9	90.2	75.9	81.8
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	0.013	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	0.004	0.005	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	<0.003	<0.003	0.008	<0.003	<0.002	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	0.113	0.1	0.082	0.177	0.043	0.057	0.069	0.223	3.42	2.92	3.24	<0.010	0.078	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	< 0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	26.5	28.7	28.3	25.6	24.9	26.4	26.6	40.2	45.2	43.6	42.4	34.6	26.1	32.3	30.2	22.4	24.5	22.4	22.7	28.8	28.5	26.3	24.5
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	0.004	0.003	<0.002	0.002	0.003	<0.002	0.002	0.197	0.222	0.204	0.206	0.057	<0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	0.003	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.42	1.24	1.26	1.15	0.99	1.11	1.14	1.14	0.96	0.83	0.83	1.63	1.1	1.89	1.86	2.13	2.05	1.49	2.07	1.14	1.06	1.22	1.02
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	4.6	4.13	4.61	3.66	3.8	4.36	4.54	82.5	100	103	99.4	50.5	3.88	124	122	89.5	94.1	111	131	64.7	75.5	119	152
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.547	0.448	0.481	0.566	0.508	0.439	0.539	0.264	0.255	0.226	0.259	0.178	0.456	0.16	0.149	0.121	0.121	0.175	0.129	0.123	0.109	0.116	0.11
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.023	0.007	0.007	<0.005	0.011	<0.005	<0.005	0.02	0.024	<0.005	<0.005	0.039	<0.005	<0.005	0.006	0.01	<0.005	0.023	0.006	0.031	0.008	0.009	0.006
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	235	223	237	223	233	228	219	313	318	332	333	309	225	306	288	213	229	210	204	288	277	267	256
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	235	223	237	223	233	228	219	313	318	332	333	309	225	306	288	213	229	210	204	288	277	267	256
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	<5	<5	<5	<5	<5	12	6	10	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	0.5	1.8	0.8	0.5	2.2	0.6	0.8	25.8	7	6.8	7.4	5	1	33.5	1.9	5.3	1.9	3.8	2.6	4.2	3	3	2.3
	DOC (mg/L)	5	0.7	0.5	0.5	ns	0.5	1.6	0.9	0.5	1.2	0.7	0.7	13.7	5	6.1	6.8	3.8	1	20.7	1.8	4.7	1.6	3.6	2.5	2.3	2.6	3	2.1
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	224	260	258	232	227	242	248	513	578	549	544	372	242	408	384	254	285	241	245	338	343	298	305
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	0.03	0.04	0.04	0.07	0.07	0.17	0.12	0.22	0.24	<0.02	0.14	0.05	<0.02	<0.02	<0.02	0.06	0.04	<0.02	<0.02	0.03	0.03
	Conductivity (us/cm)		3	2	2	ns	399	464	429	456	447	481	468	1440	1560	1570	1530	896	479	1380	1330	904	1040	1120	1160	894	1040	1200	1420
	pH	8.5	0.1	N/A	N/A	ns	8.2	8.28	8.15	8.05	8.18	8.1	8.19	8.07	7.71	8.08	7.58	8.25	8.25	7.67	7.93	8.23	8.14	8	8.13	8.11	8.09	8.01	8.06
Calculated Values	Anion sum (meq/L)		0.01			ns	5.27	5.03	4.58	5.12	5.34	5.21	4.96	15.5	16.4	15.6	15.4	10.1	5.15	13.9	13.7	9.55	10.2	11	11.3	9.9	10.5	12.2	14
	Cation sum (meq/L)		0.01			ns	4.7	5.39	5.39	4.81	4.73	5.05	5.19	13.9	15.9	15.5	15.2	9.67	5.05	13.6	13	9.03	9.85	9.68	10.6	9.6	10.2	11.2	12.7
	% Difference (%)		0.01	0.1	0.1	ns	5.7	3.5	0.3	3.1	6	1.6	2.2	5.6	1.5	0.5	0.6	2.3	1	1.2	2.4	2.8	1.6	6.4	2.9	1.6	1.9	4.6	4.8
	Langelier Index		0.0001			ns	1.09	1.21	1.11	0.93	1.07	1.01	1.1	1.38	1.07	1.44	0.94	1.45	1.16	0.88	1.08	1.07	1.07	0.81	0.94	1.21	1.18	1.02	1.06
	Saturation pH (pH units)		0.01			ns	7.11	7.07	7.04	7.12	7.11	7.09	7.09	6.69	6.64	6.64	6.64	6.8	7.09	6.79	6.85	7.16	7.07	7.19	7.19	6.9	6.91	6.99	7
	Silica (mg/L)			0.05	0.05 - 0.10	ns	15.6	6.59	15.1	14.4	15	14.3	14.7	13.2	14.2	12.9	13.2	4.65	16.1	8.05	9.2	1.38	4.08	2.6	1.92	3.37	6.75	6.25	5.39

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 128				129				130				131				132			
			2003	2008-10	2011-15	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	177	225	426	472	116	128	139	175	ns	75.5	196	206	75.8	59.6	52.1	59.2	376	333	460	350
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<0.25	<0.5	<0.05	<0.25	<0.25	<0.25	ns	<0.25	<0.25	<0.5	<0.05	<0.25	<0.10	<0.25	<0.05	<0.5	<2.5	<0.5
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.17	1	1.76	1.3	4.5	4.58	4.11	3.15	ns	<0.25	0.45	<0.5	1.41	1.2	1.44	1.56	2.42	1.93	2.54	2.1
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<0.25	<0.5	<0.05	<0.25	<0.25	<0.25	ns	<0.25	<0.25	<0.5	<0.05	<0.25	<0.10	<0.25	<0.05	<0.5	<2.5	<0.5
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.10	<0.50	<0.50	1.8	<0.10	<0.50	<0.50	1.1	ns	<0.50	<0.50	2	<0.10	<0.50	<0.20	<0.50	<0.10	<1.0	<5.0	<1.0
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	56.7	48.7	41.9	44.4	39.4	33.7	26.6	36.9	ns	17	19.3	21.6	29.5	22.6	18.3	15.7	26.1	50.3	34.1	28.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	0.006	0.004	<0.004	0.006	0.01	0.007	<0.004	<0.004	ns	0.004	0.241	0.006	<0.004	0.006	<0.004	<0.004	0.005	0.006	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.122	0.08	0.104	0.125	0.107	0.078	0.077	0.107	ns	0.062	0.078	0.103	0.045	0.032	0.033	0.037	0.123	0.087	0.146	0.121
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.01	<0.010	0.017	0.018	0.011	<0.010	<0.010	0.01	ns	0.013	0.014	0.012	0.017	<0.010	0.011	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	97.7	107	124	124	98.5	101	93.9	107	ns	80.8	85.2	95.9	70.2	80.9	81.9	86.1	85.8	91.5	113	110
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	<0.003	0.005	<0.003	0.004	<0.003	0.003	<0.003	ns	<0.003	<0.003	0.003	0.007	<0.003	0.003	<0.003	0.013	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.05	<0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	< 0.010	ns	<0.010	0.464	< 0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	ns	<0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	38.8	37.9	39.9	37.3	33.3	33.5	31.5	35.1	ns	33.5	30.6	32.6	28.1	26.5	28	28.8	25.7	27.2	37.5	31.9
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.049	0.017	0.008	0.005	0.097	0.054	0.032	0.047	ns	<0.002	0.172	0.023	0.317	0.090	0.075	0.036	0.016	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	0.007	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	< 0.05	<0.05	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	1.76	1.95	2.67	2.57	2.17	2.13	2.11	2.06	ns	0.71	1.2	0.79	2.02	1.36	1.08	1	1.56	1.64	2.3	1.8
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	63	94.4	175	198	45.4	55.5	63.4	64.7	ns	77.3	135	155	31.8	27.4	24.9	28	196	161	253	165
	Strontium (mg/L)		0.001	0.005	0.005	0.169	0.173	0.184	0.199	0.152	0.121	0.105	0.132	ns	0.221	0.197	0.205	0.116	0.115	0.096	0.101	0.118	0.143	0.164	0.143
	Thallium (mg/L)		0.0003	0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	0.012	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	0.015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	0.003	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.008	0.007	0.014	0.021	0.015	0.029	0.007	0.01	ns	0.043	0.146	0.022	0.006	0.009	<0.005	<0.005	0.021	0.019	0.018	0.017
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	267	286	316	298	280	285	290	284	ns	395	352	379	263	289	300	298	286	276	274	272
	Bicarbonate (CaCO3) (mg/L)		10	5	5	267	286	316	298	280	285	290	284	ns	395	352	379	263	289	300	298	286	276	274	272
	Carbonate (CaCO3) (mg/L)		10	5	5	<5	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	<5	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	4.3	2.4	6.5	2.1	13.8	3.3	38.9	2.4	ns	2.6	43.2	1.8	4.2	3	8.4	1.7	4.9	1.2	2.2	1.6
	DOC (mg/L)	5	0.7	0.5	0.5	3.3	1.2	5.6	1.9	6.5	2	37.7	2.3	ns	1.5	21.4	1.7	1.9	2.8	5.8	1.6	1.4	1.2	2.1	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	404	423	474	463	383	390	364	412	ns	340	339	374	291	311	320	334	320	340	437	406
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.02	<0.02	0.07	0.05	0.06	<0.02	0.12	0.08	ns	<0.02	0.03	0.02	0.03	<0.02	0.04	<0.02	<0.02	<0.02	0.03	<0.02
	Conductivity (us/cm)		3	2	2	1040	1310	1890	2030	896	1000	1060	1190	ns	974	1260	1500	724	768	745	783	1660	1610	1920	1610
	pH	8.5	0.1	N/A	N/A	8.22	8.09	8.15	8.09	8.27	8.01	8.06	8.07	ns	8.1	8.07	8.03	8.26	8.18	8.01	7.89	8.05	8.13	8.06	7.95
Calculated Values	Anion sum (meq/L)		0.01			11.5	13.2	19.3	20.3	10	10.3	10.6	11.6	ns	10.4	13	13.8	8.11	8.02	7.95	8.07	17	16.1	19.3	16.1
	Cation sum (meq/L)		0.01			10.8	12.6	17.2	17.9	9.69	10.3	10.1	11.1	ns	10.2	12.7	14.2	7.25	7.44	7.5	7.91	15	13.8	19.8	15.3
	% Difference (%)		0.01	0.1	0.1	3	2.1	6	6.2	1.7	0.4	2.3	2.3	ns	1.1	1.3	1.4	5.6	3.7	2.9	1	6.5	7.5	1.1	2.3
	Langelier Index		0.0001			1.36	1.28	1.43	1.33	1.41	1.17	1.19	1.25	ns	1.37	1.26	1.29	1.28	1.27	1.13	1.03	1.11	1.2	1.24	1.09
	Saturation pH (pH units)		0.01			6.86	6.81	6.72	6.76	6.86	6.84	6.87	6.82	ns	6.73	6.81	6.74	6.98	6.91	6.88	6.86	6.94	6.93	6.82	6.86
	Silica (mg/L)			0.05	0.05 - 0.10	5.09	11.9	8.28	8.36	5.16	11.7	10.4	10.5	ns	5.84	6.29	6.63	10	9.38	7.97	8.05	10.1	10.8	9.91	10

At or Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 133				134				135				max	min	average
			2003	2008-10	2011-15	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015			
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	99.4	91.5	78.1	88.2	anom	190	109	114	122	180	180	166	472	0.42	93.6
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.05	<0.25	0.17	<0.25	<0.50	<0.25	<1.25	<0.25	<0.05	<0.25	<1.25	<0.25	1.4	0.05	0.46
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.3	2.16	3.12	1.89	anom	0.32	<1.25	1.36	1.97	2.81	2.93	2.46	19.0	0.05	3.26
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.05	<0.25	0.26	<0.25	<0.50	<0.25	<1.25	<0.25	<0.05	<0.25	<1.25	<0.25	1.0	0.08	0.45
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.10	<0.50	<0.20	<0.50	<1.00	<0.50	<2.50	<0.50	<0.10	<0.50	<2.50	<0.50	3.4	0.16	1.13
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	34.2	19	15.5	10	79.5	40.7	37.1	24	59.4	21	19.8	21.7	89.4	4.54	23.8
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	0.024	0.007	<0.004	<0.004	0.029	0.008	<0.004	<0.004	0.037	0.007	<0.004	<0.004	4.19	0.004	0.25
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.028	0.003	0.007
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.084	0.086	0.075	0.087	0.357	0.069	0.064	0.078	0.066	0.065	0.1	0.104	1.190	0.031	0.112
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.044	0.035	0.032	0.017	0.087	0.099	0.055	0.069	0.024	<0.010	<0.010	0.01	0.099	0.01	0.018
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	0.020	0.0006	0.006
	Calcium (mg/L)		0.5	0.05	0.05	53.3	48.4	54.2	57.7	anom	88.1	67.3	63.8	80.2	80.7	77.1	88.8	157	22.9	81.3
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.008	<0.003	0.004	<0.003	anom	<0.003	<0.003	<0.003	0.012	<0.003	<0.003	<0.003	0.025	0.002	0.007
	Cobalt (mg/L)		0.0008	0.001	0.001	0.002	0.001	<0.001	<0.001	0.016	0.005	0.002	0.001	0.002	<0.001	<0.001	<0.001	0.0419	0.001	0.011
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.002	<0.003	<0.003	<0.003	0.01	0.005	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	0.167	0.002	0.033
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.983	1.34	0.552	<0.010	<0.010	<0.010	<0.010	12.2	0.012	1.505
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.591	0.001	0.111
	Magnesium (mg/L)		0.5	0.05	0.05	31.4	34.1	36	31.2	anom	42.3	35.2	38.7	32.7	26.4	26.8	27	45.2	19	28.0
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.404	0.239	0.204	0.132	0.018	0.638	0.196	0.115	0.385	0.043	<0.002	<0.002	5.2	0.002	0.62
	Molybdenum (mg/L)		0.001	0.002	0.001	0.022	0.024	0.018	0.01	0.029	0.013	0.009	0.013	0.009	0.002	<0.002	<0.002	0.029	0.002	0.007
	Nickel (mg/L)		0.002	0.003	0.003	0.004	<0.003	<0.003	<0.003	0.059	0.008	<0.003	0.003	0.005	<0.003	<0.003	<0.003	0.066	0.003	0.014
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	9.2	0.02	0.97
	Potassium (mg/L)		0.5	0.05	0.05	5.89	6.04	6.56	5.48	11.7	4.11	3.25	3.41	2.55	1.7	1.61	1.54	17.4	0.67	1.80
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.006	0.005	0.005
	Silver (mg/L)		0.0001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0003	0.0001	0.0002
	Sodium (mg/L)	20	0.5	0.05	0.05	48.8	35.6	37.3	37.7	anom	58	79.5	57.6	50.8	75.8	91.5	85.4	253	3.00	46.9
	Strontium (mg/L)		0.001	0.005	0.005	0.177	0.184	0.161	0.149	1.37	0.229	0.142	0.189	0.176	0.136	0.121	0.111	2.410	0.073	0.277
	Thallium (mg/L)		0.0003	0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	0.002	0.003
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.081	0.002	0.019
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01	0.002	0.003
	Vanadium (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	0.047	0.002	0.007
	Zinc (mg/L)	5	0.003	0.005	0.005	0.036	0.013	<0.005	<0.005	0.073	0.017	<0.005	0.007	0.048	0.012	0.009	0.013	2.14	0.005	0.099
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	237	240	259	240	anom	272	289	282	269	268	270	271	395	180	271
	Bicarbonate (CaCO3) (mg/L)		10	5	5	237	240	259	240	anom	272	289	282	269	268	270	271	395	180	271
	Carbonate (CaCO3) (mg/L)		10	5	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	18	5	10
	Colour (TCU)	5	1	5	5	<5	<5	<5	<5	12	18	5	<5	<5	<5	<5	<5	65	5	15
	Total Organic Carbon (mg/L)			0.5	0.5	4.4	2.9	5.4	3.1	anom	18	4.2	5.3	5.7	2.4	1.9	0.9	50.4	0.5	5.2
	DOC (mg/L)	5	0.7	0.5	0.5	2.6	2.1	3.3	3.1	182	18	4.4	4.9	5.1	2.1	1.8	0.8	540	0.5	5.8
	Hardness (CaCO3) (mg/L)	100	10	10	10	262	261	284	273	anom	394	313	319	335	310	303	333	578	151	319
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.19	0.33	0.17	0.02	<0.02	0.38	0.23	0.36	<0.02	<0.02	0.03	<0.02	1.05	0.02	0.13
	Conductivity (us/cm)		3	2	2	764	751	751	788	anom	1160	962	964	920	1110	1060	1070	2030	335	818
	pH	8.5	0.1	N/A	N/A	8.18	8.15	8.15	8.28	7.58	8.15	8.11	8.22	8	8.15	7.98	7.97	8.36	7.5	8.0
Calculated Values	Anion sum (meq/L)		0.01			8.28	7.93	7.96	7.63	anom	11.7	9.63	9.45	10.2	11.1	11.1	10.7	20.3	3.35	8.64
	Cation sum (meq/L)		0.01			7.52	6.94	7.46	7.22	anom	10.5	9.81	8.98	8.96	9.54	10.1	10.4	19.8	3.58	8.50
	% Difference (%)		0.01	0.1	0.1	4.8	6.7	3.2	2.7	2.4	5.2	0.9	2.6	6.4	7.5	4.8	1.5	8.3	-35.34	2.21
	Langelier Index		0.0001			1.11	1.09	1.16	1.24	2.18	1.29	1.21	1.31	1.06	1.18	1	1.04	2.18	-0.1	1.09
	Saturation pH (pH units)		0.01			7.07	7.06	6.99	7.04	5.4	6.86	6.9	6.91	6.94	6.97	6.98	6.93	7.9	5.4	6.93
	Silica (mg/L)			0.05	0.05 - 0.10	8.13	8.95	8.91	9.67	7.13	13.8	12.1	12.8	12.6	12.4	10.7	10.6	23.1	1.38	9.6

At or Exceeds ODWQS

City of Guelph

Draft 2015 Hanlon Creek Tributary A Surface Water Monitoring Report

Prepared by:

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February, 2016

Project Number: 60265453

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Revision History

Revision #	Date	Revised By:	Revision Description
0	February 2016		Draft report issued

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February 29, 2016

Mr. Andrew Schiedel
Aquatic Biologist
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225 Labrador Drive, Unit 1
Waterloo, Ontario, N2K 4M8

Dear Mr. Schidel:

Project No: 60265453
Regarding: Draft 2015

We are pleased to provide a pdf copy of our 2015 Hanlon Creek Tributary A Surface Water Monitoring Report. If you have any questions or comments regarding this report, please contact the undersigned.

Sincerely,
AECOM Canada Ltd.

Adrienne Sones, P.Eng.
Water Resources

AS:am
Encl.

Quality Information

Report Prepared By:

Andrew Minielly, H.B.E.S
Water Resource Specialist

Report Reviewed By:

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Water Resource Engineer

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1. Introduction

In 2003 AECOM was retained by the City of Guelph (City) to establish and carry out a surface water monitoring program at Hanlon Creek Tributary A in anticipation of construction at the Hanlon Creek Business Park. The purpose of this program was to identify pre-construction flow and temperature characteristics. The surface water program has evolved since 2003 and is now included as the surface water monitoring component of the Consolidated Monitoring Program established for the Hanlon Creek Business Park (HCBP). Other components of this monitoring program include groundwater (Banks Groundwater); and aquatic and terrestrial ecology (NRSI). In August 2010, the Hanlon Creek Business Park Consolidated Monitoring Program (NRSI, AECOM, Banks Groundwater) was submitted to the City of Guelph. This monitoring plan included the location, parameters and naming convention for all surface monitoring works to be completed as part of the implementation of servicing and construction at the HCBP.

2. Background

2.1 History of the Surface Water Monitoring Program

In 2003-2004 monitoring data was reported in separate memoranda to the City and a consolidated Environmental Impact Study (EIS) prepared by NRSI for the Hanlon Creek Business Park in 2004. Monitoring continued in 2006 and 2007 with continuous temperature measurements at 6 stations between the outlet of the online pond (Road A) and 150 m upstream of Laird Road. Depth and velocity were continuously measured at the Laird Road culvert (HC-A(05)) and periodic depth measurements were also recorded at this location. Sampling completed in 2006-2007 was summarized in a technical memorandum, submitted to the City of Guelph in February 2008.

The 2008 monitoring plan included temperature monitoring at the previous 6 stations along Tributary A and an additional temperature monitoring station (HC-A(14)) located downstream of the existing SWM pond (Pond 2) outlet. This additional station provided background information to identify the temperature impacts of proposed Ponds 1 and 2. Depth and velocity were monitored at the Laird Road culvert (HC-A(05)) and water depth was monitored at station HC-A(10). High flow measurements were collected to establish a rating curve for HC-A(10). Through June-September 2008, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all stations. Monitoring results from 2008 were presented in a memorandum to the City of Guelph, dated February 3, 2009.

The 2009 monitoring plan included temperature monitoring at the 7 stations monitored in 2008. Temperature monitoring consisted of logging temperature readings every 15 or 30 minutes at the 7 site locations. Temperature loggers deployed during winter months were set at a 30 minute interval to ensure adequate memory would be available throughout the winter months. Loggers re-deployed during later months were set at a 15 minute interval. A continuous level/temp logger (HC-A(10)) and the depth and velocity monitoring equipment at HC-A(05) were used to monitor flow during 2009. During May-October 2009, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity). The flow/velocity instrument stopped logging data November 22nd due to battery failure and was removed from the culvert December 14, 2009. The remainder of the data loggers continued to collect continuous data at 30 minute intervals throughout the winter.

The 2010 monitoring plan included temperature monitoring at the 7 stations monitored in 2009, a new station depth and temperature monitoring station at SR-1(01), the existing station HC-A(14) being supplemented with the installation of a level logger, and continuous depth/velocity monitoring at the Laird Road culvert (HC-A(05)). Temperature monitoring consisted of logging temperature readings every 15 minutes from April until December and every 30 minutes during the winter months at the eight site locations. During May-October 2010, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity). High flow measurements were collected to develop rating curves for HC-A(10) and HC-A(14).

In 2011 a number of additional stations were installed in Tributary A at the beginning of the monitoring season, as shown in **Table A**. Monitoring in the stormwater management facilities (SWMFs) was initiated as Ponds 1, 2 and 4 were functioning as SWMFs. Herein this report SWMF and ponds are used interchangeably. The same surface water monitoring program completed in 2011 as also carried out in 2012 and 2013.

The 2014 monitoring program followed the stations used during the 2012 and 2013 monitoring years as no new stations were deemed necessary. A small number of stations were relocated based on recommendations from the 2012 monitoring report to improve data collection.

2.2 2015 Surface Water Monitoring Program

No changes or alterations were made to the 2015 surface water monitoring program. However, at the request of the City of Guelph, a tipping bucket rain gauge (Model TB3) was installed for the 2015 monitoring season. The rain gauge was installed on the roof of the Clair Road Emergency Services Centre, located approximately 2 km west of the Hanlon Creek Business Park. A solar panel powers the rain gauge and its heater, making it operable year round. Reliable data from the station was not available until November 2015.Due to the lack of data gathered from the rain gauge in 2015, it was not used in this year’s monitoring report.

Table A and **Table B** summarize the continuous monitoring completed at each of the sites during the 2015 monitoring season. Monitoring station locations are illustrated in **Figure 2-1**.

During the winter months, the telemetry stations were removed and replaced with temperature/depth loggers set to record at 30 minute intervals. Telemetry stations were reinstalled in May 2015. Temperature/depth loggers were removed during the winter months from stations where the flow is intermittent. This was done to prevent damage from occurring to the logger.

Influent and effluent water quality monitoring of SWM pond inlets and outlets and Tributary A downstream of the SWM ponds was also monitored as per MOE Certificate of Approval (CofA) 1384-7QFPZQ requirements. Ponds 1, 2 and 4 were sampled during the 2015 monitoring program.

During May-December 2015, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all in-stream stations. High flow measurements were collected for HC-A(03), HC-A(04), HC-A(06), HC-A(10), HC-A(11), HC-A(12), HC-A(13), and HC-A(14) to develop a rating curve. Monitoring reports from 2015 site visits are included in **Appendix A**.

Table A: Tributary A Continuous Monitoring Stations

Station ID	Station ID Prior to 2010	Data Collected*	Date installed	Notes
HC-A(03)		Temperature, Depth, Turbidity	March 2011	
HC-A(04)	**1**	Temperature, Depth	March 2011	
HC-A(05)	**"FLOW"**	Area/velocity	--	Area/velocity meter was not installed to do issues with sedimentation in the culvert during the 2010 monitoring year.
HC-A(06)	**2**	Temperate, Depth, Turbidity	March 2011	
HC-A(08)	**3**	Temperature	May 2006	
HC-A(09)	**4**	Temperature	May 2006	
HC-A(10)	**5**	Temperature, Depth	May 2006	
HC-A(11)	**6**	Temperate, Depth, Turbidity	March 2011	
HC-A(12)	**7**	Temperature, Depth	April 2011	
HC-A(13)		Temperature, Depth	March 2011	
HC-A(14)		Temperate, Depth, Turbidity	March 2011	Temperature sensor replaced for 2015
SR-1(01)		Temperature, Depth	June 2010	

*Note: prior to 2010, only Station HC-A(10) (or Station #5) was monitored for level in addition to temperature. The HC-A(05) ("FLOW") station was monitored for flow. All other stations collected only temperature data prior to 2010.

Table B: Continuous Pond Monitoring Stations

SWMF	Station	Data Collected	Date installed	Location
Pond 1	HC-P1(01)	Temperature	September 2011	In pond close to bottom
	HC-P1(02)	Temperature	September 2011	In pond near mid-depth
	HC-P1(03)	Temperature	September 2011	In pond at surface
	HC-P1(04)	Temperature, Depth	September 2011	Inlet
	HC-P1(05)	Temperature, Depth	September 2011	Inlet
	HC-P1(06)	Temperature, Depth	June 2011	Outlet
	HC-P1(07)	Temperature	June 2011	Cooling trench outlet
	HC-P1(08)	Temperature	June 2011	Cooling trench outlet
Pond 2	HC-P2(01)	Temperature	April 2011	In pond close to bottom
	HC-P2(02)	Temperature	April 2011	In pond near mid-depth
	HC-P2(03)	Temperature	April 2011	In pond at surface
	HC-P2(04)	Temperature, Depth	April 2011	Inlet
	HC-P2(05)	Temperature, Depth	August 2012	Inlet
	HC-P2(06)	Temperature, Depth	June 2011	Inlet
	HC-P2(07)	Temperature, Depth	April 2011	Outlet
Pond 4	HC-P4(01)	Temperature	October 2011	In pond close to bottom
	HC-P4(02)	Temperature	November 2011	In pond near mid-depth
	HC-P4(03)	Temperature	November 2011	In pond at surface
	HC-P4(04)	Temperature, Depth	August 2012	Inlet
	HC-P4(05)	Temperature, Depth	October 2011	Outlet
	HC-P4(06)	Temperature	October 2011	Cooling trench outlet

Hanlon Creek Business Park

Surface Water Monitoring Sites

February 2016	1:7,000	Datum: NAD '83 Zone 17 Source: AECOM, GRCA
P#: 60265453	V#: 001	

Figure 2-1

2.2.1 Station Descriptions

Station HC-A(03) is located in the upper reaches of Hanlon Creek Tributary A1 (Trib. A1) within the site, about 10 m upstream of Pond 4 in a partially forested area. Station HC-A(04) is located approximately 75 m downstream of Pond 4 and 150 m upstream of Laird Road in a partially forested area. Tributary A then passes through an open area low lying/wetland and under Laird Road. Station HC-A(06) is located approximately 100 m downstream of Laird Road. Along this stretch the stream passes through a cedar wetland in which HC-A(09) is located. Station HC-A(08) is located in the same cedar wetland on a tributary of the main branch of Tributary A1. Station HC-A(10) is located approximately 50 m downstream of the confluence of the main branch and the tributary and just upstream of the Hanlon Creek Boulevard crossing. Station HC-A(11) is located at the downstream end of Hanlon Creek Boulevard culvert. From the culvert, the stream passes through another cedar wetland area. Station HC-A(12) is located in an open wetland area at the outlet of cedar wetland and upstream of Pond 1. Station HC-A(13) is located approximately 200 m downstream of HC-A(12) and immediately downstream of the outlet of Pond 1 in an open field. Station HC-A(14) is located at the downstream end of the study site, approximately 150 m upstream of Teal Drive.

2.3 Data Gaps

During the 2015 sampling year, winter stream conditions, and equipment malfunctions produced data gaps in the continuous monitoring data. **Table C** outlines time periods and monitoring parameters unavailable for the associated station.

Table C: Data Gaps in Logger Files - 2015

Location	Station	Parameter	Data Gaps
Tributary A	**HC-A(03)**	Temperature/ Water Level/Turbidity	Apr 17 – Apr 18
	HC-A(04)	Temperature/ Water Level	No Gap
	HC-A(06)	Temperature/ Water Level/Turbidity	Apr 29 – May 6
	HC-A(08)	Temperature	No Gap
	HC-A(09)	Temperature	No Gap
	HC-A(10)	Temperature/ Water Level	No Gap
	HC-A(11)	Temperature/Water Level/Turbidity	No Gap
	HC-A(12)	Temperature/ Water Level	No Gap
	HC-A(13)	Temperature/ Water Level	No Gap
	HC-A(14)	Temperature/ Water Level/Turbidity	No Gap
	SR-1(1)	Temperature/Water Level	No Gap
Pond 1	**HC-P1(01)**	Temperature	Sept 1 – Dec 30
	HC-P1(02)	Temperature	Sept 1 – Dec 30
	HC-P1(03)	Temperature	Nov 4 – Dec 30
	HC-P1(04)	Temperature/ Water Level	Nov 30 – Dec 3
	HC-P1(05)	Temperature/ Water Level	Faulty Logger – No depth data
	HC-P1(06)	Temperature/ Water Level	Installed Sept 1

Location	Station	Parameter	Data Gaps
	HC-P1(07)	Temperature	Nov 4 – Dec 30
	HC-P1(08)	Temperature	Nov 4 – Dec 30
Pond 2	**HC-P2(01)**	Temperature	Jun 4 – Sept 1
	HC-P2(02)	Temperature	No Gap
	HC-P2(03)	Temperature	May 6 – Jun 4
	HC-P2(04)	Temperature/ Water Level	No Gap
	HC-P2(05)	Temperature/ Water Level	No Gap
	HC-P2(06)	Temperature/ Water Level	No Gap
	HC-P2(07)	Temperature/ Water Level	No Gap
Pond 4	**HC-P4(01)**	Temperature	No Gaps
	HC-P4(02)	Temperature	Nov 18 – Dec 30
	HC-P4(03)	Temperature	May 6 – Sept 1
	HC-P4(04)	Temperature/ Water Level	No Gap
	HC-P4(05)	Temperature/ Water Level	No Gap
	HC-P4(06)	Temperature	No Gap

2.4 Site Construction

In July 2009 tree cover upstream of stations HC-A(11) and HC-A(14) was removed as part of the initial clearing for the Hanlon Creek Boulevard culvert construction. In the summer of 2010 construction of the site began with the works being completed at the culvert crossing in August. During 2011, construction of the Phase 1 site was completed with construction and construction of Phase 2 was completed by early 2012. The first lot level development began in Phase 1 in May 2012 and no developments were constructed in Phase 2 during 2012. Development continued in 2013, 2014 and 2015 with construction of some buildings and related parking areas occurring in Phase 1. Construction of the Laird Road overpass occurred in the Phase 2 lands in 2013.

3. In-stream Temperature Monitoring

The locations of the temperature monitoring stations for 2015 are shown in **Figure 2-1** and station descriptions are included in **Section 2.2**. The temperature loggers (HOBO Pendant Temperature/Light Logger and HOBO 12-bit Temperature Smart Sensors) and level/temperature loggers (HOBO U20 Water Level Data Logger) were placed in the creek secured to steel stakes driven into the substrate. Data was collected in 30 minute intervals during the winter months and 15 minute intervals for the remainder of the year.

3.1 In-Stream Thermal Conditions

A plot of the continuous temperature monitoring throughout the entire year is included in **Figure 3-1** and highlighting conditions during the summer is shown in **Figure 3-2**. Monthly plots of stream temperature and hourly air temperature data from the Guelph Turfgrass Institute Station are included in **Appendix B** and show a clearer comparison of thermal conditions observed at each station. These plots show the daily diurnal pattern of temperature variation, with temperatures increasing during the day and decreasing at night.

During the winter months (January to March) of 2015, temperatures at all stations appear to have been at or around freezing (0°C) for most of the winter indicating that a large portion of Tributary A periodically experienced frozen conditions. Additionally, stations HC-A(03), HC-A(04), HC-A(06), HC-A(08), HC-A(10), HC-A(11) and SR-1 had temperatures fluctuate below zero degrees indicating that loggers may have been exposed to air temperatures during the winter months.

Stations HC-A(08), HC-A(03), HC-A(04), and HC-A(06) (listed in ascending order) show trends of consistent temperatures above 0° during sub 0° air temperature conditions. This indicates these stations are likely most impacted by groundwater input. Conversely stations HC-A(14) and HC-A(09) record the coldest temperatures and are least impacted by groundwater inputs. These trends are consistent with over-winter observations made since the implementation of the monitoring program.

Station HC-A(04), located just downstream of the Pond 4 outlet shows that daily fluctuations in temperatures at this station are moderate throughout the year even in comparison to fluctuations noted at upstream station HC-A(03) and downstream station HC-A(06). Station HC-A(06) shows a similar trend but experiences greater increases on days with high ambient air temperatures. The temperature data from HC-A(04) shows that average temperatures at this station during the winter months reflect temperature conditions impacted by groundwater inputs. However as ambient temperatures increase during the year, so do thermal conditions at HC-A(04). During the summer months, stations HC-A(04) and HC-A(06), recorded high average temperatures and little daily fluctuation compared to the upstream station HC-A(03). This demonstrates that in-stream thermal conditions at HC-A(04) are impacted from the continual discharge from Pond 4. More information regarding Pond 4 and it's observed thermal conditions are included in Section 6.2.3and shown in Figure 6-8.

Downstream stations which are more exposed (HC-A(10), HC-A(12), HC-A(13) and HC-A(14)) and those with a wider flow channel and shallower depths (HC-A(09)) are stations that show the highest daily variation in temperature as they are located in areas where there is greater opportunity for solar radiation impact and there is little indication of groundwater inputs.

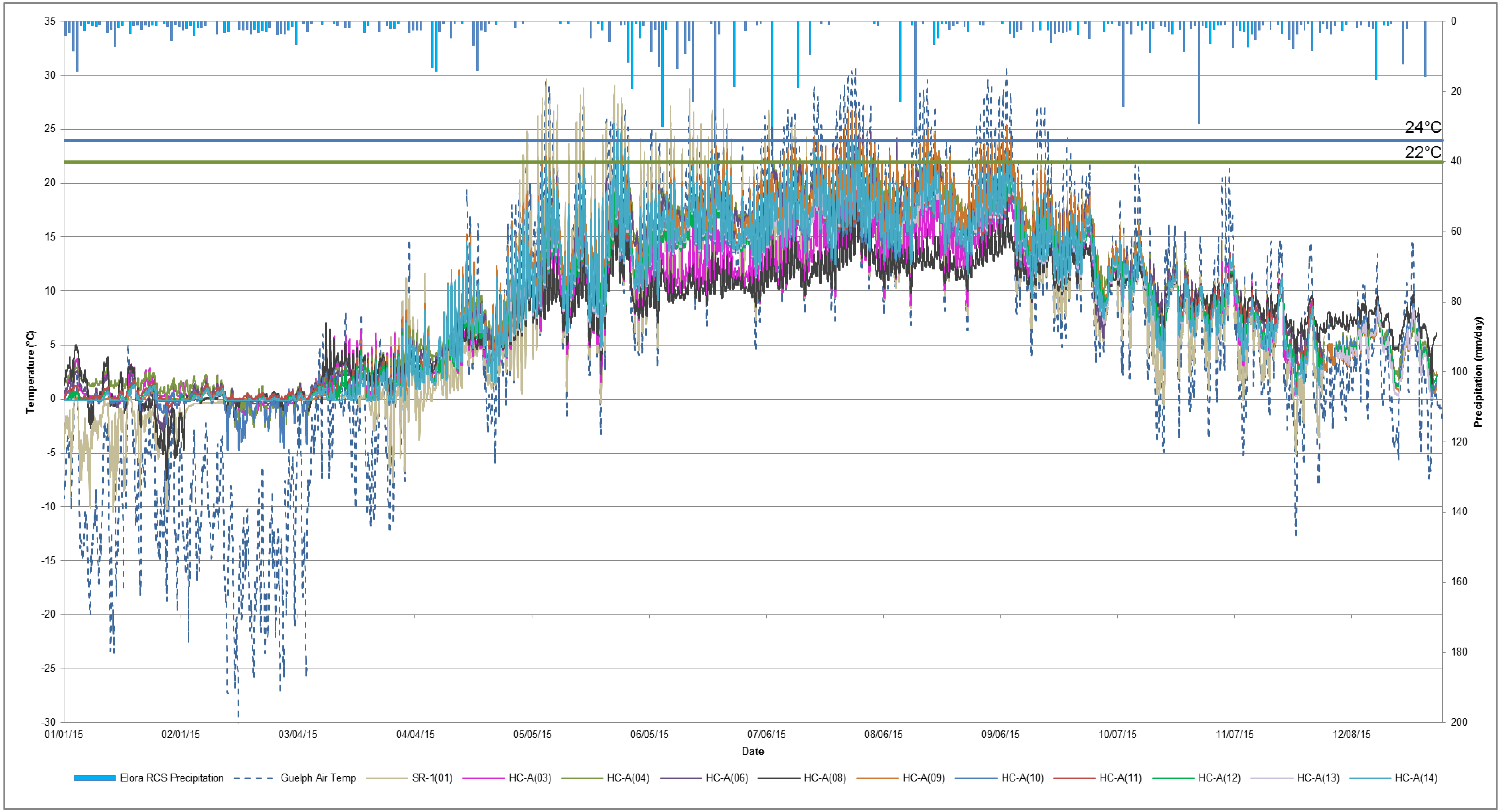


Figure 3-1: Hanlon Creek Temperature Monitoring –January –December 2015

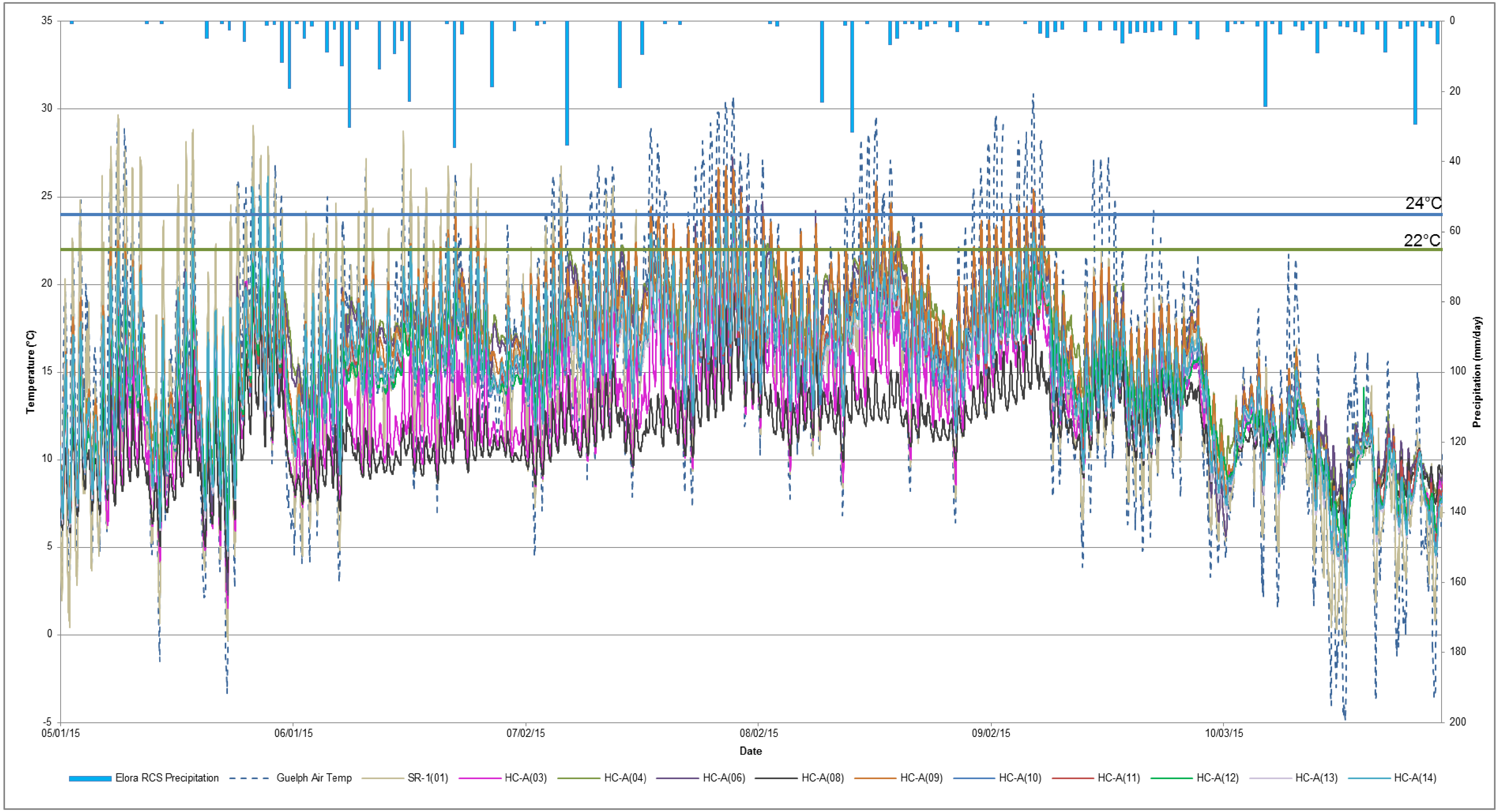


Figure 3-2: Hanlon Creek Temperature Monitoring – May – October 2015

3.2 In-stream Thermal Conditions in Comparison to Thermal Modeling Prediction

The ability of a stream to support a cold-water fish species is often defined by the temperatures throughout the summer (July and August) and autumn (mid October – end of November) months. The 2009 Hanlon Business Park Stream Temperature Impact Report (AECOM, 2009) provided a summary of reach based statistical stream temperature modeling results for future mitigated site conditions. This summary included target daily averages, maximums, minimums, the number of hours target temperatures were exceeded and exceedance frequencies during both the summer and autumn.

A summary comparison of overall modeled existing and future mitigated conditions of average temperature conditions throughout the creek were included in the modeling report. The same statistical analysis applied to the modeling results has been applied to the 2015 data and is included in **Table D** and **Table E** where sufficient data are available. To monitor the changes to Hanlon Creek over time, a comparison of 2015 data to historical conditions has been included in **Appendix C** and **Table F** includes a comparison of monthly ambient air temperatures and Canadian climate normals.

Note that the Hanlon Creek Business Park Consolidated Monitoring Plan recommends:

1. Any single temperature exceedance of 22°C is analyzed in an annual temperature and flow monitoring report, including an investigation of the cause of the exceedance and recommendations for contingency measures as warranted. The investigation should consider the frequency, duration and spatial distribution of the exceedance.
2. Any single temperature exceedance of 24°C triggers an investigation commencing within 2 days of acquiring the information. This investigation should consider the frequency, duration and spatial distribution of the exceedance, seek to identify the cause of the temperature exceedance, and provide recommendations for adaptive management measures as warranted. If contingency measures are warranted, the design and implementation of selected measures should be completed as soon as possible. At the latest, the selected measures should be implemented in the year following the exceedance of 24°C.

Table D: Summer (July-August) Temperature Summary

Station	Modeled Values[1]	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)	SR-1(01)
Summer (July-August) average maximum (ºC)	14.5 - 19.9	18.0	20.9	21.6	14.5	22.3	19.7	19.5	18.7	18.9	20.4	21.1
Summer (July-August) average (ºC)	12.5 - 14.5	14.6	19.5	18.9	12.6	19.2	16.9	17.1	16.9	17.0	17.6	16.9
Summer (July-August) average minimum (ºC)	9.0 - 12.0	11.8	18.2	16.3	11.3	16.8	14.8	15.2	15.3	15.3	15.1	12.8
Maximum 3-day mean (ºC)	14.0 - 19.0	17.3	21.7	21.4	16.2	22.0	19.3	19.4	19.2	19.2	20.2	19.8
Maximum 7-day mean (ºC)	13.0 - 17.0	16.7	21.5	21.1	15.5	21.3	18.9	18.9	18.6	18.6	19.6	19.0
Maximum 7-day mean of daily maximums (ºC)	15.0 - 23.5	21.1	22.8	25.4	19.1	25.5	21.3	21.0	21.2	21.2	23.3	23.1
	Temperature Exceedance over 19°C for July and August											
Hours over 19°C	0 - 130	84	920	753	4	742	260	259	184	199	431	364
Percent of Time over 19°C	0 - 9%	6%	62%	51%	0%	50%	17%	17%	12%	13%	29%	24%
Frequency of Exceedance over 19°C (Days)	0 - 27	19	55	57	5	58	44	43	25	28	49	52
Average Duration of Event Over 19°C (h)	3 - 6	4.0	21.9	10.5	0.6	14.6	5.7	5.9	7.4	7.1	9.0	5.4
Maximum duration of event over 19°C (h)	<<130	8.8	183.3	110.8	1.0	112.0	11.8	12.8	15.8	15.8	34.8	35.5
	Temperature Exceedance over 22°C for July and August											
Hours over 22°C		0	97	107	0	224	13	3	3	3	59	62
Percent of Time over 22°C		0%	7%	7%	0%	15%	1%	0%	0%	0%	4%	4%
Frequency of Exceedance over 22°C (Days)		1	16	24	0	38	6	1	1	1	14	21
Average Duration of Event Over 22°C (h)		0.3	5.2	3.4	0	3.9	1.4	1.8	1.4	1.4	2.9	2.1
Maximum duration of event over 22°C (h)	<<130	0.25	18.75	10.25	0.00	14.25	3.75	3.25	2.50	2.50	8.50	7.25
	Temperature Exceedance over 24°C for July and August											
Hours over 24°C	0 -3.2	0	0	15	0	48	0	0	0	0	3	12
Percent of Time over 24°C	0 - 0.21%	0.00%	0.00%	0.99%	0.00%	3.19%	0.00%	0.00%	0.00%	0.00%	0.22%	0.79%
Frequency of 24°C Exceedance (Days)		0	0	8	0	10	0	0	0	0	1	6
Average Duration of Event Over 24°C (h)		0	0	1.64	0	4.75	0	0	0	0	3.25	1.68
Maximum duration of event over 24°C (h)	<3.2	0	0	4.3	0	7.5	0	0	0	0	3.3	4.3

[1] Modeled range referees to the results of the Hanlon Creek Business Park Stream Temperate Impact Report Continuous Modeling with HSP-F (AECOM, 2009)

Table E: Fall Temperature Summary

Station	Modeled Range	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)	SR-1(01)
	Mid October to End of November											
Max Temp. (°C)	11.9 - 13.0	12.8	13.5	13.0	12.7	13.3	13.6	13.7	14.1	13.0	13.4	14.8
Frequency of 11°C Exceedance (days)	2.1 - 5.6	10.0	11.0	11.0	9.0	10.0	10.0	9.0	5.0	6.0	7.0	15.0
Hours Over 11°C	16 - 27	68.8	129.5	138.3	63.0	89.8	74.3	76.5	44.5	53.5	64.5	80.8
Average Hrs. Over 11°C per Event	4.8 - 5.9	7.6	10.8	15.4	7.0	9.0	6.8	9.6	11.1	10.7	8.1	4.5
Maximum duration of event over 11°C (h)	5.9	31.5	54.5	55.8	31.0	33.0	31.8	16.5	32.3	32.5	33.5	13.8
	November Only											
Max Temp. (°C)	9.3 - 11.3	12.8	12.5	12.5	12.7	13.3	13.6	13.7	12.5	13.0	13.4	14.8
Frequency of 11°C Exceedance (days)	0.4 - 2.0	4.0	3.0	3.0	4.0	4.0	4.0	5.0	3.0	3.0	3.0	7.0
Hours Over 11°C	0.4 - 11.3	40.3	36.3	36.0	41.5	39.5	40.5	43.0	32.5	32.8	36.5	34.3
Average Hrs. Over 11°C per Event	1.0 - 10.8	13.4	9.1	12.0	13.8	13.2	10.1	10.8	16.3	16.4	13.0	4.9
Maximum duration of event over 11°C (h)	10.8	31.5	35.3	34.3	31	33	31.8	16.5	32.3	32.5	33.5	13.8

Table F: Comparison of Monthly Ambient Air Temperatures to the Canadian Climate Normals

	Daily Average (°C)					Average Daily Maximum (°C)					Average Daily Minimum (°C)				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
Climate Normals[1]	12.3	16.9	19.7	18.6	14.1	18.6	23.3	25.9	24.5	19.8	6.0	10.6	13.5	12.6	8.4
2007	12.7	18.3	18.5	19.3	15.8	20.5	25.9	26	26.5	23.7	4.9	10.6	10.9	12.1	7.8
2008	10.1	17.9	19.7	17.5	14.9	16.3	23.3	25.7	23.7	21.1	3.9	12.5	13.6	11.2	8.7
2009	11.2	15.9	16.5	17.4	13.5	18	21.7	22.1	23.7	20	4.2	10	10.8	11	7
2010	n/a	n/a	20.3	19.8	14.1	n/a	n/a	26.4	26.1	19.6	n/a	n/a	14.2	13.3	8.5
2011	12.7	16.7	21.4	19.3	15.2	17.7	22.7	28.6	25.8	20.9	7.8	10.6	14.1	12.6	9.6
2012	15.2	18.6	22	19.3	14.4	22.8	25.2	30.1	26.6	21.1	7.5	12	13.9	11.9	7.6
2013	13.5	16.9	19.9	18	13.7	20.4	22.3	25.3	24.5	20.2	6.2	11.4	14.5	11.4	7.1
2014	12.3	17.8	17.6	17.6	14.1	18.5	24.6	23.6	23.6	20.5	5.9	10.9	11.5	11.4	7.7
2015	15.1	16.0	18.7	18.0	17.0	22.7	22.0	25.6	23.7	23.7	7.3	9.8	11.7	12.2	10.3

[1]Data is taken from Canadian Climate Normals 1971-2000 for the Guelph Arboretum, 2007 to 2014 data was collected at the Guelph Turfgrass station

3.3 Summary of Historical Thermal Exceedances

A comparison of monthly Canadian climate normal air temperatures from May through September for 2009 to 2015 is shown in above **Table F** No exceedances of 24°C were recorded in 2010, in comparison a single occurrence of 22°C was recorded at station HC-A(14) in 2009. In 2011, exceedances above 24°C were observed, with eight of ten stations experiencing temperature exceedances. The 2012 summer recorded the highest number of exceedances to date within the main branch of Hanlon Creek. It was noted that, unlike previous years, 24°C was exceeding in the headwater reaches of the creek, downstream of Pond 4 as opposed to the exceedances occurring in the furthest downstream reaches. These issues were noted in July of 2012 and the RAAP team was assembled to investigate the cause of the exceedances. It was determined that the cause of the temperature exceedances was the continuous discharge of Pond 4. Mitigation measures were put into place with a goal to decrease the quantity and temperature of water entering Tributary A via Pond 4. The weir in Pond 4 was raised during the summer in attempt to decrease continuous outflow from the SWMF into Tributary A. Vegetation along the cooling trench was installed during the fall 2012 with hopes it would act as a cooling agent once it became established.

Water temperature exceedances decreased in 2013 from 2012; however temperatures were still above the ideal habitat conditions documented for brook trout in the Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F (AECOM, 2009). The greatest contributor to stream temperature increases was the continuous discharge of warm water into the headwater of the creek from Pond 4. An exceedance of 24ºC at station HC-A(14) led to a RAAP meeting been called. It was determined that cooling trench discharge from Pond 1 combined with high air temperatures could have factored into the exceedance. Further monitoring of cooling trench temperatures was suggested in order to determine the true effectiveness of the Pond 1 cooling trenches.

In 2014, overall climate conditions were cooler than in 2013 and Canadian climate normals. Higher than average precipitation levels were recorded in 2014 than 2013 and the Canadian climate normals. As a result, fewer exceedance events occurred in 2014. Temperatures remained higher at stations found farthest downstream while the trend of increasing temperatures at reaches downstream of Pond 4, observed in 2012, also continued.

Higher average air temperatures during the summer months and lower precipitation levels compared to 2014 were observed in 2015. Precipitation levels for 2015 compared to previous years are provided in **Table H**. The combination of higher air temperatures and lower precipitation levels led to higher in-stream temperatures and an increase in the number of temperature exceedances in 2015. Even though average air temperatures were still below the Canadian climate normal as shown in **Table F**, station's HC-A(06), HC-A(09) and HC-A(14) recorded in stream temperatures higher than 24ºC. A RAAP meeting was called in late July to discuss the temperature exceedances recorded at HC-A(06). It was found that the temperature exceedance was not a direct result of Pond 4's continuous discharge as an increase in stream temperature between HC-A(04) and HC-A(06) was observed. It was suggested that a cut-off drain could be installed along the south side of Pond 4 to intercept groundwater prior to entering the pond and discharge the groundwater directly to Trib A. It was noted that this retrofit may not directly address the 24°C exceedance however, it would help to decrease overall temperatures in Trib A. Alternatively it was discussed that temperature monitors be placed between the two stations to determine whether the cause of the temperature discrepancy was a result of groundwater discharge or exposure to solar radiation.

Appendix C includes a comparison of historical conditions at each station. This summary shows that overall stations HC-(A)09, HC-A(06) and HC-A(04) have had greater number of hours above 22°C since the construction of Pond 4 and HC-(A)09 has also had a greater number of hours above 24°C. A comparison between the numbers of 24°C exceedance events per monitoring site to the average summer temperatures for 2015 has been provided in

Figure 3-3. In addition, a comparison between the recorded number of hours in stream temperatures exceeded 19°C to the average summer temperatures is shown in **Figure 3-4**. These two figures also illustrate stations HC-(A)09, HC-A(06) and HC-A(04) show to have the greatest exceedances of 22ºC and 24ºC.

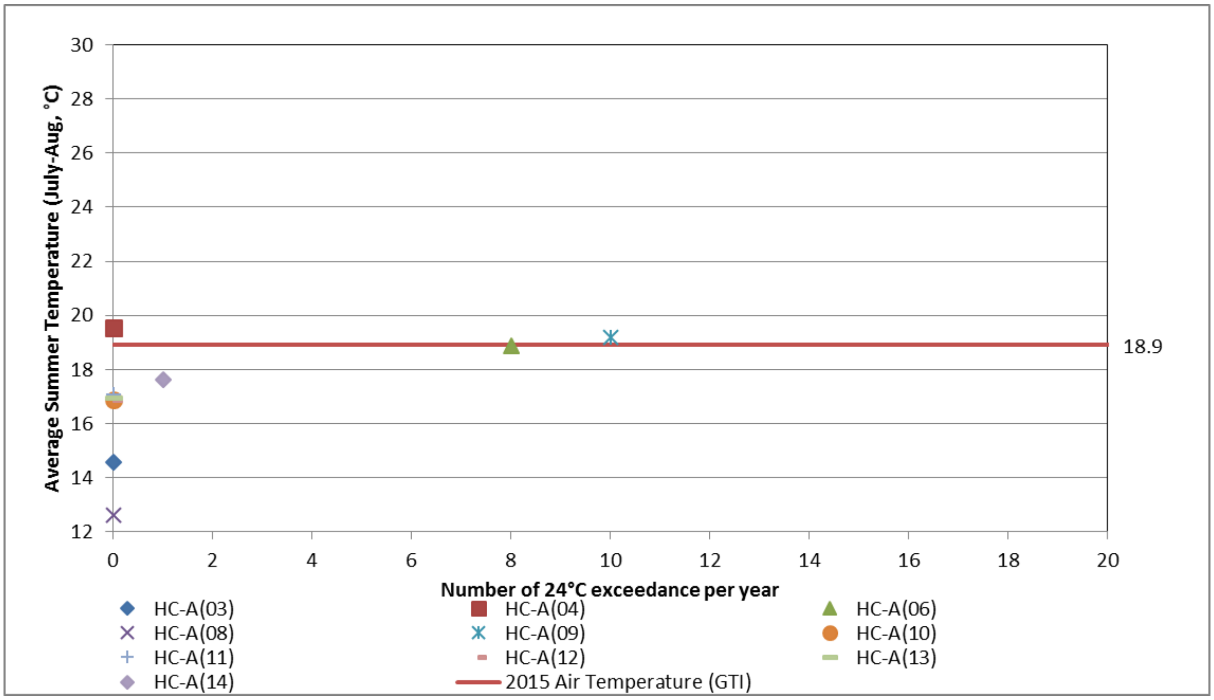
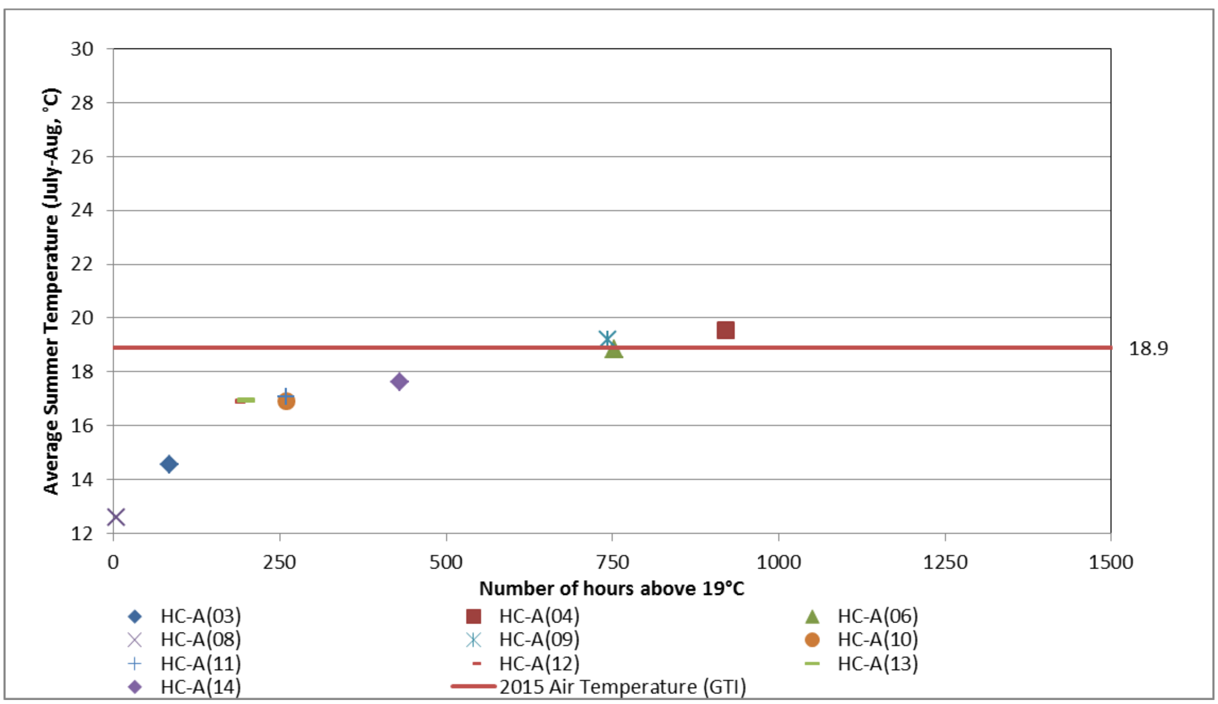


Figure 3-3: A comparison between the number of 24°C exceedance events per monitoring site to the average summer temperatures for 2015.



.Figure 3-4: A comparison between the recorded number of hours in stream temperatures exceeded 19°C to the average summer temperatures for 2015

3.4 In-stream Thermal Regime Classification

The method described in Stoneman and Jones (1996) later revised by C. Chu *et al.*(2009) is used to determine the temperature regime. Each station is based on a comparison of daily maximum air temperature and maximum in-stream water temperature measured between 16:00 and 18:00 during summer months (July 1 – August 31) when maximum daily air temperatures exceed 24.5°C. A nomograph is then used to classify results based upon water thermal characteristics of coldwater, cold-coolwater, coolwater, cool-warmwater and warmwater. **Appendix D** includes graphical representation of this analysis. **Table G** summarizes the thermal regime classification associated with each station within the study area. Noted trend changes in the thermal classification of each site are also included in **Table G** below. These noted changes are based upon trends noted in the thermal regime. These are generalized trends that could be modified as more years of data is available.

The comparison included in **Table G** indicates station HC-A(04) shows the greatest change in thermal regime from cold-cool to cool-warm. This trend is noted to occur since 2012. Other stations that show signs of increases to thermal regimes are located in the middle reaches and include HC-A(06), HC-A(09), HC-A(10). These observations are generally consistent with the observation that stations HC-A(04), HC-A(06), and HC-A(09) appear to have the greatest number of hours exceeding 22°C and 24°C as discussed in **Section 3.3**.

Overall stations HC-A(03), HC-A(08), HC-A(13) and HC-A(14) have not experience a noted change in thermal regime. Stations HC-A(03) and HC-A(08) are highly influenced by groundwater inputs which may contribute to the static nature of the thermal regime. Stations HC-A(13) and HC-A(14) are located in open areas in the downstream reach and are generally the warmest stations.

Lastly, stations which show signs of decreased thermal regimes are located in the downstream reaches however upstream of Pond 1 and Pond 2 and include HC-A(11) and HC-A(12).

Overall these trends provide further evidence that the creek reach from the Pond 4 outlet to Hanlon Creek Boulevard appears to be thermally impacted by the continuous discharge from Pond 4 during the later summer months and early autumn.

Table G: Temperature Classification Summary

Station	Based on C. Chu *et al.* (2009)								Based on Stoneman and Jones (1996)		Overall Change in Thermal Regime
	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	
HC-A(03)	Cool	Cool-Cold	Cool-Cold	Cool	Cool	n/a	n/a	n/a	n/a	n/a	None
HC-A(04)	Cool-Warm	Cool	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cold	Cold	Cold-Cool to Cool-Warm
HC-A(06)	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cool	Cool	Cool to Cool-Warm
HC-A(08)	Cold	Cold	Cold	Cool-Cold	Cold	Cold	Cold	Cold	Cold	Cold	None
HC-A(09)	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	n/a	Cool	Cold	Cool	Cool to Cool-Warm
HC-A(10)	Cool	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Cold	n/a	Cool-Cold	Cool	Cool	Cool to Cool-Warm
HC-A(11)	Cool	Cool	Cool	Cool-Warm	Cool	Cool	Cool-Warm	Cool	Warm	Warm	Cool-Warm to Cool
HC-A(12)	Cool	Cool	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	Cool-Warm to Cool
HC-A(13)	Cool	Cool-Warm	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	None
HC-A(14)	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool	Cool	n/a	n/a	None

4. In-stream Flow Monitoring

Nine flow monitoring stations were installed along Hanlon Creek. The depth/velocity meter (ISCO 2100) has not been installed since 2010 due to high sedimentation at HC-A(05) producing unreliable data.

A depth logger (HOBO U20-001-001 Water Level logger) was used to monitor water levels at HC-A(04), HC-A(10), HC-A(12), HC-A(13) and SR-1(01) throughout 2015. Depth measurements were also collected at telemetry monitoring (Instrumentation Northwest, PS9800) stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14).

Seven baseflow and three high flow measurements were taken between April 29th and December 1st 2015 at each station using a FlowTracker Handheld-ADV® (Acoustic Doppler Velocimeter). The measured flow values from 2015 and previous years were used to develop stage (level) - discharge relationships (rating curves) for each station as shown in **Appendix E.**

The following issues were experienced over the course of the 2015 monitoring year:

- Flow measurements were not collected at SR-1(01) due to very low flows or dry conditions at the culvert outlet.
- No flow measurement was taken at HC-A(03) on September 16 due to insufficient flow.
- Flow data is unavailable at stations HC-A(13) for August 1st and HC-A(14) for June 4th and August 1st due to corrupt data files.
- Stream cross-sections for stations HC-A(10), HC-A(11), HC-A(13) and HC-A(14) were affected by watercress growth during the last half of the 2015 monitoring season. **Figure 4-1** through **Figure 4-4** show the extent of growth at each station. Due to the increase of watercress at station HC-A(11) the stations cross section was moved to the mouth of the upstream culvert (11/04/2015).

Figure 4-1: Watercress growth at Station HC-A(10). Photo taken looking downstream while standing upstream from the stations cross section (11/27/2015)

Figure 4-2: Watercress growth at Station HC-A(11). Photo taken looking downstream while standing upstream from the stations cross section (11/27/2015)

Figure 4-3: Watercress growth at Station HC-A(13). Photo taken looking cross stream while standing on the left bank (10/09/2015)

Figure 4-4: Watercress growth at Station HC-A(14). Photo taken looking cross stream while standing on the left bank (11/04/2015)

4.1 Continuous Depth and High Flow Monitoring

A plot showing the creek flow at stations HC-A(03), HC-A(04), HC-A(06), HC-A(10), HC-A(11), HC-A(12) , HC-A(13) and HC-A(14), for the 2015 monitoring period is shown in **Figure 4-5**. This figure also includes recorded precipitation from the Elora Research station. It should be noted rating curves for stations HC-A(11) and HC-A(12) have been developed in the absence of high peak flow values and therefore peak flow values estimated for these stations are associated with a lower level of accuracy than the other stations. **Figure 4-5** shows flows generally increasing as stations move farther downstream.

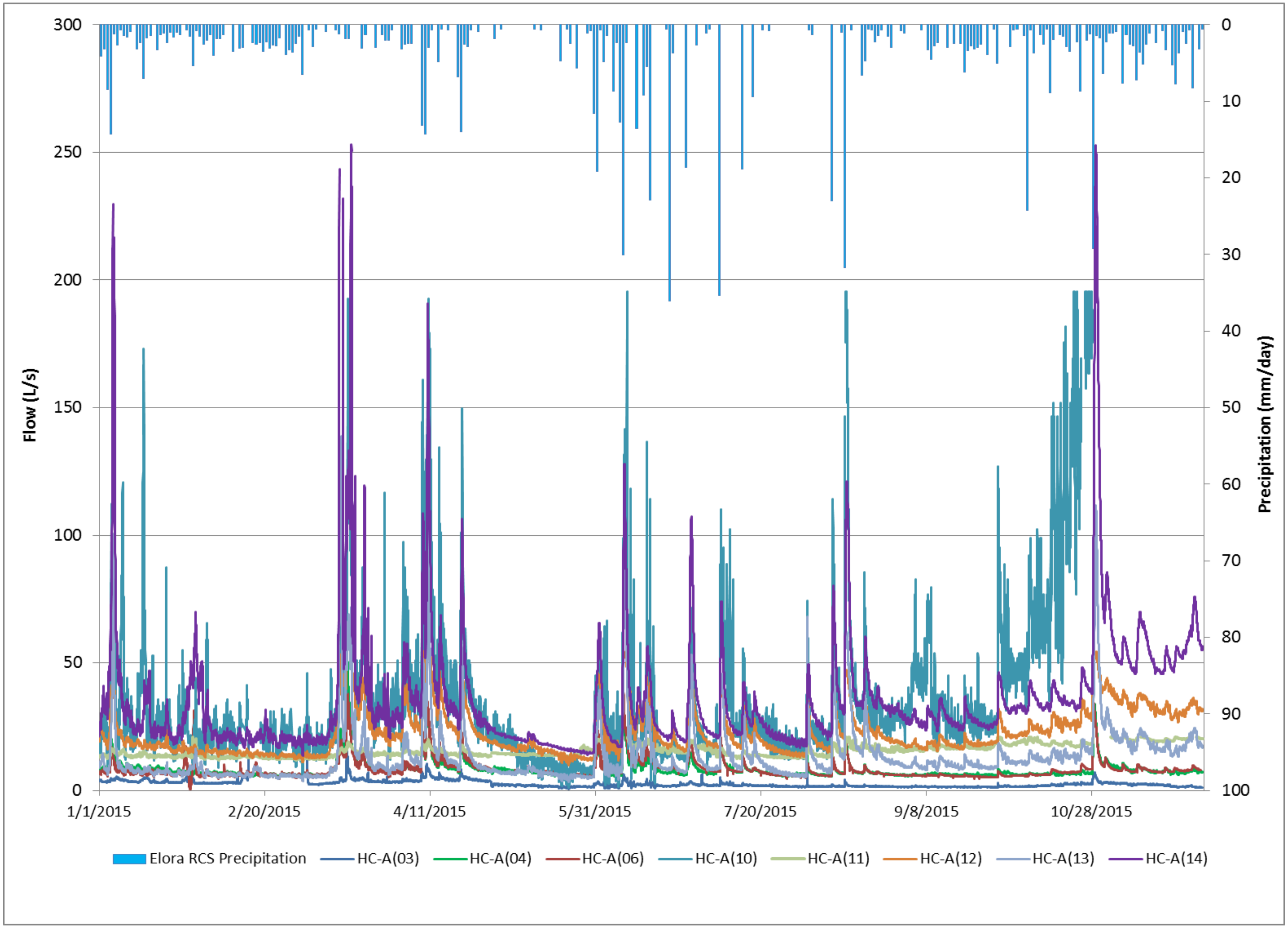


Figure 4-5: 2015 Flow Monitoring for Hanlon Creek

4.2 Precipitation

Comparisons between 2015 precipitation totals to previous years and the Canadian Climate Normals are shown in **Table H.** Previous reports have used the Guelph Turf Grass Institute weather stations precipitation data; however, data for 2015 was not available. Instead precipitation data from the Elora Research station was used because of its proximity to the project location. It is noted that the Elora Research station does contain data gaps which are a result of the Government of Canada's quality control processes. Precipitation totals from the University of Waterloo weather station were also included for comparison purposes.

Compared to the Canadian climate normals, the Elora Research station recorded above average precipitation totals for 2015. However, only 4 months measured precipitation higher than the Canadian climate monthly normals. Most of the precipitation in 2015 fell in June (175.9mm) and October (111.5mm). Lower precipitation values during the spring and summer, with the exception of June, contributed to below average baseflow levels as all stations recorded lower baseflow averages than averages recorded in 2014. Lower precipitation levels during the summer season also contributed to decreases in water levels at Pond 1 and Pond 2 which are shown in **Figure 4-7** and **Figure 4-6** below.

Figure 4-7: Low water levels observed in the main cell of Pond 1. (9/16/2015)

Figure 4-6: Low water levels observed in the main cell of Pond 2. (9/16/2015)

Table H: Observed Precipitation Trends for 2015 Compared to Canadian Climate Normals

	Units	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Canadian Climate Normals (1971-2000) Guelph Arboretum	mm	56.4	50.8	72.1	78.3	79.9	76	88.5	95.9	92.1	69.2	86.3	77.7	**923.3**
Observed Elora Research Station 2008	mm	98.5	57.4	85.5	64.6	86.1	81.6	131.3	120.7	119.3	68.4	103.1	100.4	**1116.9**
Observed Elora Research Station 2009	mm	66.1	82.0	72.7	106.2	79.3	69.2	79.5	92.1	53.7	91.5	37.3	65.8	**895.4**
Observed Elora Research Station 2010	mm	27.2	24.4	41.3	47.5	99.9	184.1	89.4	12.1	117.8	52.6	50.8	21.1	**768.2**

	Units	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Observed Elora Research Station 2011	mm	47.6	58.2	86.1	100.7	113.3	87.0	31.9	158.6	76.1	128.9	90.5	85.5	**1064.4**
Observed Guelph Turf Grass Institute 2011	mm	20	23.8	89.6	92.8	147.4	100.4	26.8	51.2	71.4	93.4	84.6	59.2	**860.6**
Observed Elora Research Station 2012	mm	46.8	32.0	31.0	30.0	28.2	64.6	30.4	62.6	106.2	127.3	40.2	79.9	**679.2**
Observed Guelph Turf Grass Institute 2012	mm	39.2	17.0	28.4	31.0	32.2	90.0	54.6	98.4	127.0	129.0	11.6	57.8	**716.2**
Observed Elora Research Station 2013	mm	80.5	71.2	40.6	123.8	102.0	122.3	130.9	69.5	142.9	133.6	33.7	43.2	**1094.2**
Observed Guelph Turf Grass Institute 2013	mm	72.4	41.4	25.2	98.6	70.8	82.4	173.6	54.8	79.4	116.4	26.4	44.0	**885.8**
Observed Elora Research Station 2014	mm	51.2	58.1	46.7	101.7	54.1	68.8	133.7	51.1	27.9	74.3	63.3	45.8	**776.7**
University of Waterloo Weather Station 2014	mm	74.2	30.7	17.5	90.9	63.6	52.4	165.9	91.5	159.8	79.6	90.6	33.3	**950**
Observed Elora Research Station 2015*	mm	77.0	58.2	34.4	77.3	48.0	175.9	66.8	80.6	53.1	111.5	78.2	66.7	**927.7**
University of Waterloo Weather Station 2015	mm	49.6	48.2	23.9	77	61.6	117.9	60	78.2	53.8	109.6	68.2	66.2	**814.2**

*Precipitation data gaps for the Elora RCS: Jan 17, Jun 28, Jul 23, Jul 31, Aug 2, Sept 4, Spet 30, Dec 8, Dec, 23, Dec 25 – 26, Dec 28 – 29

4.3 Baseflow

In addition to the continuous flow monitoring, baseflow measurements for each station HC-A(03), HC-A(04), HC-A(06), HC-A(08), HC-A(10), HC-A(11), HC-A(12), HC-A(13) and HC-A(14) were taken on between April 29th and December 1st, 2015, using a Flow Tracker 6300 - Acoustic Doppler Velocity Meter. These results are shown graphically in **Figure 4-8** and presented in **Table I**.

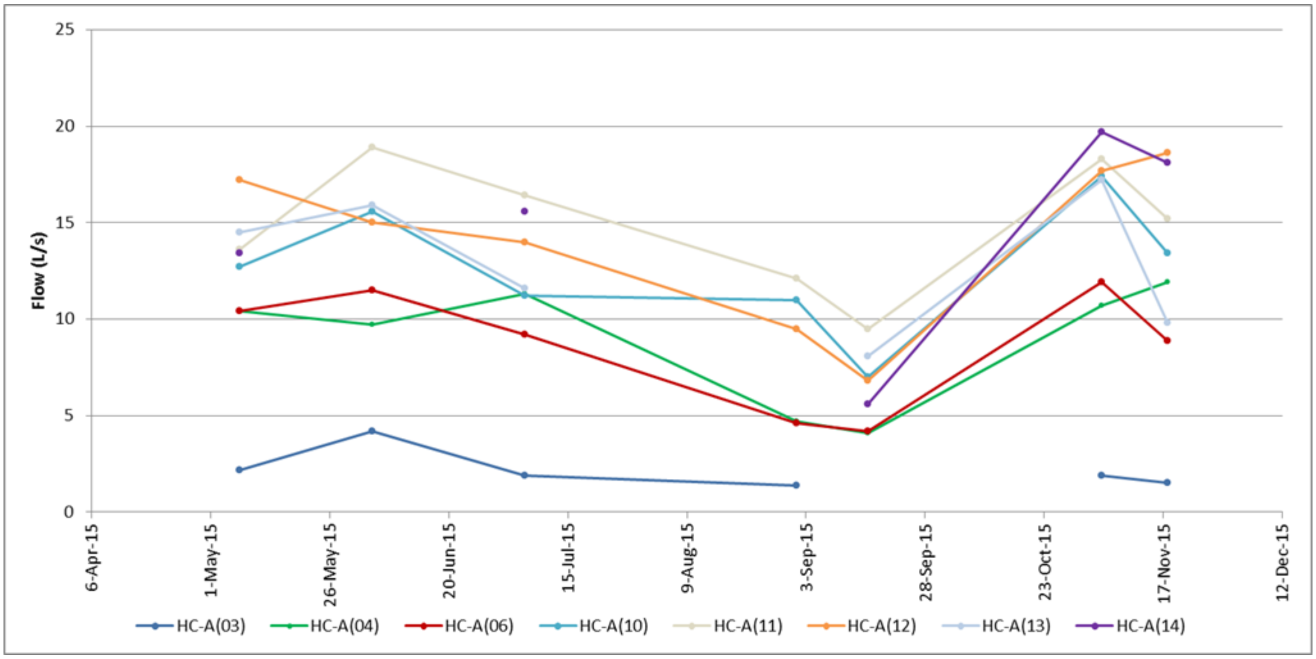


Figure 4-8: Hanlon Tributary A Baseflow Measurements – 2015

Table I: Hanlon Creek Baseflow Monitoring (L/s) – April 2015 to December 2015

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
5/7/2015	2.2	10.4	10.4	12.7	13.6	17.2	14.5	13.4
6/4/2015	4.2	9.7	11.5	15.6	18.9	15.0	15.9	n/a[1]
7/6/2015	1.9	11.3	9.2	11.2	16.4	14.0	11.6	15.6
9/1/2015	1.4	4.7	4.6	11.0	12.1	9.5	n/a[1]	n/a[1]
9/16/2015	n/a[2]	4.1	4.2	7.0	9.5	6.8	8.1	5.6
11/4/2015	1.9	10.7	11.9	17.4	18.3	17.7	17.2	19.7
11/18/2015	1.5	11.9	8.9	13.4	15.2	18.6	9.8	18.1

1. Missing data due to corrupt data files
2. Missing data due to insufficient flow

A comparison of 2008 -2015 average baseflow measurements are shown graphically in **Figure 4-9** and presented in **Table J.** Baseflows were influenced only in 2011 by construction impacts such as dewatering activities.

Average baseflow measurements in 2015 were similar to the overall averages recorded in 2008 and 2009. Recorded baseflow discharge from all stations was slightly lower than 2014 values. However, average baseflow levels were generally higher in 2015 compared to 2013 and 2012 at all eight stations.

Historical and recent baseflow measurements have been used to classify which reaches are losing (contributing groundwater) or gaining (receiving groundwater) reaches. These conclusions are corroborated with temperature data.

Although measures were taken to reduce the outflow from Pond 4 in 2013, pond discharge was still observed to be near continuous causing high baseflow levels at HC-A(04) compared to recorded upstream baseflow at station HC-A(03). Station HC-A(06) exhibited slightly lower baseflow levels compared to station HC-A(04). . The reach between HC-A(09) and HC-A(10) receives input from a small groundwater-fed tributary in the cedar swamp which contributes to the increased baseflow between HC-A(06) and HC-A(10). Stations HC-A(10) and HC-A(11) have historically been groundwater recharge areas and this was the case for 2015. HC-A(12) and HC-A(13) were both areas of groundwater recharge/ losing reaches in 2015 while the reach between HC-(13) and HC-A(14) was a groundwater recharge area according to measured baseflow levels.

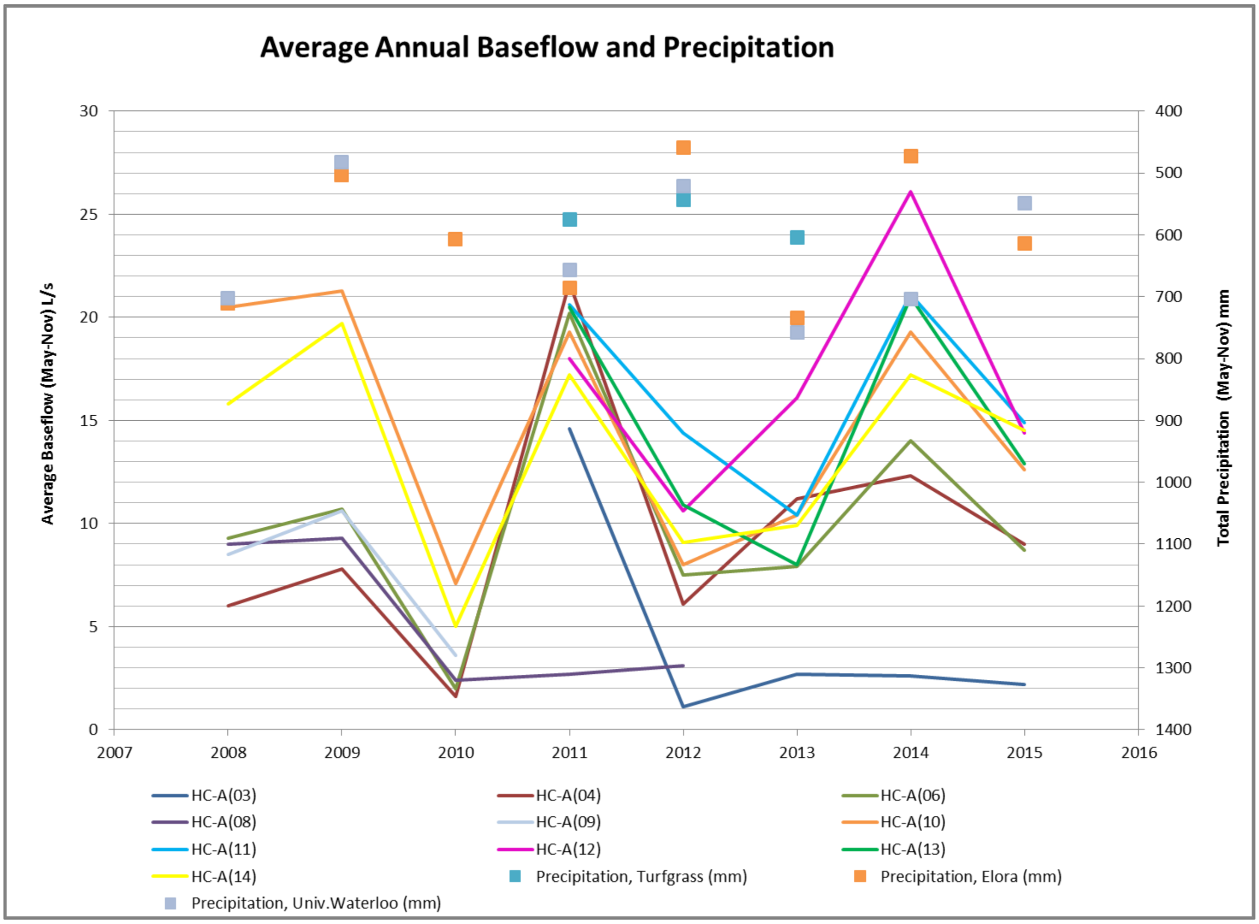


Figure 4-9: Average annual baseflow and precipitation from 2008 to 2015

Table J: Hanlon Creek Baseflow Monitoring – 2008-2015 Summary (L/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08) Tributary	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2008 Min	n/a	3.5	2.7	2.1	3.8	7.7	n/a	n/a	n/a	0.9
2009 Min	n/a	3.9	1.2	3.0	4.2	5.0	n/a	n/a	n/a	1.8
2010 Min	n/a	0.4	0.4	-7.3	1.1	0.8	n/a	n/a	n/a	0.9
2011 Min[2]	2.8	5.5	0.8	1.5	n/a	2.4	4.6	5.0	2.8	1.5
2012 Min	0.1	3.2	3.1	0.5	n/a	1.3	0.7	1.7[1]	0.6[1]	0.7[1]
2013 Min	1.2	8.2	5.5	n/a	n/a	6.4	2.7	12.5	3.4	3.4
2008 Max	n/a	11.3	10.7	10.0	9.4	16.8	n/a	n/a	n/a	12.1
2009 Max	n/a	14.9	25.6	22.1	18.7	56.3	n/a	n/a	n/a	53.8
2010 Max	n/a	2.9	4.9	12.3	6.7	22.2	n/a	n/a	n/a	1.2
2011 Max[2]	47.4	56.6	50.0	5.9	n/a	31.5	46.0	31.9	18.2	48.0
2012 Max	2.5	10.5	14.6	7.4	n/a	13.2	45.6	17.6	36.6	20.7
2013 Max	4.4	16.8	10.3	n/a	n/a	16.9	16.0	21.7	15.8	15.7
2014 Max	3.6	15.4	16.9	n/a	n/a	27.7	27.3	33.1	30.0	28.2
2015 Max	4.2	11.9	11.9	n/a	n/a	17.4	18.9	18.6	17.2	19.7
2008 Average	n/a	6.0	9.3	9.0	8.5	20.5	n/a	n/a	n/a	15.8
2009 Average	n/a	7.8	10.7	9.3	10.6	21.3	n/a	n/a	n/a	19.7
2010 Average	n/a	1.6	2.0	2.4	3.6	7.1	n/a	n/a	n/a	5.0
2011 Average[2]	14.6	21.7	20.2	2.7	n/a	19.3	20.6	18.0	20.5	17.2
2012 Average	1.1	6.1	7.5	3.1	n/a	8.0	14.4	10.6	10.9	9.1
2013 Average	2.7	11.2	7.9	n/a	n/a	10.4	10.4	16.1	8.0	9.9
2014 Average	2.6	12.3	14.0	n/a	n/a	19.3	21.1	26.1	21.0	17.2
2015 Average	2.2	9.0	8.7	n/a	n/a	12.6	14.9	14.4	12.9	14.5
Notes	[1] Hanlon Creek was noted to be dry or flows were below the measurement threshold flow at stations HC-A(03),HC-A(12), HC-A(13) and HC-A(14) [2] Baseflows were influenced by construction activities									

5. In-stream Water Quality Data

During each field visit a YSI multi-parameter probe (556R) was used to collect dissolved oxygen, pH, and specific conductivity conditions at each site. The 2015 results and historic site comparisons are shown graphically in **Figure 5-1** to **Figure 5-6**. The majority of the sites were within the ranges of the Provincial Water Quality Objectives (PWQO). It should be noted that the average annual comparisons provided show general trends of water quality parameters measured during baseflow conditions and do not provide a definite representation of stream conditions.

During some of the baseflow monitoring events, dissolved oxygen (DO) was found to be below PWQO guidelines. This occurred at station HC-A(04) on four occations (Jul. 14, Aug. 20, Sept. 1, Sept. 19), at station HC-A(11) once (Aug. 20), at station HC-A(06) once (Sept. 16) and at station HC-A(10) once (Sept. 16). Lower DO levels observed on this date could be attributed to below average flow rates, high temperatures and an extended period of no precipitation. The average annual dissolved oxygen levels shown in **Figure 5-2** show DO levels have been fairly consistent since 2010, with the exception of 2012 which was noted to be a particularly warm summer.

The number of days where pH levels were above PWQO guidelines was also recorded. Stations HC-A(03), (04), (06) and (10) all recorded pH levels above the PWQO guidelines on May 7th. Stations HC-A(03) and (04) also recorded pH levels below PWQO standards. Overall the annual trend shown in **Figure 5-4** shows pH levels to have been decreasing since 2012.

The is no PWQO for conductivity. Overall in 2015 the upstream reaches had lower conductivity readings and greater results in the downstream reaches with values ranging from 400 to 1200 µS/cm. Overall specific conductivity appears to be consistent throughout the system with the exception of HC-A(03) which appears to be trending to lower levels.

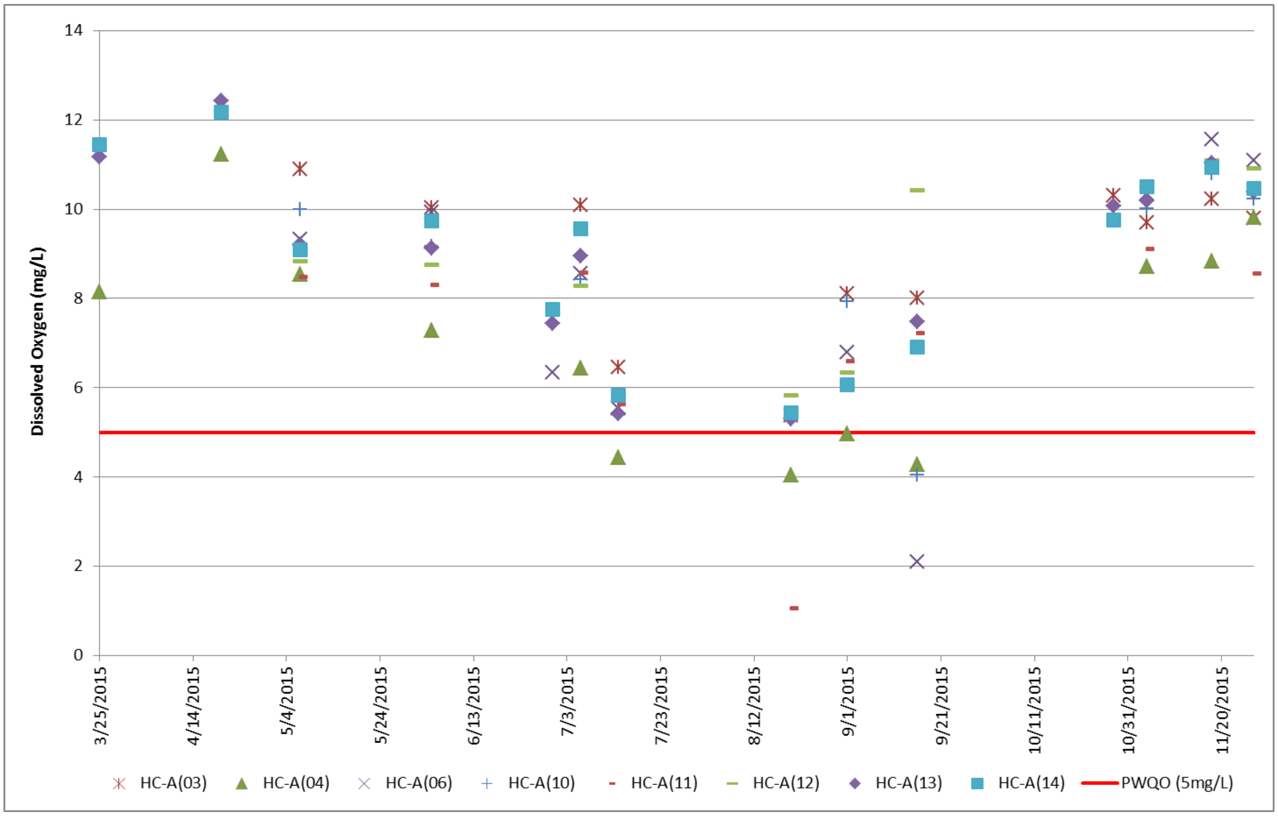


Figure 5-1: 2015 YSI Dissolved Oxygen Readings

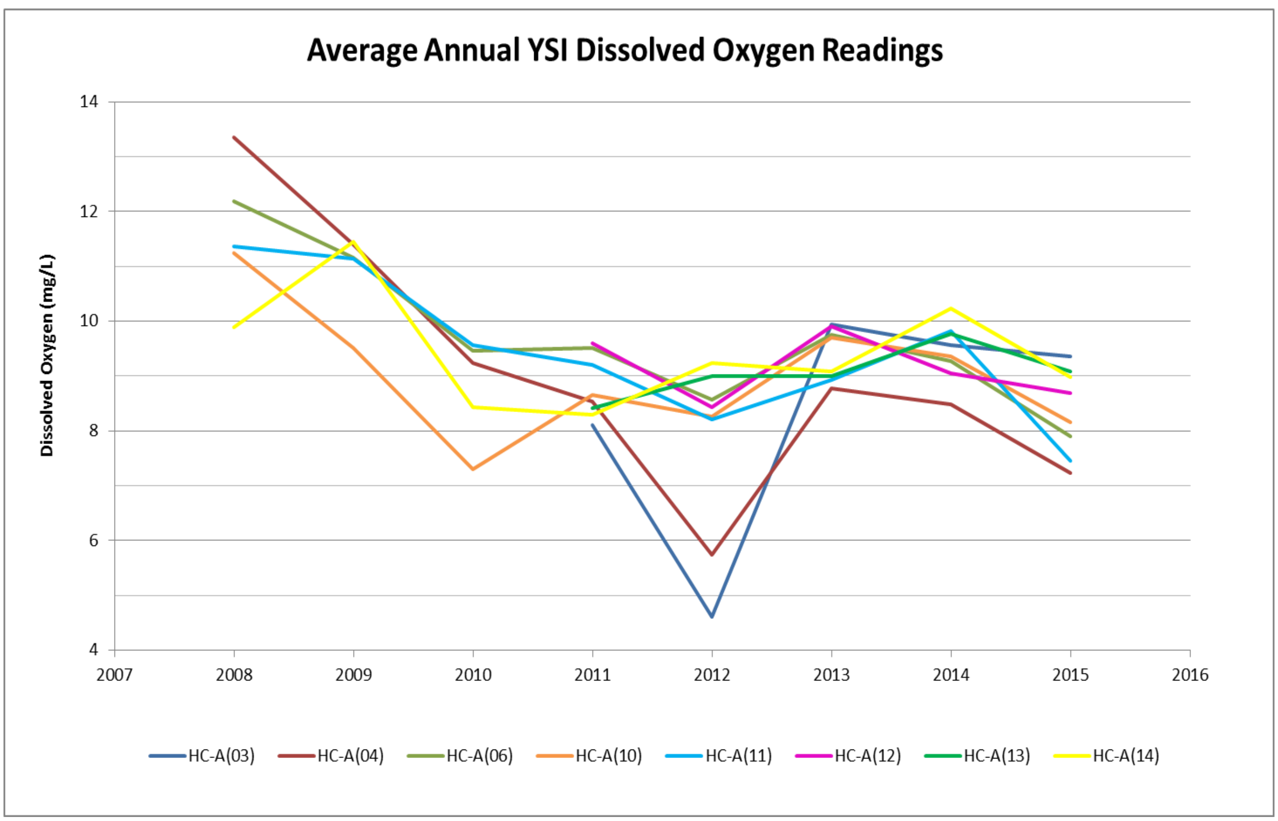


Figure 5-2: Average Annual YSI Dissolved Oxygen Readings from 2008 to 2015

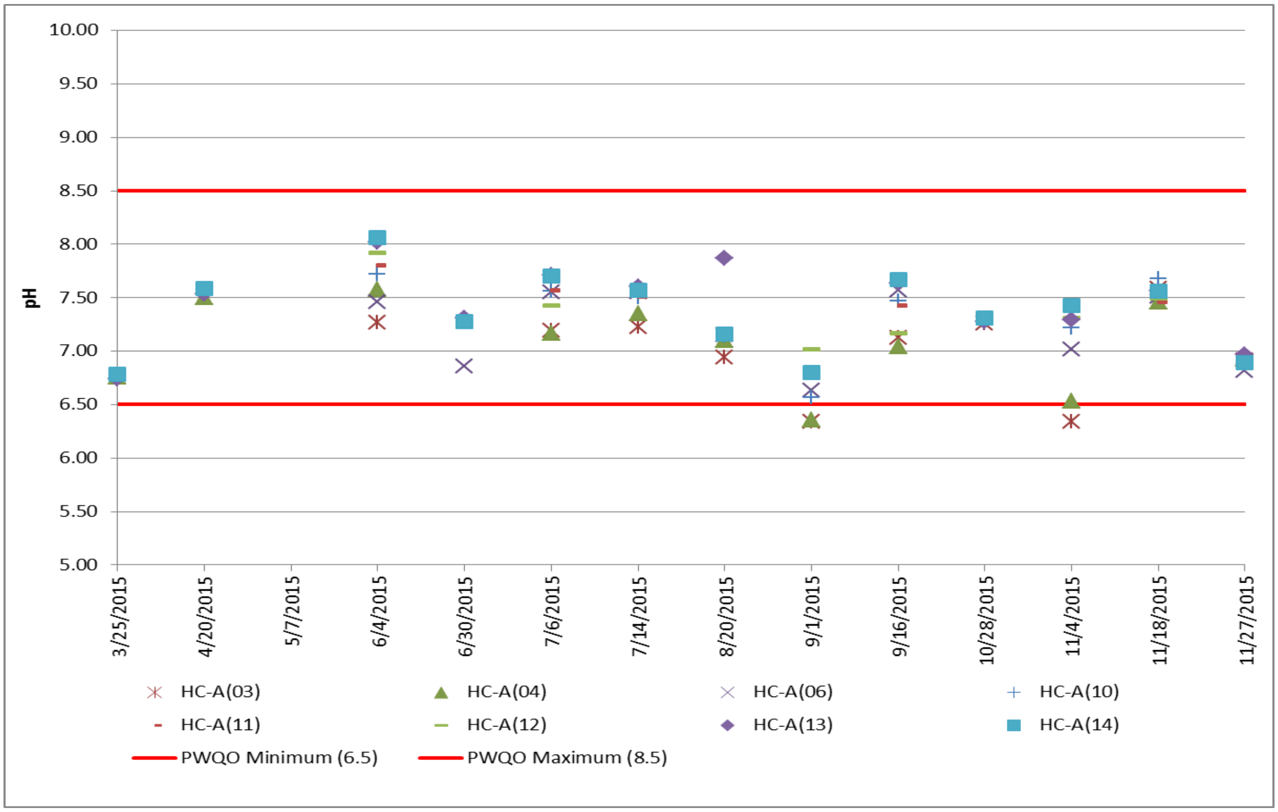


Figure 5-3: 2015 YSI pH Readings

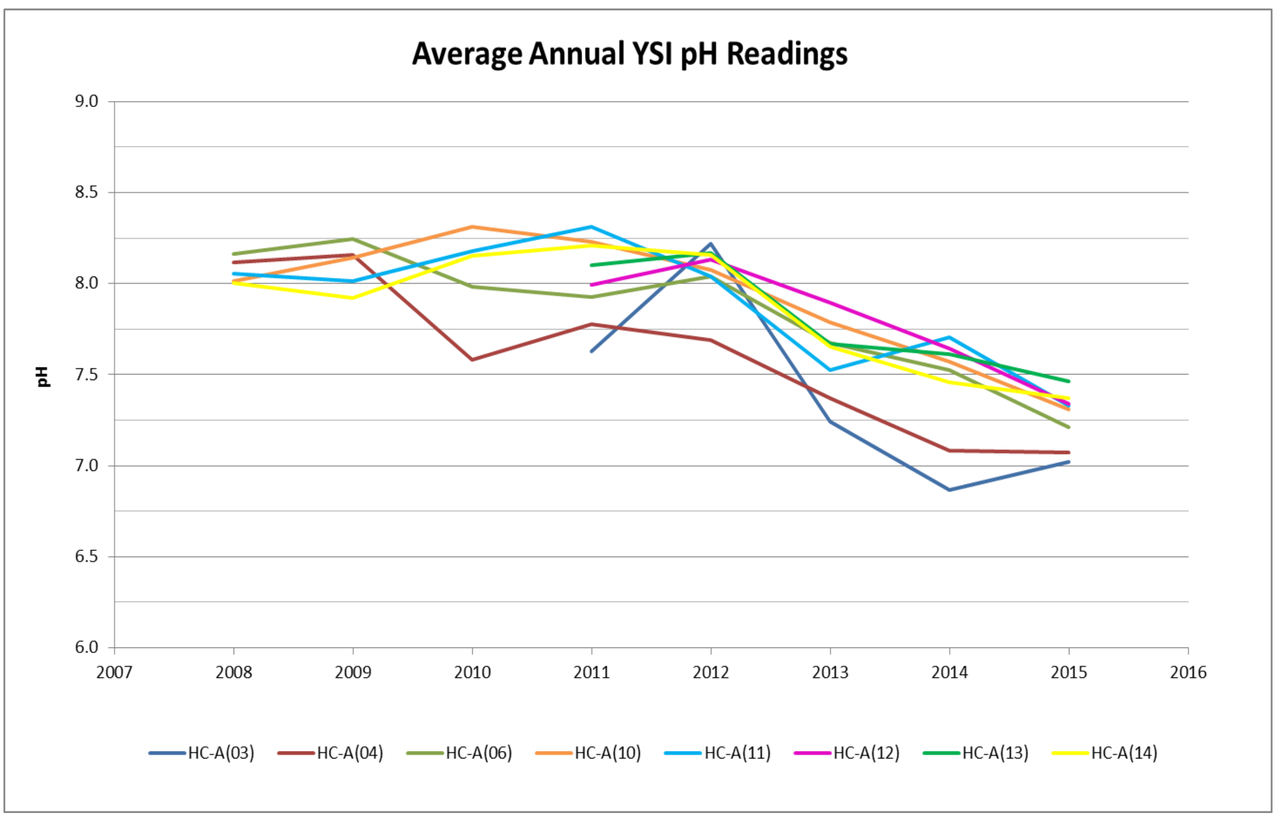


Figure 5-4: Average Annual YSI pH Readings from 2008 to 2015

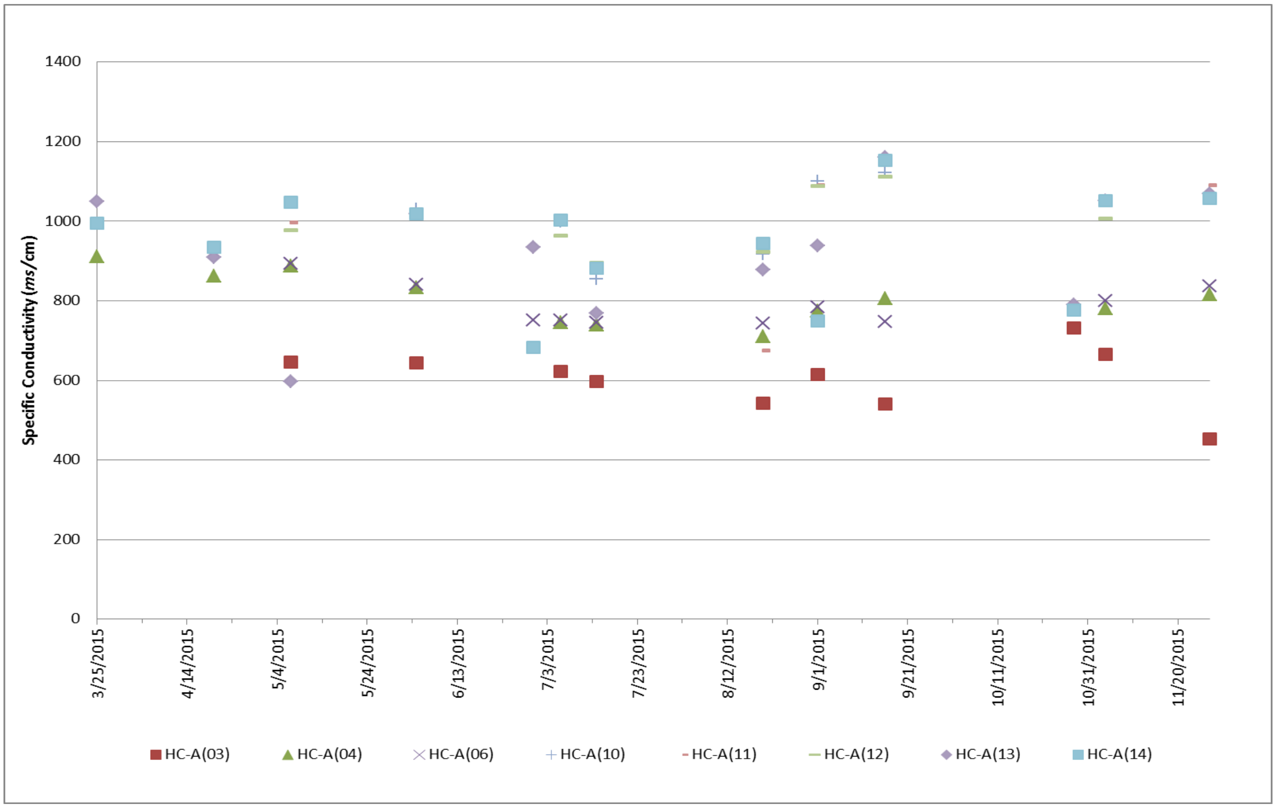


Figure 5-5: 2015 YSI Conductivity Reading

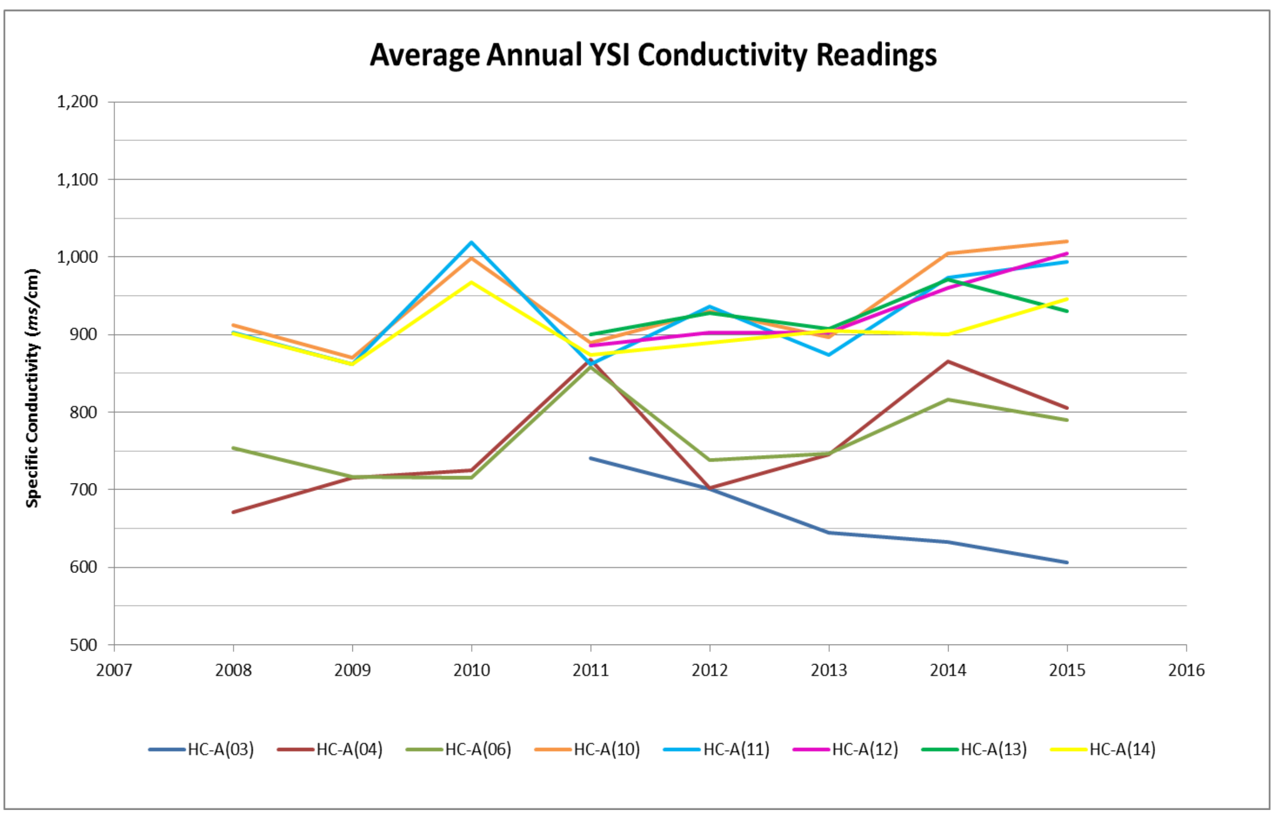


Figure 5-6: Average Annual YSI Conductivity Readings from 2008 to 2015

In 2015, four turbidity monitoring stations were installed along Hanlon Creek at stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14). A Turner Designs Cyclops turbidity sensor uses an optical scattered light method to determine turbidity. **Figure 5-7** presents the turbidity monitoring results observed for the 2015 year, however some issues were encountered with the turbidity data. It appears that loggers at HC-A(03) and HC-A(11) were buried under sediment for extended periods causing the sensor to record maximum turbidity levels. During site visits turbidity sensors were checked and cleaned however sediment buildup in between visits occurred. There is also potential that biofouling and vegetation growth in the stream interfered with the sensor readings. The data shows overall the turbidity levels at the most downstream station are lowest. Turbidity levels at station HC-A(06) appears to increase relative to rainfall events. Due to fouling occurring at stations HC-A(03) and HC-A(11) no conclusions can be made regarding turbidity conditions at these locations.

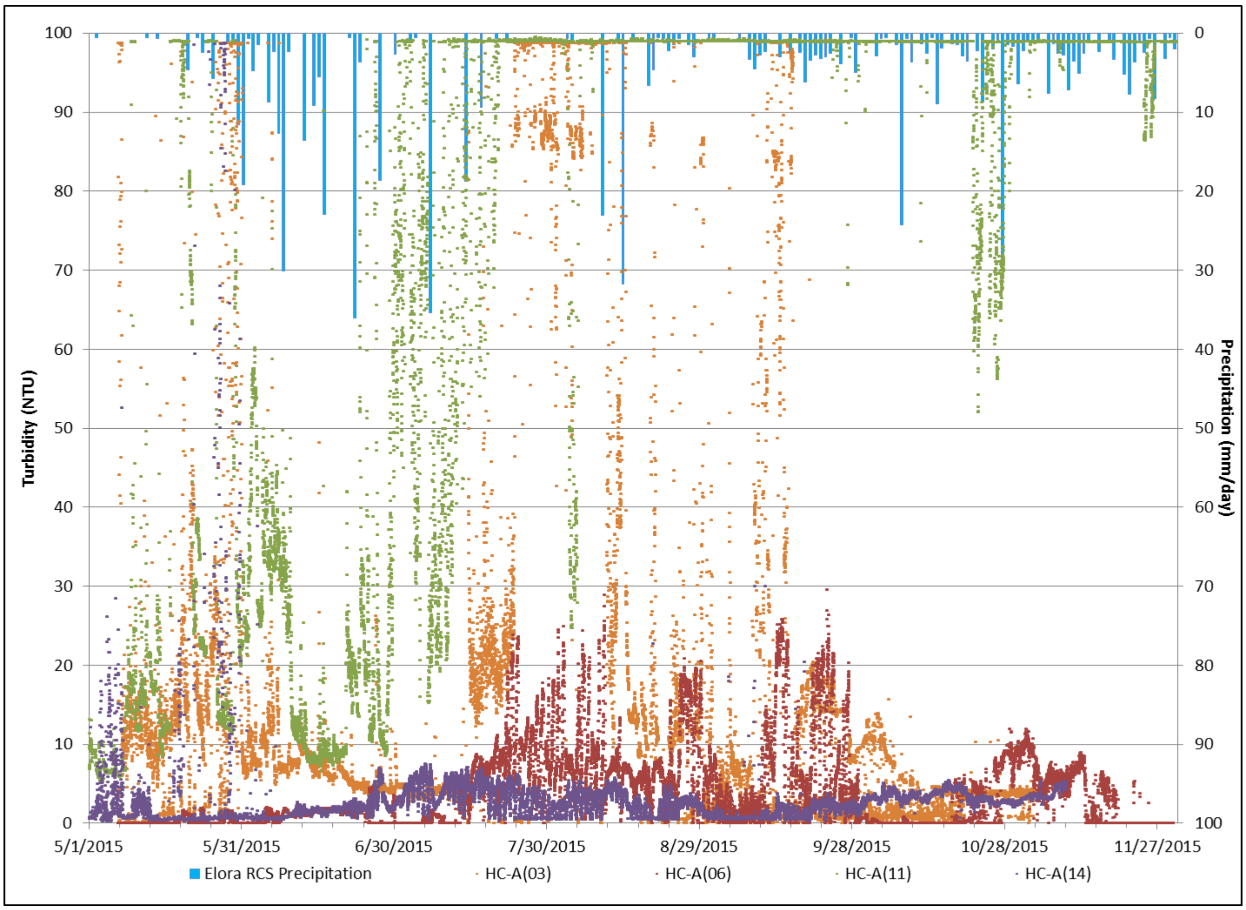


Figure 5-7: In stream Turbidity Measurements for 2015

6. Stormwater Management Facility Monitoring

As part of the Ministry of Environments CofA 1384-7QFPZQ and the Grand River Conservation Authorities (GRCA) requirements, monitoring was completed at each of the stormwater management (SWM) facilities (Pond 1, 2 and 4). The monitoring included three components, inflow and discharge flow rates, water temperature, and water quality sampling.

6.1 Flow

Water level loggers were located at each facility's inlet and outlet structures. This continuous depth data was used to estimate inflows and outflows of the facilities.

For Pond 1, flow was calculated for the two inlet structures (HC-P1(04) and HC-P1(05)) using Manning's equation for flow through a partially full concrete pipe. Due to a logger malfunction depth data for HC-P1(05) was unavailable for the 2015 monitoring season. Due to past incidents of vandalism a data logger was not installed at station HC-P1(06) until September 1st, 2015. Estimated flows for Pond 1's inlet structure and outlet structure are shown in . Pond water levels were not high enough during the second half of the monitoring season to trigger a pond discharge event.

For Pond 2, flows were calculated at the inlet structure HC-P2(06)) and the outlet structure (HC-P2(07)). At HC-P2(04), inflow rates to the pond at the 655 mm inlet pipe could not be estimated as the logger is significantly influenced by tail water conditions for throughout the monitoring season. Additionally, flow was not calculated for HC-P2(05) due to faulty logger data. Inflows were calculated at HC-P2(06) using Manning's equation for a grass lined trapezoidal swale. Due to an impediment to flow in the upstream channel, flow in this drainage swale only occurred during large storm events. Flows at Pond 2 are illustrated in **Figure 6-2**. Pond 2 was only found to be discharging for short durations in 2015.

For Pond 4, flow was calculated for both the inlet (HC-P4(04)) and the outlet (HC-P4(05)) structures. Inflows were calculated at HC-P4(04) using Manning's equation for a grass lined trapezoidal swale. The outflow from Pond 4 was calculated using the orifice equation based on the water level recorded by a level logger that was placed inside the outlet control structure (P4-(05)). Pond 4 continuously discharged water throughout the 2015 monitoring season. Flows for Pond 4 are illustrated in **Figure 6-3**.

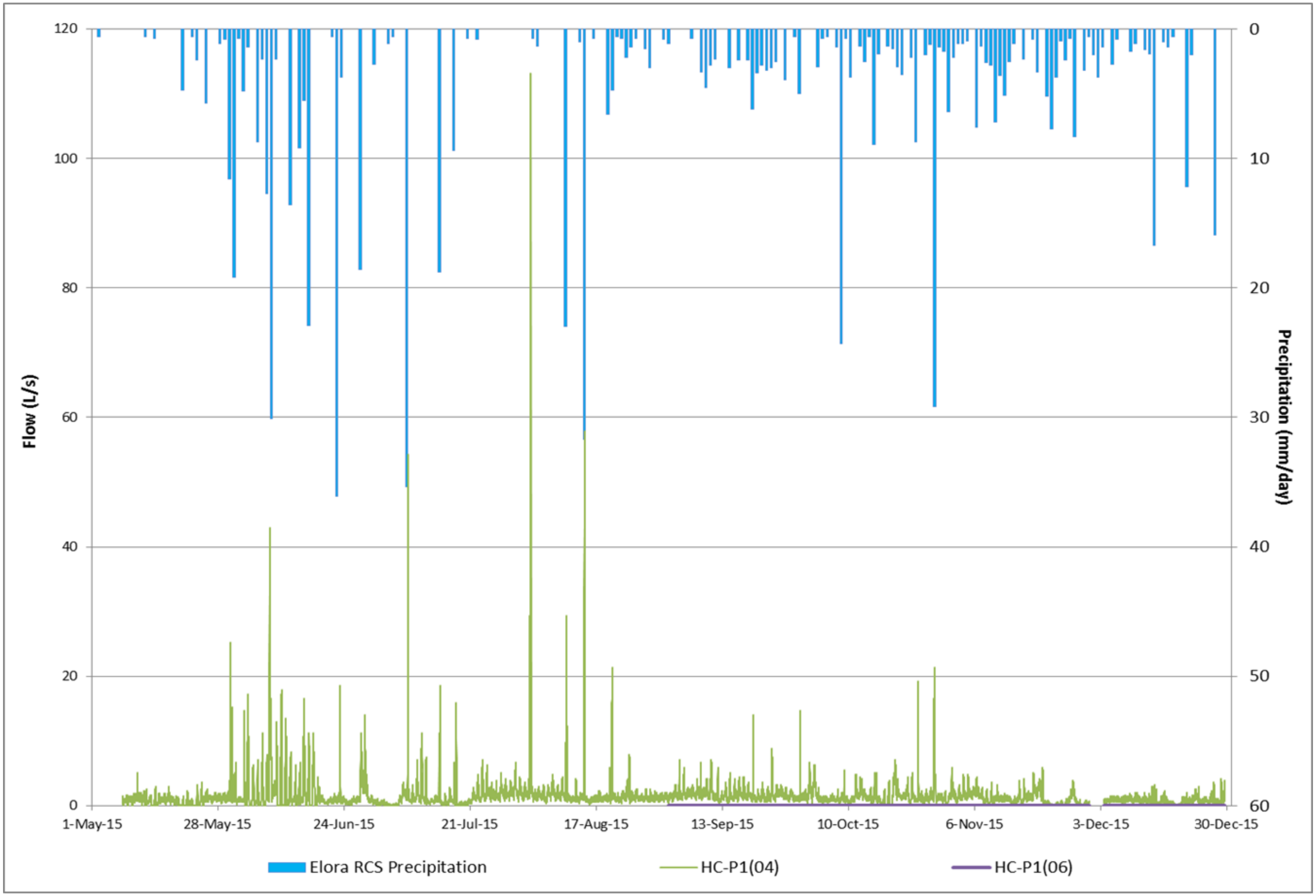


Figure 6-1: Estimated Flow for Pond 1

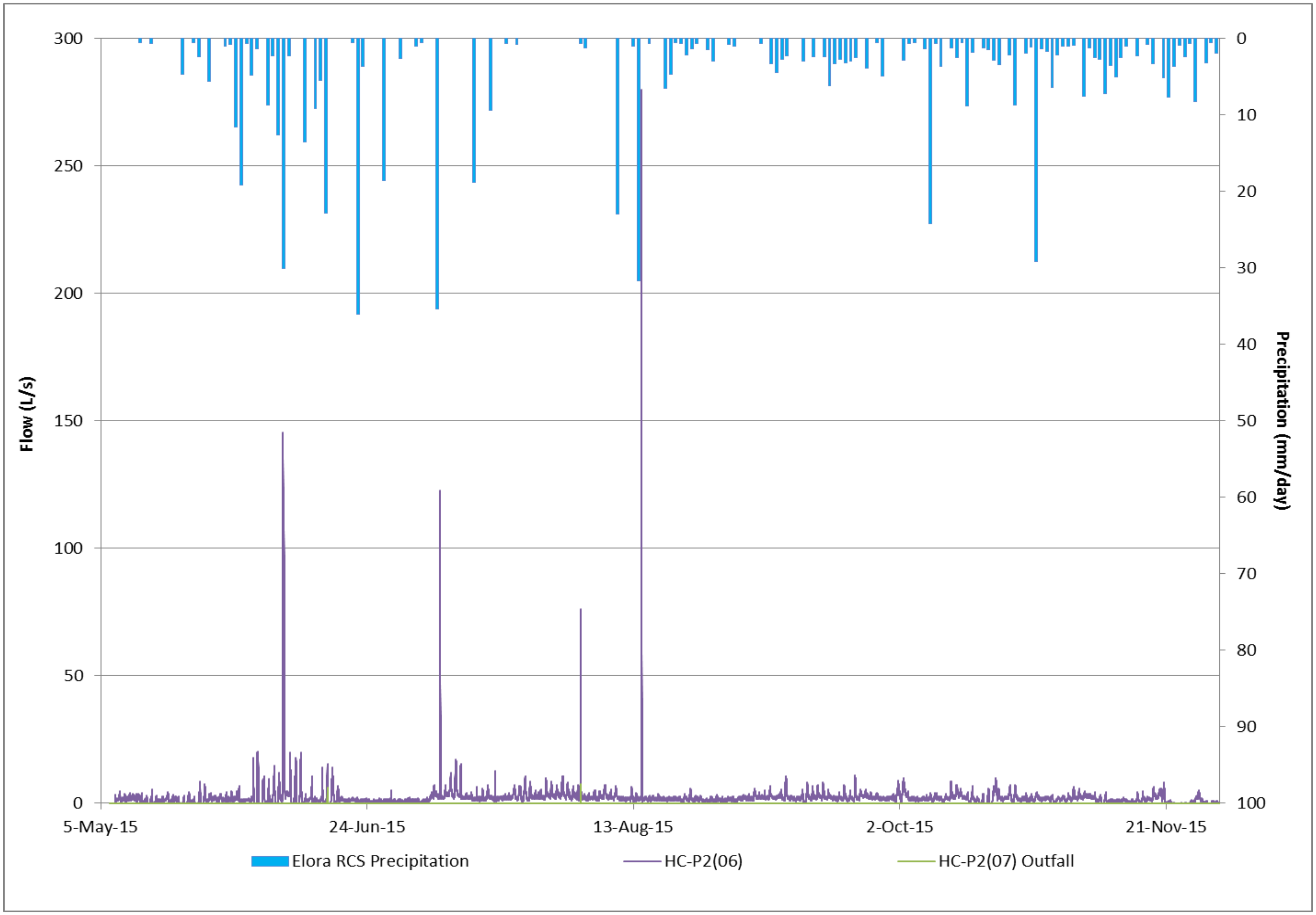


Figure 6-2: Estimated flow for Pond 2

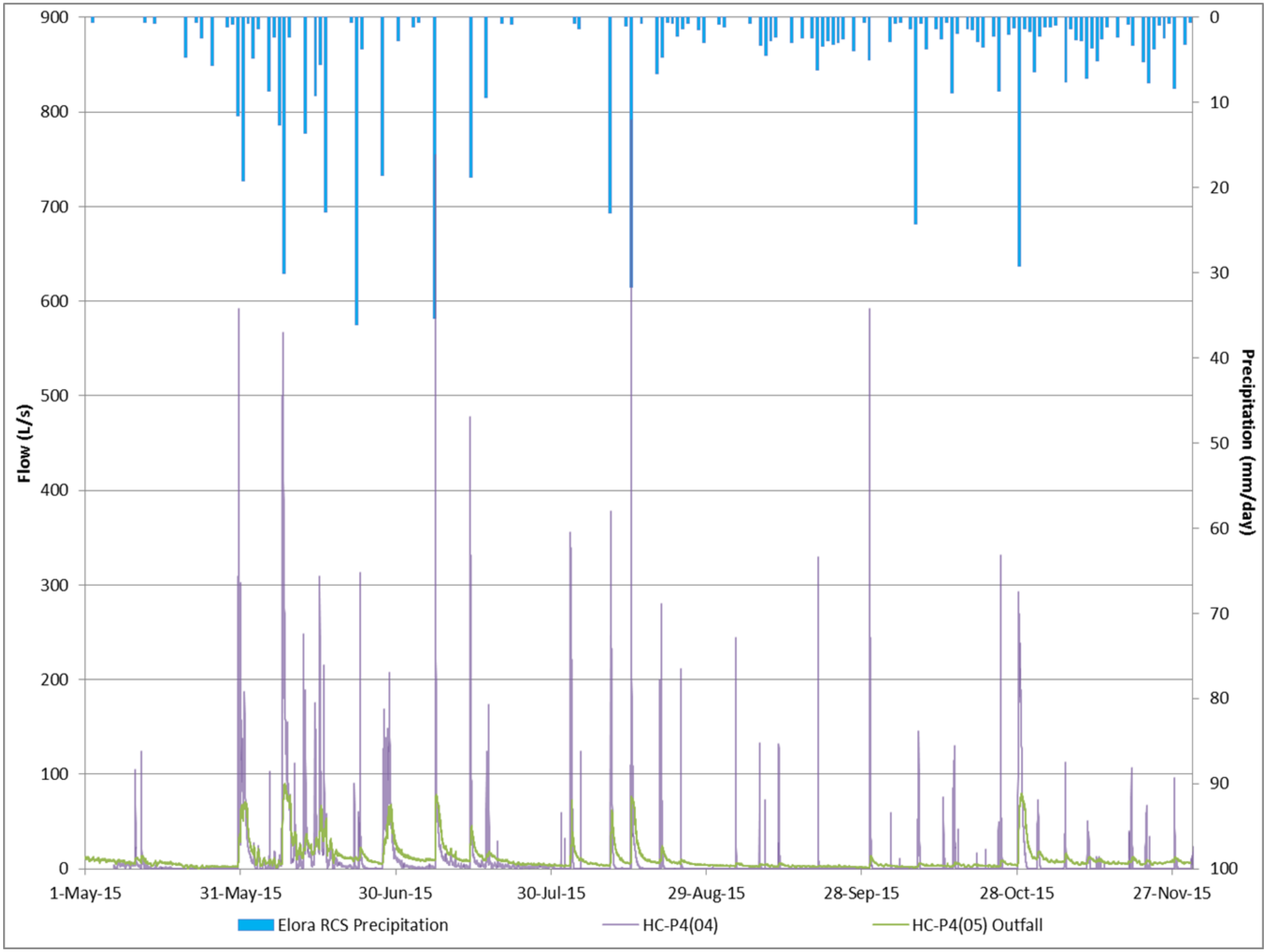


Figure 6-3: Estimated flow for Pond 4

6.2 Temperature

Water temperature was monitored at the following locations at each of the SWM facilities:

- inflow structures;
- cooling trench outlets;
- outflow structures; and
- pond stratification temperate monitoring clusters.

The purpose of monitoring temperature in the SWM facilities is to illustrate that the mitigation measures that were incorporated into Hanlon Creek Tributary A are effective and that the water being discharged to the creek will not contribute to the warming of the steam.

6.2.1 Pond 1

Pond 1 was designed with multiple mitigation features. Stormwater is conveyed to the SWM facility via two grass drainage swales that discharge into the settling forbays. Before water can pass though to the main body of the pond, the flow must pass though a planted wetland area. The water is discharged via a bottom draw structure and discharged into one of two cooling trenches prior to being discharged into the wetland areas. These measures allow for maximum infiltratration, and minimize the amount of water directly discharged from the SWMF to the creek.

Water temperatures were monitored in the inlet channels (HC-P1(04,05)), at the pond outflow catchbasin structure (HC-P1(06)) and at the cooling trench outflows (HC-P1(07,08)). The thermal profile in the pond was also measured (HC-P1(01), HC-P1(02), HC-P1(03) - in order of deepest to shallowest placement, with HC-P1(03) located closest to the surface. A sample of the summer temperature variations and the complete temperature monitoring records at Pond 1 for 2015 is shown in **Figure 6-4** and **6-5**. The temperature monitoring results during a precipitation event at Pond 1 is shown in **Figure 6-5** in order to more clearly illustrate the general pattern of the thermal regime throughout the pond. Temperature data for the closest upstream reach (HC-A(12)) and the next two downstream reaches (HC-A(13,14)) are also included in both figures.

The HC-P1(03) temperature record demonstrated the greatest degree of fluctuation in measured water temperatures. This is due to its location near the surface of the water where temperature would be expected to change more rapidly in response to air temperature fluctuations and solar radiation. The logger located closer to the bottom generally recorded lower temperatures than the surface during the summer. During the winter, the surface of the pond froze or was near-freezing and temperatures were recorded as 0^{o}C, while below the surface, the water did not freeze and average 4^{o}C

The loggers in the inlet channels (HC-P1(04,05)) were often exposed to solar heating and air temperatures due to low water levels in the channels. This resulted in temperature records with extreme daily fluctuations. Since these records do not accurately represent water temperature, they were excluded from **Figures 6-4** and **6-5**.

It should be noted that outflow from the Pond were not recorded during the period shown in **Figures 6-4.** Therefore conclusions regarding the function of Pond 1's cooling trench cannot be determined based on the 2015 data and therefore it is still unclear how effective the Pond 1 cooling trench is at reducing thermal impacts to the creek.

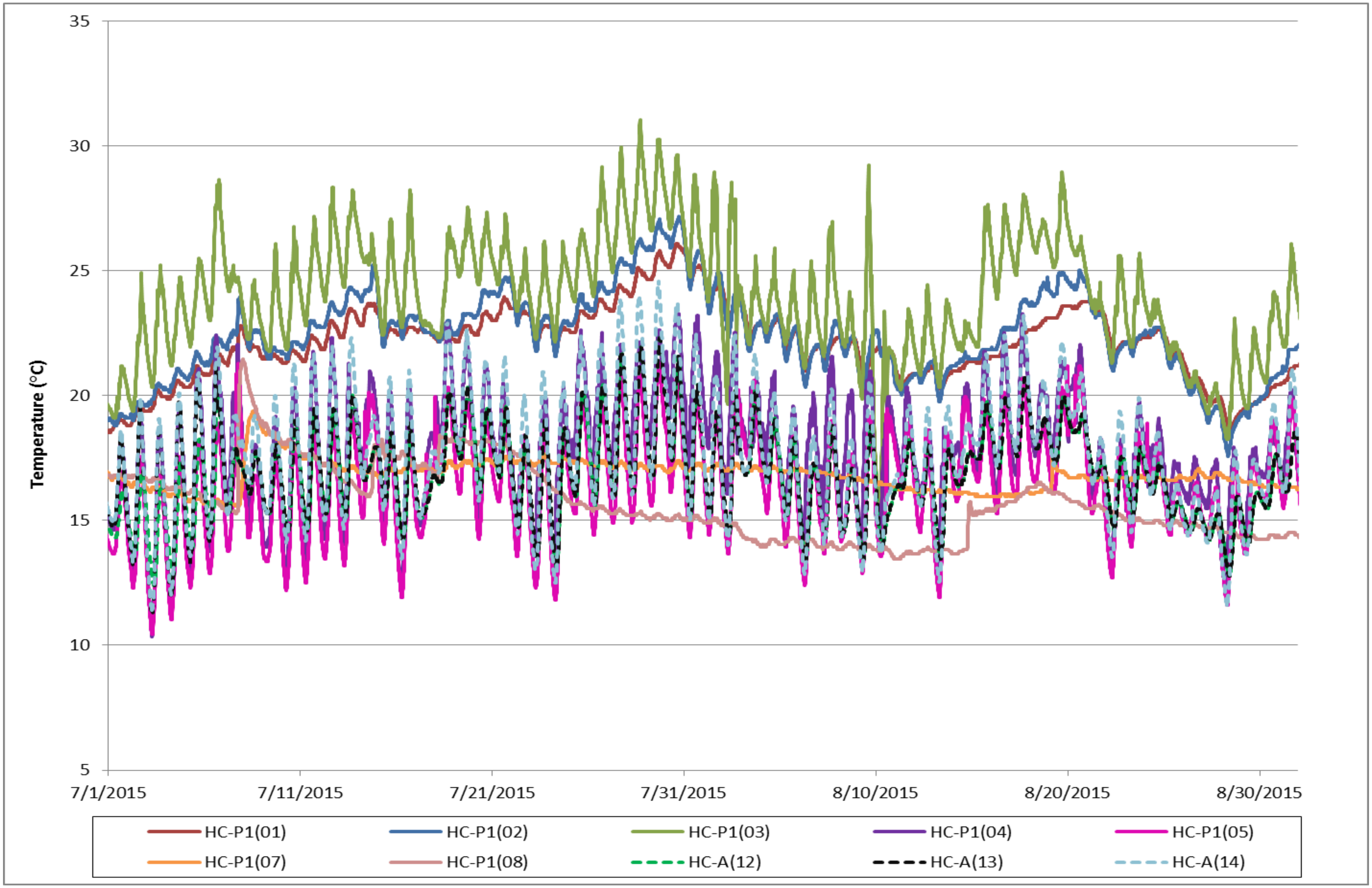


Figure 6-4: Measured summer temperatures through Pond 1

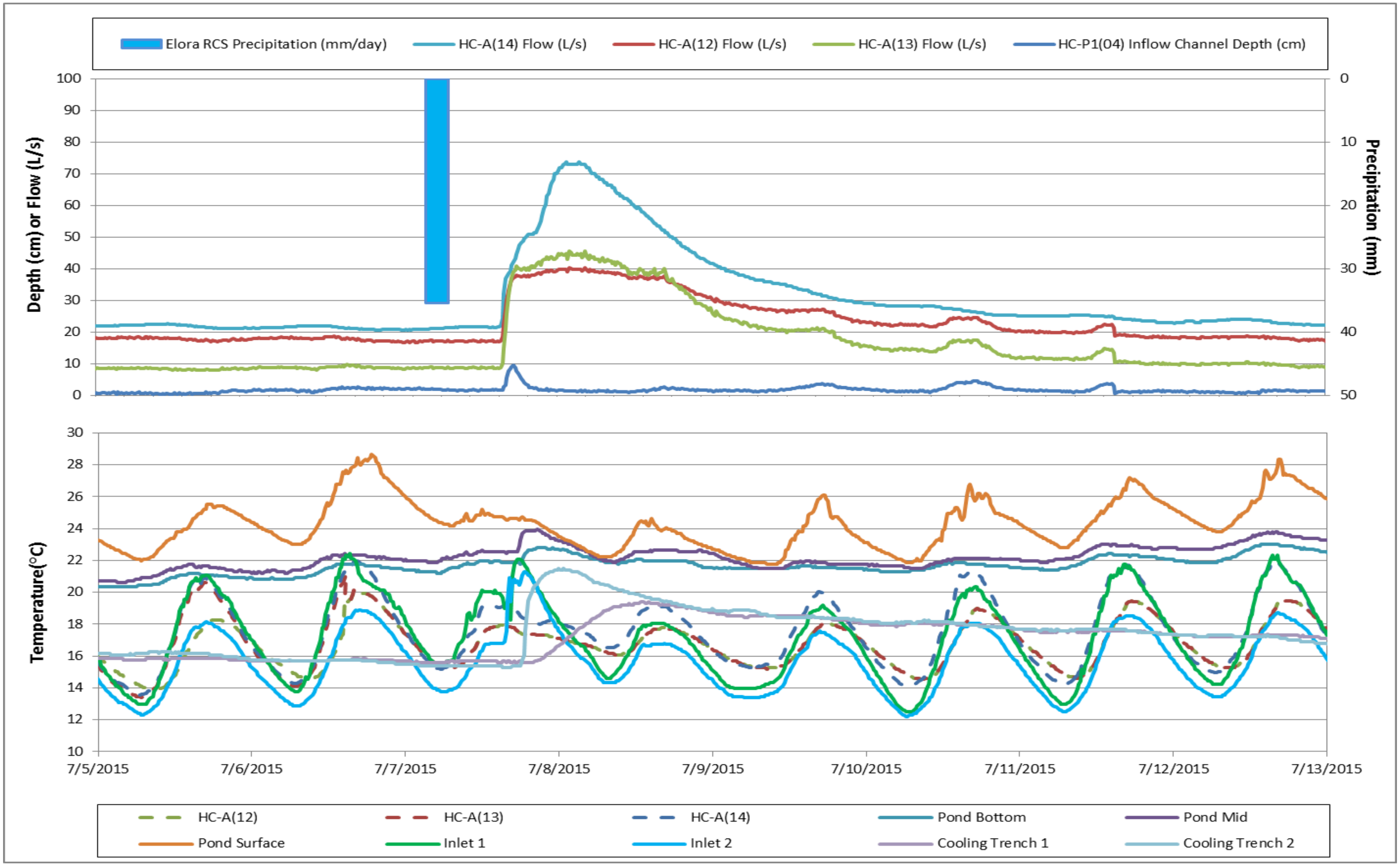


Figure 6-5: Pond 1: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(12)) upstream and downstream (HC-A(13, 14)) of pond 1. Data missing for Pond 2's outlet (HC-P1(06)).

6.2.2 Pond 2

The design of Pond 2 was a retrofit of an existing SWM facility. There are three inlets to the SWM facility, two storm sewer outlets (HC-P2(04,05)) and one grass drainage swale (HC-P2(06)). Each inlet discharges into its own sediment forbay. Before the water can pass through to the main body of the pond, the flow must pass through a planted wetland area, and then into the main body of the pond. The water is discharged via a bottom draw structure into an infiltration gallery that was constructed as part of the pond design for the original SWM facility. Similar to Pond 1, depth loggers were placed at each inlet as well as the at the Pond 2 outlet(HC-P2(07)). Temperature loggers were also installed in the ponds main cell to record the ponds temperature profile (HC-P2(01,02,03)). Summer temperature records and an example of a pond discharge event in 2015 are displayed in **Figures 6-6** and **6-7** respectively. These figures show overall the cooling trench has little impact on reducing water temperature before they outlet to the creek.

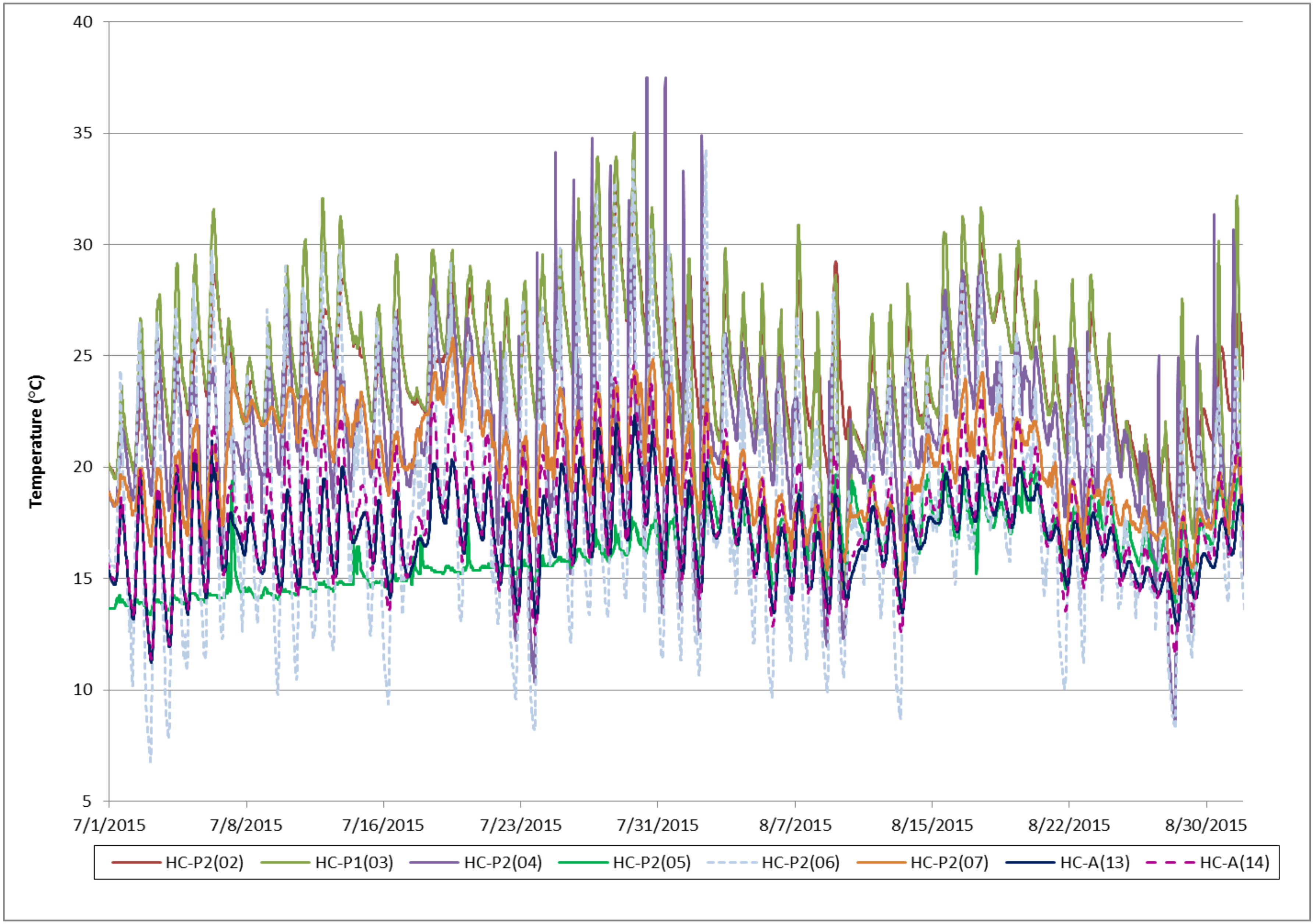


Figure 6-6: Measured temperatures through Pond 2. Data missing for HC-P2(02) (data gap)

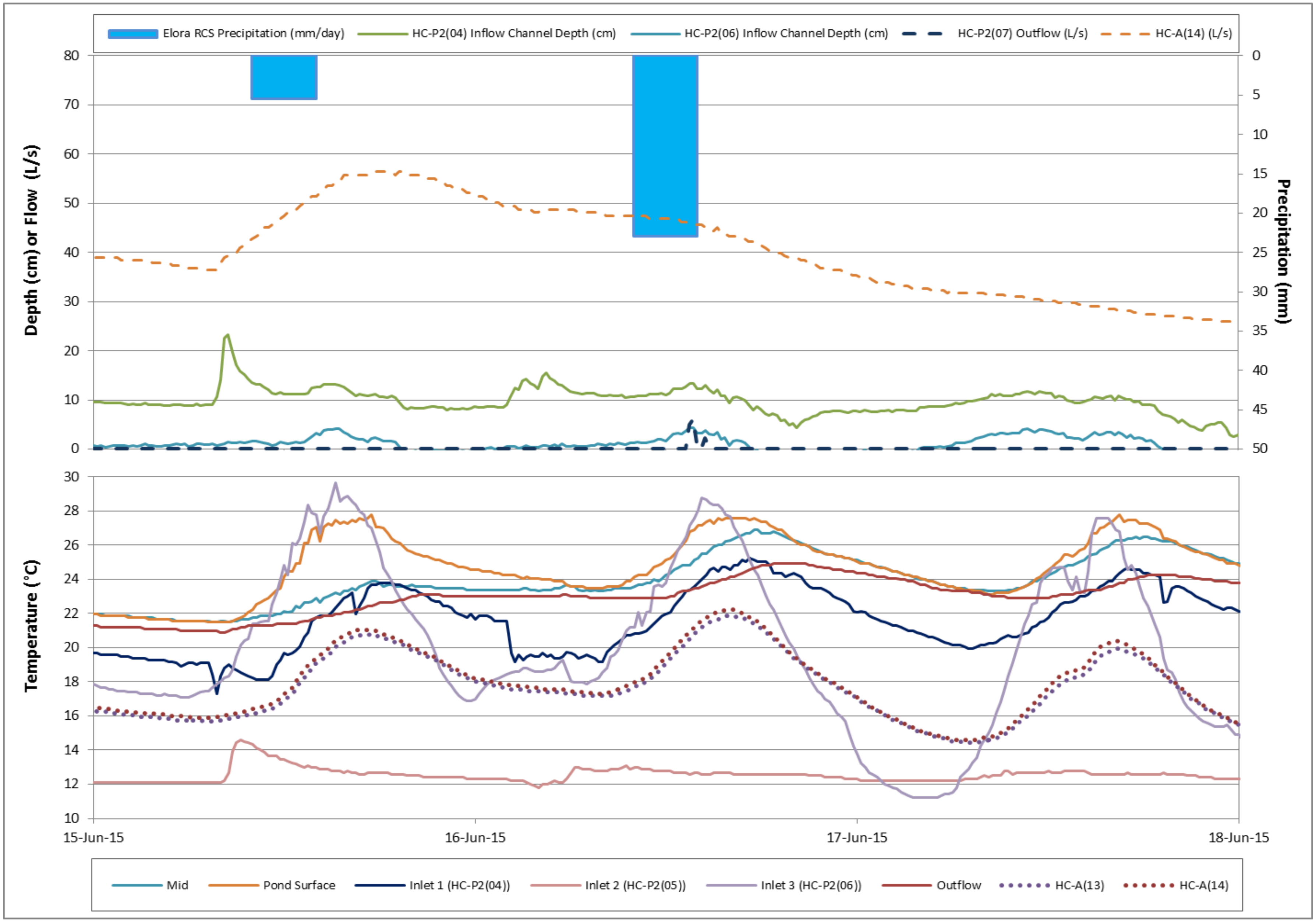


Figure 6-7 Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(13)) upstream and downstream (HC-A(14)) of pond 2. Data missing for Pond Bottom (HC-P2(01)) (data gap)

6.2.3 Pond 4

Pond 4 was designed with mutiple mitigation features. Stormwater is first conveyed to the SWM facility via a grass drainage swale and discharged into a settling forbay. Before the water can pass though to the main body of the pond, the flow must pass though a wetland area, however due to increased water levels via a 300 mm weir installed in 2012, all wetland vegetation has been submerged. The water is discharged via a bottom draw structure into a cooling trench prior to being discharged into Hanlon Creek Tributary A.

While the cooling design features at Pond 4 resulted in outflows that were often more than 5ºC less than the surface temperatures, the cooling trench outflows were still typically 3-6ºC warmer than the upstream station. In September 2012, vegetation was planted in the pond and the outlet weir was raised in efforts to reduce the impacts from Pond 4. Raising the weir height did not stop Pond 4 from continuously discharging. Additionally, plantings of vines and other fauna on the cooling trench were installed to shade the exposed rock. The plantings have not yet matured to cover the cooling trench. However, in 2015 minor improvements in the amount of vegetation taking root along the cooling trench was noted as shown in **Figure 6-11** and **Figure 6-12**. Although the current impact is minor, these additional design features are anticipated to provide additional cooling to the ponds discharge in future summer seasons.

Water temperatures were monitored in the inlet channel (HC-P4(04)), at the pond outflow structure (HC-P4(05)) and at the cooling trench outflow (HC-P4(06)). Again, similar to Ponds 1 and 2, temperature loggers were installed in the pond's main cell to record the pond's temperature profile. The complete temperature monitoring records at the Pond 4 stations for 2015 are shown in **Figure 6-8**. The temperature monitoring during a storm event in August is shown in to more clearly illustrate the general pattern of the thermal regime throughout the pond before and after a precipitation event. The temperature records from the creek stations upstream (HC-A(03)) and downstream (HC-A(04) and HC-A(06)) as well as precipitation and inflows are shown **in Figure 6-9**

The logger in the inlet channel (HC-P4(04)) is exposed and sometimes stagnant or dry and therefore subject to solar heating. These conditions resulted in a temperature record with extreme daily fluctuations. Since this record does not accurately represent water temperatures, it was excluded from **Figures 6-8, 6-9** and **6-10**.

Similar temperature characteristics to Pond 1 and Pond 2 were observed at Pond 4 over the course of the 2015 monitoring season. In addition, the temperature at the bottom-draw outlet (HC-P4(05)) was generally lower (during summer months) than the in-pond loggers (HC-P4(01-03)); it appears that the bottom draw outlet successfully allows for the discharge of the coldest (deepest) water first. The temperature recorded at the outlet of the cooling trench tended to have the least variation: it appears that the cooling trench did have a moderating, and generally cooling, effect on the flow discharged to Hanlon Creek Tributary A. Despite the cooling effects of the trench and bottom draw outlet, temperatures leaving the pond were still higher than in-stream water temperatures upstream from the outlet of Pond 4. The temperatures recorded at the creek station HC-A(04) downstream of Pond 4 were higher than those recorded upstream of the pond outlet (HC-A(03)). The moderating temperature effect of the cooling trench highlights the pond's thermal impacts on HC-A(04), which has a much smaller magnitude of diurnal temperature fluctuations than those observed in the creek sites upstream (HC-A(03)) and downstream (HC-A(06)). At station HC-A(06), daily peak temperatures remain as high as those of HC-A(04), but atmospheric cooling at night exerts a greater impact on the daily minima observed at HC-A(06).

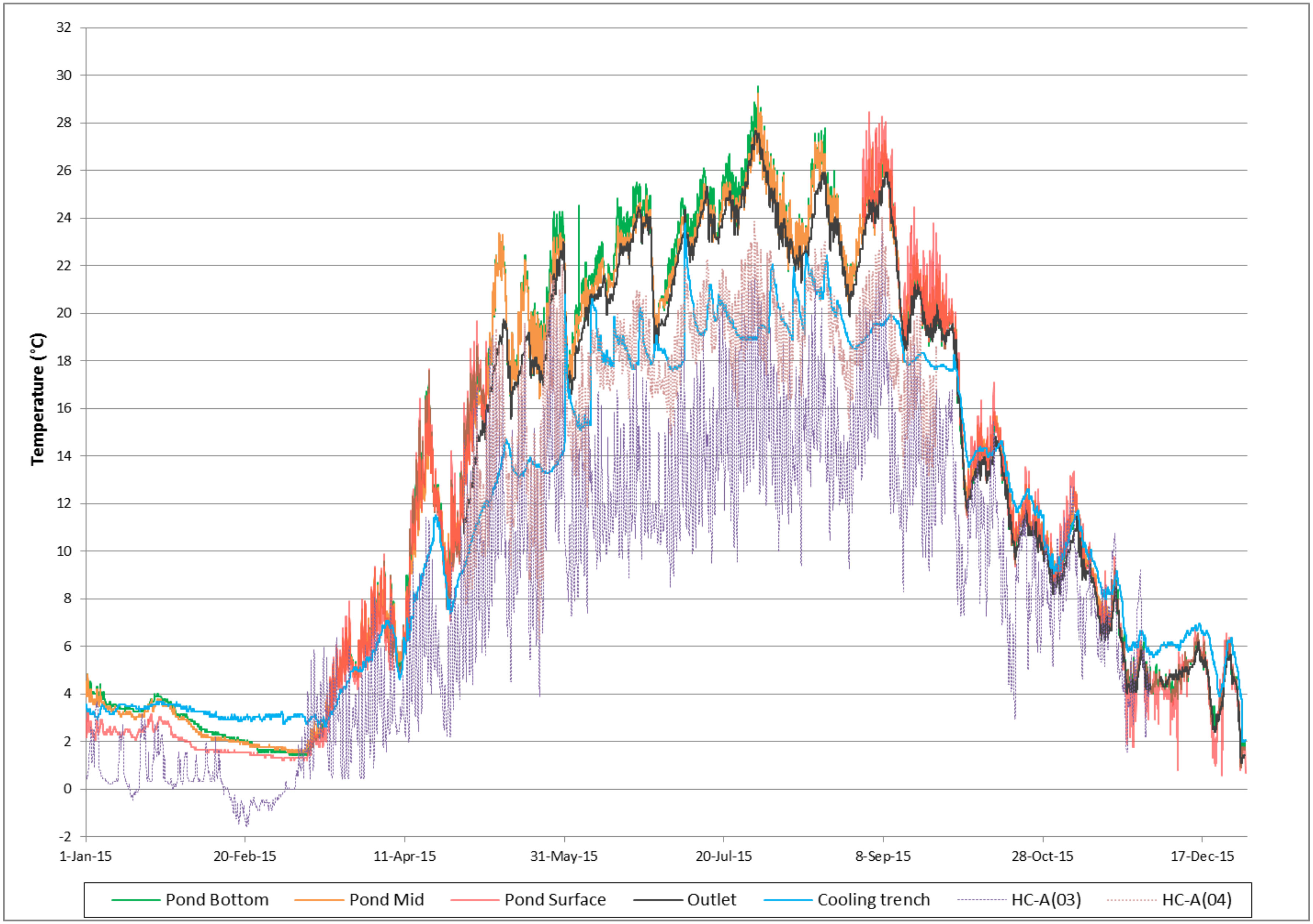


Figure 6-8: Measured temperatures through Pond 4

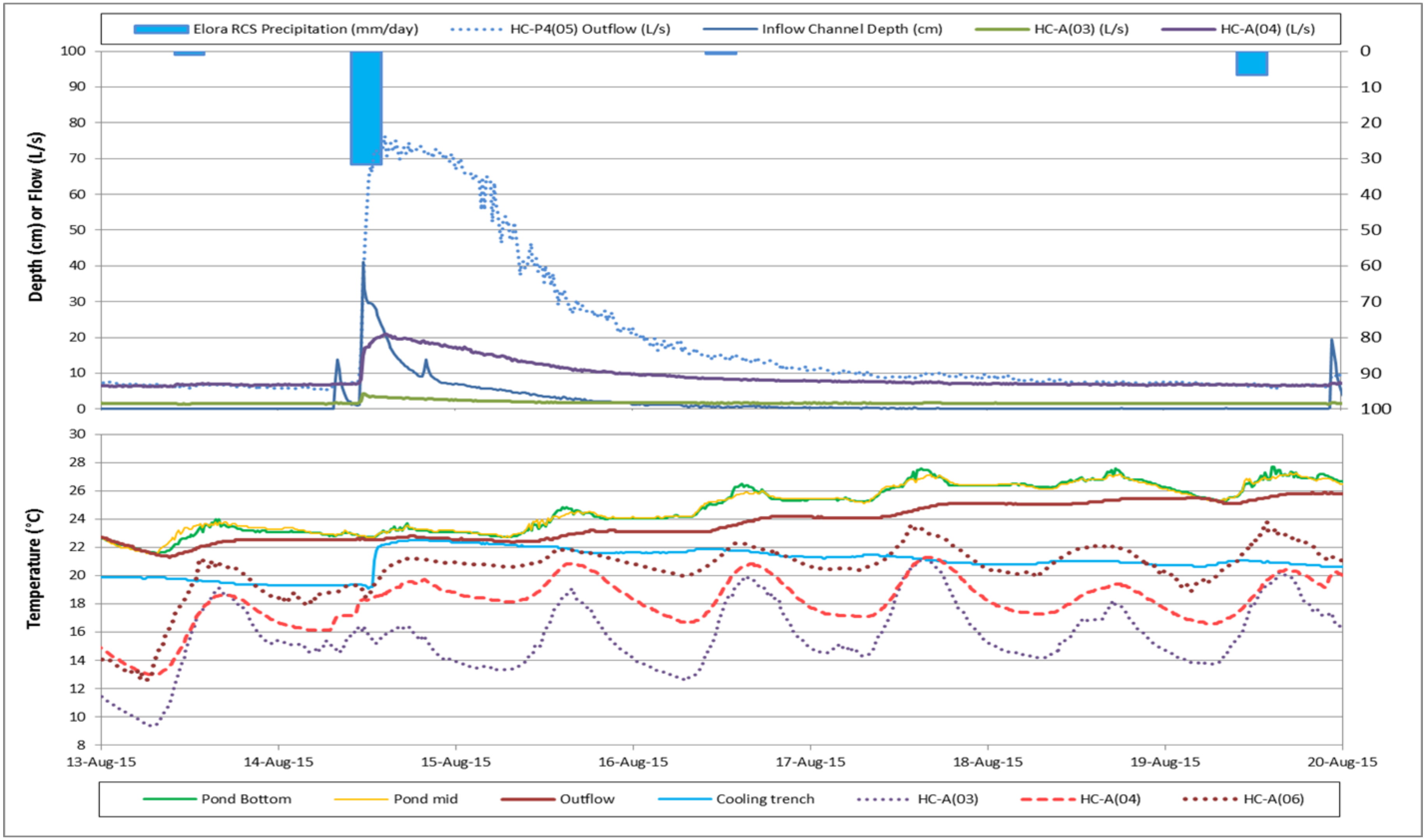


Figure 6-9: Figure 6-10: Pond 4: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(03)) upstream and downstream (HC-A(04, 06)) of pond 4 during a wet period. Data missing for the Pond Surface (HC-P4(03)) (data gap).

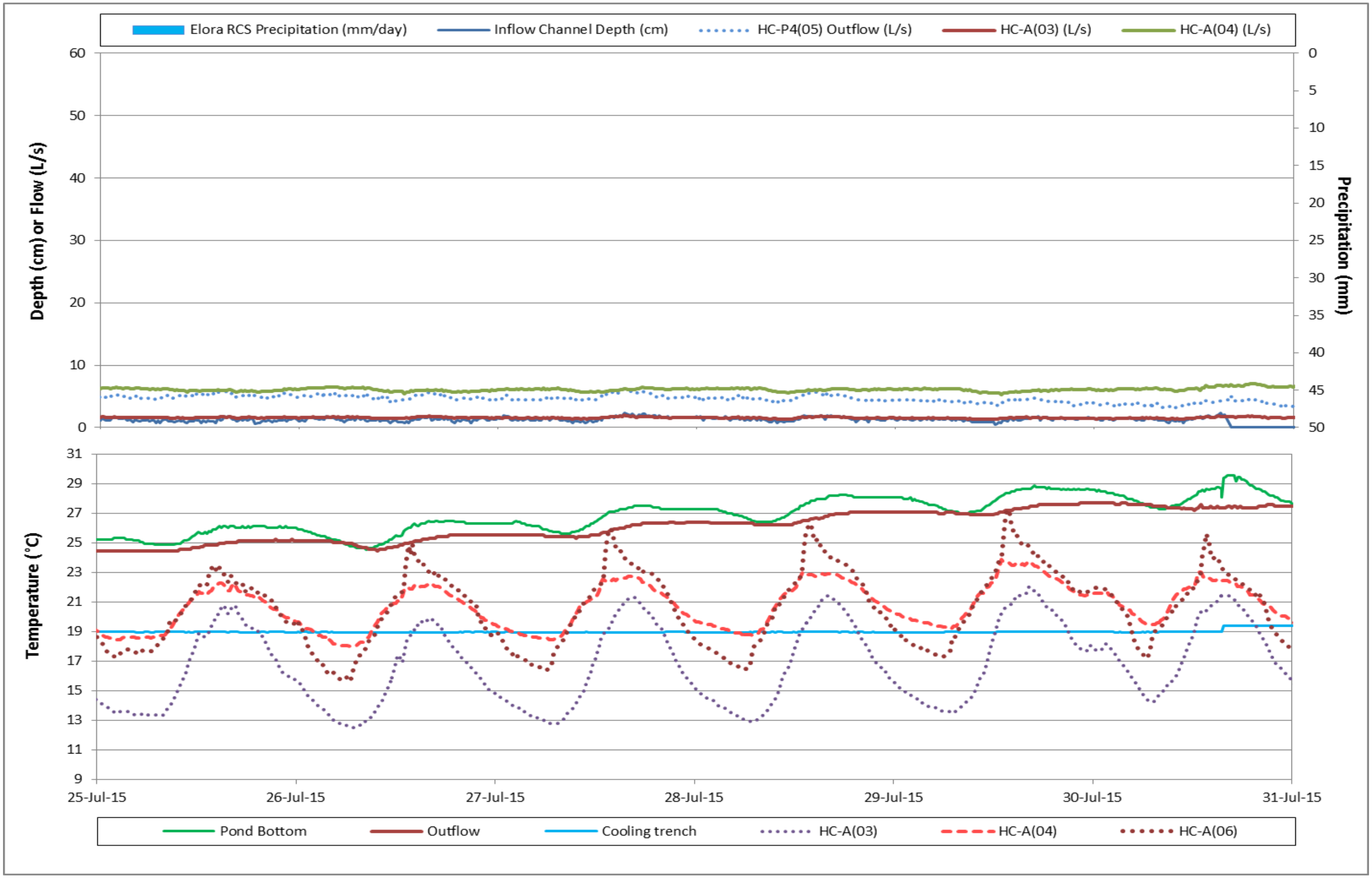


Figure 6-11: Pond 4: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(03)) upstream and downstream (HC-A(04, 06)) of pond 4 during a dry period.

Figure 6-12: Vegetation along Pond 4's cooling trench looking towards tributary A. (2015/10/09)

Figure 6-13: Vegetation along Pond 4's cooling trench looking towards Pond 4. (2015/10/09)

6.3 Effluent Water Quality

To establish the performance efficiency of the SWM facilities and to satisfy the MOE Certificate of Approval, the water quality sampling program consists of grab samples at the inlet, outlet and downstream of each pond. Parameters that were analyzed in 2014 included:

- CBOD (5)
- Total Suspended Solids
- Total Phosphorus
- Dissolved Phosphorus
- Metals (total and dissolved, lead, zinc and copper)
- Escherichia coli
- Nitrate as N
- Chloride

The Consolidated Monitoring Program included the following water quality sampling requirements:

- One sample per season (Winter and Fall) within one hour commencement of a storm event;
- Five wet weather samples collected during summer months (June-September);
- One sample collected during the snowmelt freshets (Spring); and
- Three dry samples taken 72 hours after a wet weather event

Eight wet weather samples were collected over the course of the 2015 monitoring season. Both the winter and spring freshet samples were collected. Five wet weather samples were collected between May and October 2015. The reaming wet weather sample was taken during the month of November. One dry sample was taken during the spring, summer and fall (three total). From May to October, water levels at Pond 1 and 2 were too low prior to a rainfall event to result in stormwater being discharged from the outlet into Hanlon Creek Tributary A. Therefore, samples taken at Pond 1 and 2 were not taken during discharge events. As a result, the only interactions between these SWM facilities and Hanlon Creek Tributary A would have occurred though ground water interactions. Samples collected during non-discharge periods in the summer months were taken directly from the SWM facilities. As such, the water samples did not necessary represent the water flowing into Hanlon Creek Tributary A. Pond 4 was discharging during the summer months and stormwater samples were collected from the pond outlet. The tabular results of the water quality sampling have been included in **Appendix E**.

Water quality sampling results are presented as a number of exceedances as compared to the Provincial Water Quality Objectives (PWQO) in **Table K.** A number of water quality parameters were typically higher in the SWM facilities with lower concentration in Hanlon Creek. E.Coli concentrations exceeded the recommended PWQO guidelines for recreational use for both wet weather and dry weather sampling events. Total phosphorus showed an overall reduction in phosphorus levels as the water moved though the pond. The instream phosphorus levels exceed the PWQO during both wet and dry weather sampling events. However; this is not uncommon for streams in the Grand River watershed (GRCA, 2012). Nitrate, total suspended solids, copper and lead all showed higher concentrations entering the SWM facilities with concentrations decreasing in the outlet samples. Aluminum, cadmium, copper, iron, lead, vanadium and zinc exceeded PWQO in the SWM facilities. However, instream levels did not exceed PWQO guidelines for aluminum or vanadium. Copper, iron, lead and zinc exceeded PWQO guidelines for both wet weather and dry weather sampling events. Zinc concentration in both the SWM facilities and instream exceeded PWQO.

In 2011, the Canadian Council of Ministers of the Environment (CCME) set standards for Chloride exposure indicating increased risk of harm to aquatic life after long term exposure to concentrations above 120 mg/L and short term exposure to concentrations above 640 mg/L(CCME 2011). Chloride concentrations were typically higher at pond outlets and in-stream locations, compared to samples taken at pond inlets. However, inlet chloride levels sharply increased during winter sampling. Short term exposure targets were exceeded at pond inlets HC-P1(04,05), HC-P2 (04,05) and HC-P4(05) during winter sampling events.

Table K: Number of Guideline Exceedances per Water Quality Sampling Location

			PWQO		CCME		Guelph Storm Sewer By-Law			Number of Exceedances for Wet Weather Sampling Events												Number of Exceedances for Dry Weather Sampling Events			Total
Analyte	Units	LOR[1]	Lower Limit	Upper Limit	Short Term	Long Term	Lower Limit	Upper Limit	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4 (04)	HC-P4 (05)	HC-A (04)	HC-A (13)	HC-A (14)	HC-A(04)	HC-A(13)	HC-A(14)	
Dissolved Oxygen(DO)	mg/L	0.05	5	-	-	-	-	-	2	2	1	2	0	2	1	1	0	0	0	0	1	0	0	12
pH	pH units	0.1	6.5	8.5	-	-	6	9	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	4
Chloride	mg/L	2	-	-	120	640	-	-	4	3	8	1	5	5	1	3	8	8	8	8	3	3	3	71
Total Phosphorus	mg/L	0.003	-	0.02	-	-	-	-	6	7	8	8	6	7	8	7	1	4	6	7	2	2	0	79
E. Coli	CFU/100mL	10	-	100	-	-	-	-	3	4	2	8	4	3	4	6	1	4	5	5	1	1	1	52
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	-	-	7	8	8	8	8	8	8	8	4	8	8	7	3	3	3	99
Arsenic (As) - Total	Mg/L	0.001	-	0.005	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	-	-	0.001	0	1	0	1	2	0	0	1	0	1	0	0	1	0	0	7
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	-	-	0	2	0	1	0	0	0	2	0	0	0	0	0	0	0	5
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	-	-	0.01	8	7	3	8	8	6	7	8	2	4	4	5	2	2	2	76
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	-	-	1	6	1	7	3	2	3	7	0	1	0	1	1	1	0	34
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	-	-	0.05	0	5	1	6	2	1	4	7	0	1	0	0	1	1	0	29
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	-	-	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	3
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	-	-	0.05	0	5	0	4	3	0	0	4	0	8	0	0	3	0	0	27
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	-	-	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	-	-	0	0	0	5	3	4	7	4	0	0	0	0	0	0	0	23
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	-	-	7	7	2	8	8	2	5	7	0	0	0	0	0	0	0	46
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	-	-	0	0	0	0	0	0	0	1	0	6	0	0	3	0	0	10

Notes: [1] Limit of reporting (LOR)

- 8 Wet weather grab samples and 2 dry weather grab samples were collected
- Exceedances based upon the PWQO limits, Chloride exceedances were based upon the CCME short term level.

7. Conclusions and Recommendations

7.1 In-stream Thermal Conditions

The 2015 in-stream thermal monitoring program showed similar results as previous year. Overall, air temperatures during the summer of 2015 were generally cooler and precipitation was lower in the summer months compared to previous years and Canadian climate normals. These monitored temperature results show that the system overall experienced cooler temperatures than in previous years, largely due to the cooler summer months. However, overall monitoring results show summer temperatures may still not have been suitable for brook trout habitat based on the ranges provided in the Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F (AECOM, 2009). Thermal monitoring results consistently produce higher thermal conditions than those predicted by the HSP-F model for average summer temperatures and exceedances above 19°C in the summer as well as for all autumn predicted values for all in-stream monitoring stations.

General trends observed in the in-stream thermal monitoring data indicates that continuous discharge from Pond 4 impacts thermal conditions in the stream from downstream of the pond outlet to station HC-A(09). Downstream of this station the cool groundwater fed tributary and elimination of online ponding downstream of Hanlon Creek Boulevard provide for slight improvements to the thermal regime in this section of the creek. Further downstream the open nature of the creek, and it’s exposure to ambient air temperatures and solar radiation have resulted in little change to in-stream thermal conditions to this section of creek since monitoring has begun.

Recommended improvements to Pond 4 to reduce overall thermal impacts to the Creek have been made and were provided to the City in a memo dated August 27, 2015. Following discussion with stakeholders, AECOM recommended that the water level in Pond 4 be lowered to its original design elevation and that plantings as originally intended are provided throughout the pond to provide shading. As well, it was recommended that two additional thermal monitoring stations are installed between HC-A(04) and HC-A(06). These additional stations would be implemented to further evaluate causes of temperature exceedances of 24°C at station HC-A(06). Additionally, if in the future the implementation of a cut-off drain at Pond 4 is considered, it is recommended a review is completed by all three disciplines (aquatic ecology, groundwater and surface water) to evaluate the net benefit to the system prior to moving forward with this option.

7.2 In-stream Flows

In-stream flow conditions were generally consistent with those observed in previous years when climatic conditions are considered. Low precipitation during the summer months made for overall dryer conditions throughout the system, however lower average air temperatures generally resulted in average baseflow conditions.

In 2016, rating curve data for HC(A)-11 and HC(A)-12 should continue to be improved upon to provide accurate flow estimates for these two stations.

7.3 In-stream Water Quality

Overall in-stream water quality conditions appeared to be consistent with conditions noted in previous years. Of the three parameters collected during baseflow measurements (DO, pH and specific conductivity), pH is the only parameter has produced a visible change in trend. Overall pH levels within the system appear to have been decreasing since 2012. Further years of data collection are required to confirm this observation.

7.4 Pond Thermal Conditions

Discharge data for Pond 1 shows that no water exited Pond 1 during the second half of 2015. Site inspections confirmed low water levels in both Pond 1 and 2 in the late summer. Previous annual monitoring reports have assumed that infrequent flows at Pond 1 may have contributed to high temperatures observed at HC-A(13) and HC-A(14), however this was not indicated in the 2015 monitoring results. Further temperature monitoring of the Pond 1 cooling trench should be completed to further evaluate the effectiveness of this system as it is unknown at this time.

Similarly, it is not expected that the Pond 2 SWM facility was the cause of the single temperature exceedance of 24°C observed during 2015, as minimal flow exited the facility during the summer months. Monitoring data has confirmed that Pond 2 cooling trench is not very effective at reducing temperatures.

Pond 4 was continuously discharging into Hanlon Creek Tributary A during the summer of 2015 and is likely a contributing factor to the observed increased temperatures at stations downstream of the pond outflow including HC-A(04), HC-A(06) and HC-A(09). However, it does not appear that the continuous discharge from Pond 4 led to the 24ºC exceedance events that took place in 2015 at station HC-A(06). The bottom-draw and cooling trench design of Pond 4 appears to be functionally well and overall reducing outflow temperatures resulting in discharge cooler than water in the pond, but still higher than the creek monitoring station upstream of the creek. Vegetation that was planted on the banks of the pond and along its cooling trench in 2012 had not matured and therefore did not provide additional cooling benefits to Pond 4. It is expected that with the vegetation growth, water temperatures will decrease. Other considerations for Pond 4 are provided above in Section 7.1.

The SWMF temperature monitoring program includes data recording throughout each SWMF. The previous years of data collection have confirmed the thermal stratification within the SWMF. It is recommended that each component of this program is reviewed and only necessary data collection continues. This would likely include temperatures at inlets, outlets and cooling trench outlets. Results of pond temperature program should continue to be annually reported to ensure the recommended adaptive management approach is meeting the intended targets.

7.5 Pond Flow Conditions

The 2015 pond flow data identified little outflow from Ponds 1 and 2 and consistent outflow from Pond 4. Overall due to the nature of flow into the SWMF it has been difficult to estimate pond inflows. Additionally this data does not provide essential data to the overall monitoring program. Pond inflow monitoring is not recommended to be carried through in future monitoring initiatives. However, outflow conditions of Ponds should continue to be monitored to continue to provide an understanding of the impacts of the SWMFs on the creek system.

7.6 Pond Effluent Water Quality

Overall SWMF effluent water quality samples indicate conditions typically for SWMF located with the Grand River watershed for both dry and wet weather conditions.

7.7 Recommendations

The following recommendations were formulated based on observations made during the 2015 monitoring program.

7.7.1 In-stream Monitoring Program

- Stations HC-A(10), HC-A(11), HC-A(13) and HC-A(14) all experienced significant watercress growth in 2015. It is recommended that flow cross sections be slightly altered to avoid interference between flow measurements and instream watercress populations. Cross sections should be adjusted using photo of each station to try and estimate areas of watercress growth.
- Water depth/temperature loggers (U20) should be installed at each telemetry station (HC-A(03), HC-A(06), HC-A(11) and HC-A(14). While each telemetry station is thoroughly checked each year before installation equipment malfunctions have occurred in the past causing large data gaps. The U20 loggers will serve as a back-up to prevent unnecessary data loss.
- It is recommended that up to two temperature loggers are installed between stations HC-A(04) and HC-A(06).
- High flow measurements are required for stations HC-(A)11 and HC-(A)12 to obtain greater confidence in the existing rating curves.

7.7.2 Stormwater Management Facility Monitoring Program

- It is recommended that the inlet depth loggers at each SWMF are abandoned and a single depth logger is installed within each SWMF to provide a continuous record of referenced water levels within each SWMF throughout the monitoring period.
- The overall SWMF temperature monitoring program has collected a robust data set over the past few monitoring seasons. This program should be reviewed to ensure the current data collection is relevant and provides value to the overall program.
- Thermal monitoring of conditions within the Pond 1 cooling is required to verify the effectiveness of the Pond 1 cooling trench.
- Prior to any rehabilitation works to Pond 4, a multidiscipline review is required to establish the overall net benefit of any proposed works.

8. References

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Appendix A

Monitoring Reports

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, High flow measurements		
Date	March 25, 2015	Project Number	60265453

Weather: Overcast/partial cloudiness, low of 1.4°C. Precipitation event triggering high flows in the morning and afternoon of March 25 (total historical precipitation values missing from the WeatherNetwork.com for this day).

Tasks:
- Water Samples
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Mir Talpur

Notes: Surface ice (over 6” in some locations) was present at a number of sites. Snow depth was between 1’ in most locations. Access was difficult and varied as a result.

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(04)	03/25/2015 15:42	3.78	911	8.15	6.76	0.8
HC-A(13)	03/25/2015 17:08	1.83	1050	11.16	6.74	1.9
HC-A(14)	03/25/2015 17:18	1.87	995	11.44	6.78	0.0

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	03/25/2015 16:05	-0.04	1594	11.21	6.74	1.8
HC-P1(05)	03/25/2015 16:41	1.67	1572	10.05	6.71	3.4
HC-P1(06)	03/25/2015 16:23	0.15	993	18.48	6.81	-1.5
HC-P2(04)	03/25/2015 17:46	0.75	1497	11.09	6.83	-2.7
HC-P2(05)	03/25/2015 17:58	3.59	2510	7.50	6.79	-0.5
HC-P2(06)	03/25/2015 18:05	4.23	883	10.43	6.98	-9.5
HC-P2(07)	03/25/2015 17:28	5.85	884	9.37	6.97	-9.2
HC-P4(04)	03/25/2015 15:13	1.28	1257	10.58	7.06	-13.4
HC-P4(05)	03/25/2015 15:25	5.29	1232	9.87	6.85	-3.2

Weather, General Conditions
Site: HC-A(04)
Time: 03/25/2015 15:42
Comments: Depth of snow made access to site difficult. Samples and YSI measurements collected in the channel. No surface ice present.


Looking Upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 03/25/2015 17:08
Comments: Samples and YSI measurements collected in the channel. No surface ice present.

Looking Upstream

Looking downstream

Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 03/25/2015 17:18
Comments: Samples and YSI measurements collected in the channel. No surface ice present.


Looking Upstream


Looking downstream


Looking across stream

Site: Pond 1
- Significant ice cover on pond
- Both inlets pipes (HC-P1(04) and HC-P1(05)) were frozen
- HC-P1(04) was flowing at inlet. Sample and YSI were taken at the inlet.
- HC-P1(05) had some flow. Sample and YSI were taken in channel. Missing photos.
- Pond outlet (HC-P1(06)) was not flowing. Samples and YSI were taken at pond.

Site: Pond 2
- Significant ice cover at pond
- Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond.
- HC-P2(06) was not flowing. Sample and YSI were taken at pond.
- HC-P2(05) was flowing. Sample and YSI were taken at inlet.
- HC-P2(04) is backwatered. Sample and YSI were taken at inlet.

Site: Pond 4
- Significant ice cover at pond
- HC-P4(04) was flowing. Sample and YSI were taken in channel.
- HC-P4(05) was flowing higher than normal. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing under ice


Pond 1: Forebay looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(05)


Pond 2: Deep Cell looking from HC-P2(07)


Pond 2: (HC-P2(04)) flowing


Pond 2: HC-P2(04) looking toward forebay


Pond 2: HC-P2(05)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: Drainage Swale (HC-P2(06))


Pond 4: HC-P4(04) looking upstream


Pond 4: HC-P4(04) looking downstream


Pond 4: HC-P4(04) looking across


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Main cell


Pond 4: Pond Outlet (HC-P4(05)) flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, High flow measurements		
Date	April 20, 2015	Project Number	60265453

Weather: Overcast/partial cloudiness, low of 5.9 °C with a high of 17.3 °C. Spring melt/precipitation event triggering high flows on April 20, with intermittent rain totaling 10.1 mm (recorded in Kitchener-Waterloo).

Tasks:
- Water Samples
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(04)	04/20/2015 11:10	8.80	862	11.23	7.50	22.3
HC-A(13)	04/20/2015 13:04	8.77	909	12.42	7.54	20.5
HC-A(14)	04/20/2015 13:22	8.97	934	12.17	7.59	18.1

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	04/20/2015 11:29	8.69	586	12.76	7.61	17.1
HC-P1(05)	04/20/2015 12:00	7.58	595	12.52	7.63	16.0
HC-P1(06)	04/20/2015 11:51	10.84	1335	14.18	7.75	10.1
HC-P2(04)	04/20/2015 13:55	8.61	629	13.31	7.56	19.3
HC-P2(05)	04/20/2015 14:05	6.53	1890	8.41	7.51	22.0
HC-P2(06)	04/20/2015 14:10	11.73	1564	15.36	7.71	11.7
HC-P2(07)	04/20/2015 13:13	11.77	1017	11.14	7.78	8.1
HC-P4(04)	04/20/2015 10:45	7.08	331	13.65	7.63	16.1
HC-P4(05)	04/20/2015 10:57	11.39	1034	13.61	7.56	19.2

Weather, General Conditions
Site: HC-A(04)
Time: 04/20/2015 11:10
Comments: Samples Collected


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 04/20/2015 13:04
Comments: Samples Collected


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 04/20/2015 13:22
Comments: Samples Collected


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1	• HC-P1(04) was flowing. Samples and YSI were taken in channel. • HC-P1(05) was flowing. Samples and YSI were taken in channel. • Pond outlet (HC-P1(06)) had higher flow than normal. Samples and YSI were taken at outlet.
Site: Pond 2	• Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond. • HC-P2(06) was not flowing. Small pocket of water pool in the channel. Sample and YSI were taken at pond. • HC-P2(05) had visible flow (normally backwatered/stagnant). Sample and YSI were taken at inlet. • HC-P2(04) had visible flow (normally backwatered/stagnant). Sample and YSI were taken at inlet.
Site: Pond 4	• HC-P4(04) was flowing. Sample and YSI were taken in channel. • HC-P4(05) had higher flow than normal. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing


Pond 1: Looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(05)


Pond 1: HC-P1(05) flowing


Pond 1: Drainage Swale (HC-P1(05))


Pond 1: Pond Outlet (HC-P1(06)) flowing


Pond 1: Pond Outlet (HC-P1(06))


Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell


Pond 2: (HC-P2(04)) flowing


Pond 2: HC-P2(04) looking toward forebay


Pond 2: HC-P2(04) looking toward forebay


Pond 2: HC-P2(05)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: Drainage Swale (HC-P2(06))


Pond 2: Deep Cell


Pond 2: Deep Cell


Pond 2: HC-P2(07) not flowing


Pond 2: HC-P2(07) not flowing


Pond 4: HC-P4(04) looking upstream


Pond 4: HC-P4(04) looking downstream


Pond 4: HC-P4(04) looking across


Pond 4: Main cell looking toward HC-P4(04)


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: HC-P4(06)) drainage swale outlet flowing


Pond 4: HC-P4(06)) drainage swale outlet flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Telemetry Station Installations		
Date	April 29-May 6, 2015	Project Number	60265453

Weather: Clear skies with a high of 18.5 °C (recorded in Kitchener-Waterloo).

Tasks:

- Telemetry Station Setups
- Logger Downloads/Resets (all sites)
- Atmospheric Logger Installation
- Photos

Field Crew: Steve Scott, Andrew Minielly, Sachet, Siwakoti

Weather, General Conditions
Site: HC-A(03)
Comments: Telemetry station was never installed in 2014 due to damaged water level sensor. Water level sensor was replaced in 2015 and installed in previous location. A U20 level logger was left at site to use for QA/QC purposes with regards to newly installed water level sensor.

Battery levels were low upon installation requiring new battery to be installed. Connection issues to HOBOlink persisted after battery install until May 6th when minor wiring repair was made to positive connection wire for battery.


Looking upstream


Looking downstream


Looking across stream


Telemetry Station Install

Weather, General Conditions
Site: HC-A(06)
Comments: Battery replacement was also required for HC-A(06). Connection issues to HOBOlink persisted until battery replacement was made. Connection with HOBOlink restored shortly after battery installation. A U20 level logger was left at site to use for QA/QC purposes.


Looking upstream


Looking downstream


Looking across stream


Telemetry Station Install


Telemetry Station Sensors and Logger Location


Telemetry Station Install

Weather, General Conditions
Site: HC-A(10)
Comments: No significant issues with telemetry station install. Solar panel successfully repowered battery and connection with HOBOlink was restored shortly after installation.


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Comments: No significant issues with telemetry station install. Solar panel successfully repowered battery and connection with HOBOlink was restored shortly after installation.


Looking upstream


Looking downstream


Looking across stream

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Baseflow measurements and dry samples		
Date	May 7, 2015	Project Number	60265453

Weather: Overcast with a high of 27 °C (recorded in Kitchener-Waterloo). No rainfall occurred over the 72-hour period prior to monitoring, however, rainfall was witnessed after noon during field work.

Tasks:

- Dry Water Samples
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Steve Scott and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	05/07/15 10:35:46	10.87	645	10.89	8.90	-56.0
HC-A(04)	05/07/15 10:46:08	13.33	888	8.54	9.35	-78.8
HC-A(06)	05/07/15 11:44:58	15.35	894	9.33	8.99	-61.9
HC-A(10)	05/07/15 12:55:03	16.26	1048	10.00	8.58	-41.8
HC-A(11)	05/07/15 13:52:59	17.57	996	8.47	7.94	-10.3
HC-A(12)	05/07/15 14:21:27	17.98	978	8.84	8.02	-14.3
HC-A(13)	05/07/15 15:50:58	20.49	597	9.21	8.38	-32.6
HC-A(14)	05/07/15 16:17:48	20.92	1048	9.08	8.28	-28.1

Weather, General Conditions
Site: HC-A(03)
Flow Tracker Filename: HC-A(03) 2015-05-07.WAD
Time: 2015/05/07 10:51:08
Measured Flow: Q= 0.0022 m^3/s
Comments: Water levels were very low in the creek due to relatively dry month resulting in narrower than normal cross-section width.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.5	0.06
0.1	0.03	0.6	0.02
0.2	0.04	0.7	0.02
0.3	0.04	0.8	0
0.4	0.06		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/05/07 11:10:58
Comments: None

Flow Tracker Filename: HC-A(04) 2015-05-07.WAD
Measured Flow: Q= 0.0104 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.7	0.16
0.1	0.04	0.8	0.10
0.2	0.07	0.9	0.03
0.3	0.10	1.0	0.03
0.4	0.15	1.2	0.02
0.5	0.15	1.3	0
0.6	0.17		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/05/07 11:56:11
Comments: Photos not available.

Flow Tracker Filename: HC-A(06) 2015-05-07.WAD
Measured Flow: Q= 0.0104 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.7	0.10
0.1	0.03	0.8	0.10
0.2	0.06	0.9	0.10
0.3	0.09	1.0	0.09
0.4	0.09	1.1	0.08
0.5	0.09	1.2	0
0.6	0.09		


Looking upstream


Looking downstream


Looking across stream


Logger and Telemetry Sensors Location

Weather, General Conditions
Site: HC-A(10)
Time: 2015/05/07 13:13:12
Flow Tracker Filename: HC-A(10) 2015-05-07.WAD
Measured Flow: Q= 0.0127 m^3/s
Comments: The absence of watercress allowed for the flow to be more accurately measured throughout the entire cross-section.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.7	0.08
0.1	0.10	0.8	0.08
0.2	0.10	0.9	0.08
0.3	0.10	1.0	0.07
0.4	0.10	1.1	0.07
0.5	0.09	1.2	0
0.6	0.09		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/05/07 13:44:22
Flow Tracker Filename: HC-A(11) 2015-05-07.WAD
Measured Flow: Q= 0.0136 m^3/s
Comments: The absence of watercress allowed for the flow to be measured at its original location rather than directly at the culvert.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.4	0.14
0.5	0.10	1.5	0.14
0.7	0.12	1.6	0.14
0.9	0.10	1.8	0.14
1.0	0.10	2.0	0.14
1.1	0.13	2.2	0.08
1.2	0.14	2.3	0
1.3	0.14		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/05/07 14:31:29
Comments: None

Flow Tracker Filename: HC-A(12) 2015-05-07.WAD
Measured Flow: Q= 0.0172 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.6	0.21
0.1	0.07	0.7	0.21
0.2	0.07	0.8	0.19
0.3	0.10	0.9	0.18
0.4	0.12	1.0	0.10
0.5	0.19	1.2	0


Looking upstream


Looking downstream


Looking upstream

Weather, General Conditions
Site: HC-A(13)
Time: 2015/05/07 16:09:35
Comments: None

Flow Tracker Filename: HC-A(13) 2015-05-07.WAD
Measured Flow: Q= 0.0145 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.6	0.12
0.1	0.11	0.7	0.12
0.2	0.11	0.8	0.12
0.3	0.125	0.9	0.10
0.4	0.14	1.0	0.06
0.5	0.12	1.1	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 2015/05/07 16:42:01
Comments: None

Flow Tracker Filename: HC-A(14) 2015-05-07.WAD
Measured Flow: Q= 0.0134 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0.15	0	0.75	0.10
0.25	0.06	0.85	0.10
0.35	0.06	0.95	0.12
0.45	0.06	1.05	0.10
0.55	0.08	1.15	0.10
0.65	0.10	1.25	0


Looking upstream


Looking downstream


Looking across stream

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Baseflow measurements		
Date	June 4, 2015	Project Number	60265453

Weather: Partially cloudy with a high of 22.4 °C (recorded in Guelph).

Tasks:

- Downloaded Temperature Loggers Only
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Andrew Minielly and Sachet Siwakoti

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	6/4/2015 10:43	11.08	644	10.03	7.27	-24.4
HC-A(04)	6/4/2015 11:23	15.61	833	7.28	7.58	-31.7
HC-A(06)	6/4/2015 12:33	16.84	841	9.93	7.46	-29.1
HC-A(10)	6/4/2015 13:34	16.15	1030	9.16	7.72	-35.0
HC-A(11)	6/4/2015 14:15	16.35	1012	8.30	7.80	-37.0
HC-A(12)	6/4/2015 15:00	16.52	1011	8.75	7.92	-39.8
HC-A(13)	6/4/2015 15:39	17.88	1018	9.13	8.02	-42.2
HC-A(14)	6/4/2015 15:57	18.16	1018	9.73	8.06	-43.3

Weather, General Conditions
Site: HC-A(03)
Time: 2015/06/04 10:43:15
Comments: None

Flow Tracker Filename: HCHC-A(03) 2015-06-04.WAD
Measured Flow: Q= 0.0043 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.40	0.10
0.10	0.08	0.45	0.110
0.20	0.08	0.50	0.10
0.25	0.09	0.70	0.0
0.30	0.09		
0.35	0.10		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/06/04 11:23:24
Comments: None

Flow Tracker Filename: HC-A(04) 2015-06-04.WAD
Measured Flow: Q= 0.0097 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.19
0.20	0.04	0.75	0.20
0.35	0.08	0.85	0.16
0.45	0.14	1.05	0.0
0.55	0.19		
0.60	0.19		
0.65	0.19		


Looking upstream

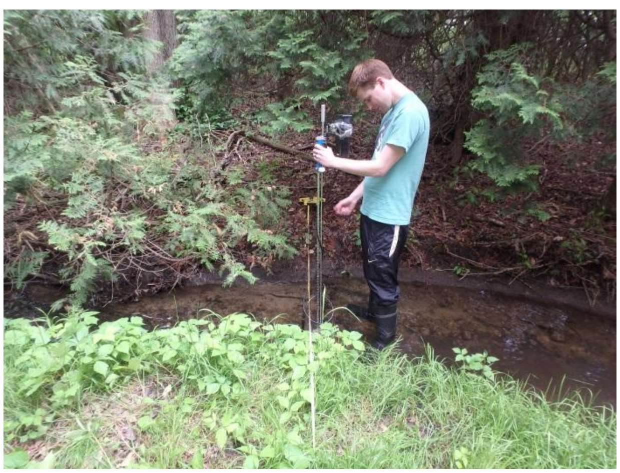

Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/06/04 12:23:13
Comments: Photos N/A

Flow Tracker Filename: HC-A(06) 2015-06-04.WAD
Measured Flow: Q= 0.0115 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.08
0.10	0.08	0.70	0.07
0.20	0.08	0.80	0.07
0.30	0.10	0.90	0.06
0.40	0.10	1.10	0
0.50	0.08		



Weather, General Conditions
Site: HC-A(10)
Time: 2015/06/04 13:34:07
Comments: None

Flow Tracker Filename: HC-A(10) 2015-06-04.WAD
Measured Flow: Q= 0.0156 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.08
0.10	0.06	0.80	0.07
0.20	0.08	0.90	0.10
0.30	0.08	1.00	0.10
0.40	0.06	1.10	0.10
0.50	0.07	1.20	0.10
0.60	0.07	1.30	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/06/04 14:15:17
Comments: None

Flow Tracker Filename: HC-A(11) 2015-06-04.WAD
Measured Flow: Q= 0.0189 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.50	0.12
0.60	0.14	1.70	0.13
0.80	0.14	1.90	0.12
1.00	0.15	2.10	0.12
1.20	0.15	2.60	0.0
1.30	0.15		
1.40	0.14		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/06/04 15:15:00
Comments: none

Flow Tracker Filename: HC-A(12) 2014-09-05.WAD
Measured Flow: Q= 0.0150 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.50	0.20
0.10	0.20	0.55	0.20
0.20	0.20	0.60	0.20
0.30	0.20	0.70	0.20
0.40	0.20	0.80	0.20
0.45	0.20	0.90	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Flow Tracker Filename: HC-A(13) 2015-06-04.WAD
Time: 2015/06/04 15:55:00
Measured Flow: Q= 0.0159 m^3/s
Comments: Watercress beginning to build up directly upstream from the flow monitoring cross section.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.13
0.20	0.13	0.80	0.13
0.30	0.13	0.90	0.13
0.40	0.13	1.00	0.13
0.50	0.13	1.20	0
0.60	0.14		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Flow Tracker Filename: HC-A(14) 2015-06-04.WAD
Time: 2015/06/04 16:25:00
Measured Flow: Q= 0.0274 m^3/s
Comments: Flow is being deflected by the additional vegetation in the channel.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.10	0.12
0.60	0.12	1.20	0.10
0.70	0.12	1.30	0.08
0.80	0.13	1.40	0.08
0.90	0.13	1.50	0.08
0.95	0.13	1.80	0
1.00	0.12		


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1	• HC-P1(01,02,03,07,08) loggers downloaded and reset • HC-P1(04) was not flowing. • HC-P1(05) was not flowing. • Pond outlet (HC-P1(06)) was not flowing.
Site: Pond 2	• HC-P2(01,02) loggers downloaded and reset. HC-P2(03) logger not found (possibly stolen), logger replaced • Pond outlet (HC-P2(07)) was not flowing.
Site: Pond 4	• HC-P1(01,02,03) loggers downloaded and reset. • HC-P4(05) was flowing. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) dry


Pond 1: Forebay looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(05)


Pond 1: Drainage Swale (HC-P1(05))


Pond 1: HC-P1(05) Dry


Pond 2: HC-P2(07) Deep cell


Pond 2: HC-P2(07) Deep Cell


Pond 2: HC-P2(07) Not flowing


Pond 2: HC-P4(05) Deep Cell


Pond 4: HC-P4(05) Flowing

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, High flow measurements		
Date	June 30, 2015	Project Number	60265453

Weather: Overcast/partial cloudiness, low of 10.5 °C with a high of 18.2 °C. A precipitation event triggered high flows on June 30, with intermittent rain totaling 6.1 mm (recorded in Guelph (GRCA)).

Tasks:

- Water Samples
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(04)	06/30/15 14:16:00	17.06	752	6.34	6.86	-10.4
HC-A(13)	06/30/15 15:12:01	15.65	935	7.44	7.31	-27.2
HC-A(14)	06/30/15 15:22:03	15.68	682	7.75	7.28	-26.1

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	6/30/2015 14:31	15.23	2272	6.92	7.27	-25.7
HC-P1(05)	6/30/2015 14:53	14.58	1338	7.23	7.26	-25.1
HC-P1(06)	6/30/2015 14:46	19.13	944	8.12	7.44	-32.2
HC-P2(04)	6/30/2015 15:51	19.2	894	5.95	7.15	-21.3
HC-P2(05)	6/30/2015 15:44	13.88	1633	9.12	7.07	-18.3
HC-P2(06)	6/30/2015 15:33	18.54	642	3.25	7.14	-20.8
HC-P2(07)	6/30/2015 15:06	19.72	428	6.8	7.13	-20.6
HC-P4(04)	6/30/2015 13:51	16.14	712	6.18	7.09	-18.9
HC-P4(05)	6/30/2015 14:03	19.67	774	10.11	7.98	-52.5

Weather, General Conditions
Site: HC-A(04)
Time: 04/20/2015 11:10
Comments: Samples Collected


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 04/20/2015 13:04
Comments: Samples Collected


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 04/20/2015 13:22
Comments: Samples Collected


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1
- HC-P1(04) was flowing. Samples and YSI were taken in channel.
- HC-P1(05) was flowing. Samples and YSI were taken in channel.
- Pond outlet (HC-P1(06)) had higher flow than normal. Samples and YSI were taken at outlet.

Site: Pond 2
- Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond.
- HC-P2(06) was not flowing. Small pocket of water pool in the channel. Sample and YSI were taken at pond.
- HC-P2(05) had visible flow (normally backwatered/stagnant). Sample and YSI were taken at inlet.
- HC-P2(04) had visible flow (normally backwatered/stagnant). Sample and YSI were taken at inlet.

Site: Pond 4
- HC-P4(04) was flowing. Sample and YSI were taken in channel.
- HC-P4(05) had higher flow than normal. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing


Pond 1: Looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(05)


Pond 1: HC-P1(05) flowing


Pond 1: Drainage Swale (HC-P1(05))


Pond 1: Pond Outlet (HC-P1(06)) flowing


Pond 1: Pond Outlet (HC-P1(06))


Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell


Pond 2: HC-P2(05)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: Deep Cell


Pond 2: HC-P2(07) not flowing


Pond 4: HC-P4(04) looking upstream

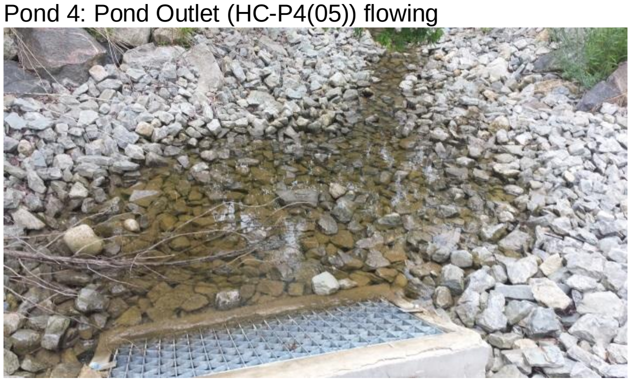

Pond 4: HC-P4(04) looking downstream


Pond 4: HC-P4(04) looking across


Pond 4: Main cell looking toward HC-P4(04)


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: HC-P4(06)) drainage swale outlet flowing


Pond 4: HC-P4(06)) drainage swale outlet flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Base flow measurements		
Date	July 6, 2015	Project Number	60265453

Weather: Clear skies with a high of 26.7 °C (recorded in Guelph). No rain recorded in the past 72 hours.

Tasks:
- Downloaded U30 creek loggers
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Andrew Minielly and Sachet Siwakoti

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	7/6/2015 10:23	11.81	622	10.09	7.19	-27.0
HC-A(04)	7/6/2015 11:03	18.61	746	6.43	7.17	-26.4
HC-A(06)	7/6/2015 11:46	19.53	752	8.57	7.55	-41.4
HC-A(10)	7/6/2015 13:02	18.72	998	8.42	7.56	-42.0
HC-A(11)	7/6/2015 13:41	19.18	1001	8.57	7.57	-42.3
HC-A(12)	7/6/2015 14:32	19.85	964	8.29	7.43	-36.8
HC-A(13)	7/6/2015 15:19	21.19	768	8.94	7.71	-48.1
HC-A(14)	7/6/2015 15:26	21.46	1003	9.56	7.70	-47.6

Weather, General Conditions
Site: HC-A(03)
Time: 2015/06/04 10:22:21
Comments: None

Flow Tracker Filename: HC-A(04) 2015-07-06.WAD
Measured Flow: Q= 0.0019 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.40	0.06
0.15	0.06	0.45	0.06
0.20	0.06	0.50	0.04
0.25	0.06	0.55	0.04
0.30	0.06	0.75	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/07/06 10:56:03
Comments: None

Flow Tracker Filename: HC-A(03) 2015-07-06.WAD
Measured Flow: Q= 0.0113 m^3/s seepage

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.18
0.10	0.08	0.70	0.18
0.20	0.08	0.80	0.16
0.30	0.12	0.90	0.12
0.40	0.16	1.00	0
0.50	0.16		


Looking upstream


Looking downstream

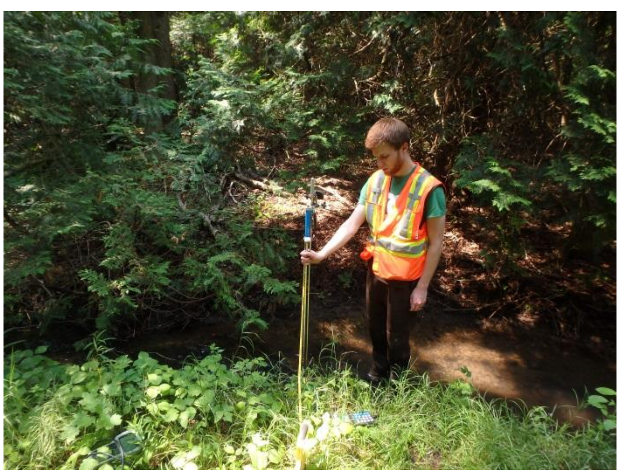

Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/07/06 11:43:36
Comments:

Flow Tracker Filename: HC-A(06) 2015-07-06.WAD
Measured Flow: Q= 0.0092 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.07
0.10	0.06	0.70	0.07
0.20	0.07	0.80	0.06
0.30	0.06	0.90	0.06
0.40	0.06	1.00	0.04
0.50	0.08	1.10	0





Weather, General Conditions
Site: HC-A(10)
Time: 2015/07/06 13:03:35
Comments: None

Flow Tracker Filename: HC-A(10) 2015-07-06.WAD
Measured Flow: Q= 0.0112 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.80	0.08
0.20	0.05	0.90	0.08
0.30	0.05	1.00	0.08
0.40	0.07	1.10	0.10
0.50	0.07	1.20	0.07
0.60	0.06	1.40	0.09
0.70	0.08	1.60	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/07/06 13:43:32
Comments: None

Flow Tracker Filename: HC-A(11) 2015-07-06.WAD
Measured Flow: Q= 0.0164m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.30	0.14
0.60	0.14	1.50	0.14
0.70	0.14	1.70	0.14
0.80	0.14	1.90	0.11
0.90	0.14	2.10	0.11
1.00	0.15	2.30	0.10
1.10	0.14	2.50	0
1.20	0.14		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/07/06 14:23:19
Comments: none

Flow Tracker Filename: HC-A(12) 2015-07-06.WAD
Measured Flow: Q= 0.014 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.50	0.20
0.10	0.19	0.60	0.20
0.20	0.19	0.70	0.22
0.30	0.19	0.80	0.22
0.40	0.20	1.00	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 2015/07/06 15:00:45
Comments:

Flow Tracker Filename: HC-A(13) 2015-07-06.WAD
Measured Flow: Q= 0.0116 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.12
0.20	0.12	0.80	0.12
.030	0.12	0.90	0.12
0.40	0.13	1.00	0.13
0.50	0.13	1.20	0.11
0.60	0.13	1.30	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 2015/06/04 15:25:53
Comments:

Flow Tracker Filename: HC-A(14) 2015-07-06.WAD
Measured Flow: Q= 0.0156 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.90	0.12
0.40	0.14	1.00	0.12
0.50	0.15	1.10	0.12
0.60	0.15	1.20	0.12
0.70	0.15	1.30	0.1
0.80	0.14	1.40	0


Looking upstream


Looking downstream


Looking across stream

Site: Pond 4

- Photos taken at outlet
- HC-P4(05) was flowing


Pond 4: HC-P4(05) Deep Cell


Pond 4: HC-P1(06) low flow


Pond 4: HC-P1(06) low flow

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, High flow measurements and samples		
Date	July 14, 2014	Project Number	60265453

Weather: Overcast, intermittent rain with low of 15.2°C. Precipitation event triggering high flows on July 15 (missing rainfall data in Kitchener-Waterloo and Guelph Turfgrass weather station).

Tasks:
- Water Samples
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	7/14/2015 10:48	13.47	598	6.46	7.23	-18.6
HC-A(04)	7/14/2015 11:22	21.26	739	4.43	7.35	-23.5
HC-A(06)	7/14/2015 12:28	21.06	745	5.54	7.55	-30.9
HC-A(10)	7/14/2015 13:03	17.83	854	5.71	7.5	-28.9
HC-A(11)	7/14/2015 13:19	18.02	877	5.63	7.51	-29
HC-A(12)	7/14/2015 15:19	17.92	896	5.87	7.58	-31.8
HC-A(13)	7/14/2015 14:06	18.04	877	5.42	7.6	-32.6
HC-A(14)	7/14/2015 14:28	18.14	882	5.83	7.57	-31.3

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	7/14/2015 13:45	19.28	804	3.15	7.25	-19.3
HC-P1(05)	7/14/2015 13:58	24.49	367	5.47	8.78	-78.2
HC-P1(06)	7/14/2015 15:04	24.86	938	7.75	8.52	-68.3
HC-P2(04)	7/14/2015 15:34	22.32	123	4.34	7.34	-22.9
HC-P2(05)	7/14/2015 15:47	15.31	1382	6.72	7.25	-19.2
HC-P2(06)	7/14/2015 15:52	22.45	872	4.24	7.42	-25.9
HC-P2(07)	7/14/2015 15:12	19.83	316	3.76	7.55	-30.8
HC-P4(04)	7/14/2015 10:15	18.72	369	5.26	7.15	-15.7
HC-P4(05)	7/14/2015 10:26	25.01	723	7.64	8.54	-69.2

Weather, General Conditions
Site: HC-A(03)
Time: 2015/07/14 10:44:51
Comments: None

Flow Tracker Filename: HC-A(03) 2015-07-14.WAD
Measured Flow: Q= 0.0029 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.30	0.08
0.05	0.02	0.35	0.09
0.10	0.04	0.40	0.10
0.15	0.05	0.45	0.06
0.20	0.06	0.50	0.06
0.25	0.08	0.60	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/07/14 11:19:52
Comments: None.

Flow Tracker Filename: HC-A(04) 2015-07-14.WAD
Measured Flow: Q= 0.0175 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.18
0.10	0.04	0.70	0.22
0.20	0.10	0.80	0.22
0.30	0.14	0.90	0.16
0.40	0.16	1.00	0.08
0.50	0.20	1.10	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/07/14 12:02:04
Comments: None.

Flow Tracker Filename: HC-A(06) 2015/07/14.WAD
Measured Flow: Q= 0.0206 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.65	0.08
0.15	0.10	0.75	0.08
0.25	0.11	0.85	0.08
0.35	0.10	0.95	0.08
0.45	0.10	1.05	0.08
0.55	0.11	1.15	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(10)
Time: 2015/07/14 12:55:16
Comments: None.

Flow Tracker Filename: HC-A(10) 2015/07/14.WAD
Measured Flow: Q= 0.0283 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.90	0.12
0.15	0.06	1.05	0.12
0.30	0.08	1.20	0.10
0.45	0.10	1.35	0.12
0.60	0.08	1.50	0.14
0.75	0.12	1.65	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/07/14 13:19:56
Comments: None.

Flow Tracker Filename: HC-A(11) 2015/07/14.WAD
Measured Flow: Q= 0.0301 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.40	0.18
0.40	0.12	1.60	0.18
0.60	0.18	1.80	0.16
0.80	0.18	2.00	0.16
1.00	0.18	2.20	0.14
1.20	0.19	2.60	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/07/14 15:02:58
Comments: None.

Flow Tracker Filename: HC-A(12) 2015/07/14.WAD
Measured Flow: Q= 0.0360 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.32
0.10	0.28	0.70	0.34
0.20	0.30	0.80	0.32
0.30	0.32	0.90	0.32
0.40	0.32	1.10	0
0.50	0.33		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 2015/07/14 13:56:51
Comments: None.

Flow Tracker Filename: HC-A(13) 2015/07/14.WAD
Measured Flow: Q= 0.0287 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.18
0.10	0.16	0.80	0.18
0.20	0.17	0.90	0.18
0.30	0.18	1.00	0.17
0.40	0.18	1.10	0.18
0.50	0.18	1.30	0
0.60	0.18		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 2015/07/14 14:25:31
Comments: None.

Flow Tracker Filename: HC-A(14) 2015/07/14.WAD
Measured Flow: Q= 0.03 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.90	0.18
0.40	0.20	1.00	0.17
0.50	0.22	1.10	0.16
0.60	0.22	1.20	0.16
0.70	0.20	1.80	0
0.80	0.20		


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1
- HC-P1(04) was flowing. Samples and YSI were taken in channel.
- HC-P1(05) was flowing. Samples and YSI were taken in channel.
- Pond outlet (HC-P1(06)) was not flowing. Samples and YSI were taken at pond.

Site: Pond 2
- HC-P2(04) was flowing. Sample and YSI were taken at inlet.
- HC-P2(05) was flowing. Sample and YSI were taken at inlet.
- HC-P2(06) was flowing. Sample and YSI were taken in channel.
- Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond.

Site: Pond 4
- HC-P4(04) was flowing. Sample and YSI were taken in channel.
- HC-P4(05) was flowing. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing


Pond 1: Forebay looking toward HC-P1(05)


Pond 1: Forebay looking toward HC-P1(04)

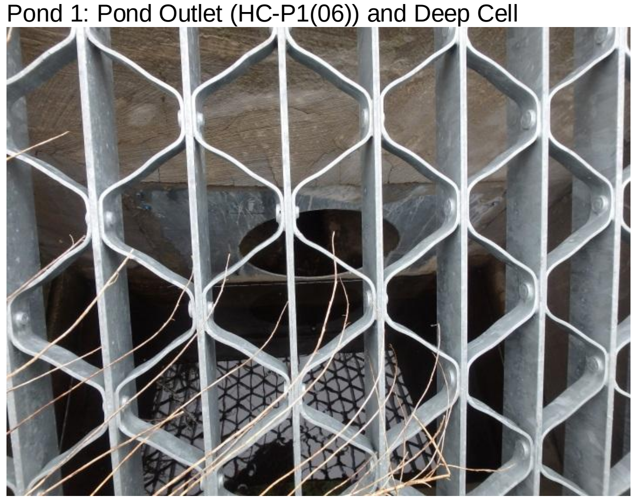

Pond 1: HC-P1(05) flowing


Pond 1: Drainage Swale (HC-P1(05))


Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell


Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell


Pond 1: Pond Outlet (HC-P1(06)) Not Flowing


Pond 1: Pond Outlet (HC-P1(06)) Not Flowing


Pond 2: (HC-P2(04)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: HC-P2(05)) flowing

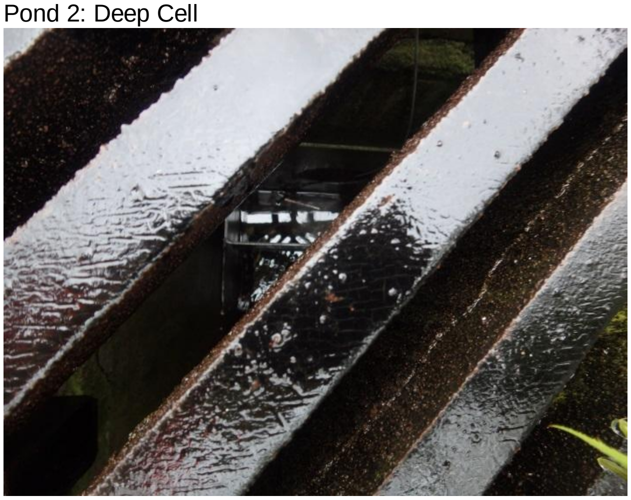

Pond 2: HC-P2(05) looking toward forebay


Pond 2: Drainage Swale (HC-P2(06))


Pond 2: HC-P2(06) looking toward forebay


Pond 2: Deep Cell


Pond 2: Deep Cell


Pond 2: HC-P2(07) not flowing


Pond 2: HC-P2(07) not flowing


Pond 4: HC-P4(04) looking upstream


Pond 4: HC-P4(04) looking downstream


Pond 4: HC-P4(04) looking across


Pond 4: Main Cell


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(06)) flowing


Pond 4: Pond Outlet (HC-P4(06)) flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Dry Samples		
Date	July 30, 2015	Project Number	60265453

Weather: Sunny day with a high of 28 °C (recorded in Guelph, Ontario). No rainfall occurred over the 72-hour period prior to monitoring.

Tasks:
- Dry Water Samples
- Photos

Field Crew: Mahmutjan Nur and Andrew Minielly

YSI Results: Did not take YSI measurements

Weather, General Conditions
Site: HC-A(04)
Time: 2015/07/30 15:41:42
Comments: WQ Samples and Photos


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 2015/07/30 16:08:32
Comments: WQ Samples and Photos


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 2015/05/07 10:51:08
Comments: WQ Samples and Photos


Looking upstream


Looking downstream


Looking across stream

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, High flow measurements and samples		
Date	August 20, 2015	Project Number	60265453

Weather: Overcast/partial cloudiness, low of 14.9°C. Precipitation event triggering high flows with total precipitation of 5.5 mm on August 19 and 6.6 mm on August 20 (recorded in Kitchener/Waterloo station).

Tasks:

- Water Samples
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	8/20/2015 8:43	16.35	543	6.66	6.94	-14.3
HC-A(04)	8/20/2015 9:04	21.73	710	4.04	7.1	-20.9
HC-A(06)	8/20/2015 9:39	21.19	743	5.38	7.15	-22.6
HC-A(10)	8/20/2015 10:20	18.77	917	5.36	7.14	-22.2
HC-A(11)	8/20/2015 10:30	18.78	675	1.05	7.13	-21.9
HC-A(12)	8/20/2015 11:24	18.93	923	5.83	7.19	-24.5
HC-A(13)	8/20/2015 15:42	20.67	938	5.29	7.87	-51.8
HC-A(14)	8/20/2015 16:20	20.74	945	5.44	7.16	-23.3

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	8/20/2015 10:59	21.14	335	4.33	6.94	-14.1
HC-P1(05)	8/20/2015 11:10	20.53	241	4.68	6.36	9.2
HC-P1(06)	8/20/2015 11:18	24.9	797	4.65	7.41	-33.6
HC-P2(04)	8/20/2015 11:45	22.98	110	3.59	6.83	-9.8
HC-P2(05)	8/20/2015 11:53	18.58	990	8.11	7.09	-20.3
HC-P2(06)	8/20/2015 12:00	24.29	526	4.94	8.18	-64.9
HC-P2(07)	8/20/2015 15:27	26.42	196	7.29	8.26	-68.4
HC-P4(04)	8/20/2015 8:11	19.54	683	2.99	6.95	-14.6
HC-P4(05)	8/20/2015 8:23	25.55	778	6.11	7.92	-54.4

Weather, General Conditions
Site: HC-A(03)
Time: 2015-08-20 08:38:38
Comments: None

Flow Tracker Filename: HC-A(03) 2015-08-20.WAD
Measured Flow: Q= 0.0024 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.45	0.09
0.15	0.04	0.50	0.10
0.25	0.06	0.55	0.08
0.30	0.08	0.85	0
0.35	0.09		
0.40	0.09		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015-08-20 09:04:03
Comments: None.

Flow Tracker Filename: HC-A(04) 2015-08-20.WAD
Measured Flow: Q= 0.0180 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.9	0.16
0.3	0.06	1.0	0.13
0.4	0.10	1.1	0.12
0.5	0.14	1.3	0
0.6	0.18		
0.7	0.18		
0.8	0.14		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015-08-20 09:37:13
Comments: None.

Flow Tracker Filename: HC-A(06) 2015-08-20.WAD
Measured Flow: Q= 0.0145 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.65	0.08
0.15	0.09	0.75	0.08
0.25	0.11	0.85	0.08
0.35	0.10	0.95	0.08
0.45	0.10	1.25	0
0.55	0.10		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(10)
Time: 2015-08-20 10:09:53
Comments: Watercress present

Flow Tracker Filename: HC-A(10) 2015-08-20.WAD
Measured Flow: Q= 0.0274 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.05	0.12
0.15	0.10	1.20	0.12
0.30	0.11	1.35	0.14
0.45	0.11	1.50	0.15
0.60	0.12	1.65	0
0.75	0.12		
0.90	0.12		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015-08-20 10:34:10
Flow Tracker Filename: HC-A(11) 2015-08-20.WAD
Measured Flow: Q= 0.0299 m^3/s
Comments: Watercress growth occurring around cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.75	0.21
0.85	0.2	1.90	0.20
1.00	0.22	2.05	0.20
1.15	0.22	2.20	0.20
1.30	0.22	2.60	0
1.45	0.22		
1.60	0.21		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015-08-20 11:16:06
Comments:

Flow Tracker Filename: HC-A(12) 2015-08-20.WAD
Measured Flow: Q= 0.0343 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.38
0.10	0.32	0.80	0.38
0.20	0.32	0.90	0.38
0.30	0.33	1.10	0
0.40	0.34		
0.50	0.34		
0.60	0.34		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Flow Tracker Filename: HC-A(13) 2015-08-20.WAD
Time: 2015-08-20 15:29:27
Measured Flow: Q= 0.0371 m^3/s
Comments: Samples and YSI measurements collected in the channel.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.10	0.20
0.60	0.05	1.20	0.21
0.70	0.20	1.30	0.21
0.80	0.20	1.40	0.21
0.90	0.20	2.00	0.14
1.00	0.20	2.10	0
1.10	0.20		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Flow Tracker Filename: HC-A(14) 2015-08-20.WAD
Time: 2015-08-20 15:55:06
Measured Flow: Q= 0.0371 m^3/s
Comments: Samples and YSI measurements collected in the channel.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.80	0.21
0.20	0.14	1.10	0.23
0.30	0.18	1.40	0.26
0.40	0.18	1.70	0.26
0.50	0.18	2.30	0.08
0.60	0.20	2.40	0
0.70	0.20		


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1
- HC-P1(04) was flowing. Samples and YSI were taken in channel.
- HC-P1(05) was flowing. Samples and YSI were taken in channel.
- Pond outlet (HC-P1(06)) was not flowing. Samples and YSI were taken at pond.
- Pictures not available.

Site: Pond 2
- HC-P2(04) was flowing. Sample and YSI were taken at inlet.
- HC-P2(05) was flowing. Sample and YSI were taken at inlet.
- HC-P2(06) was flowing. Sample and YSI were taken in channel.
- Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond.

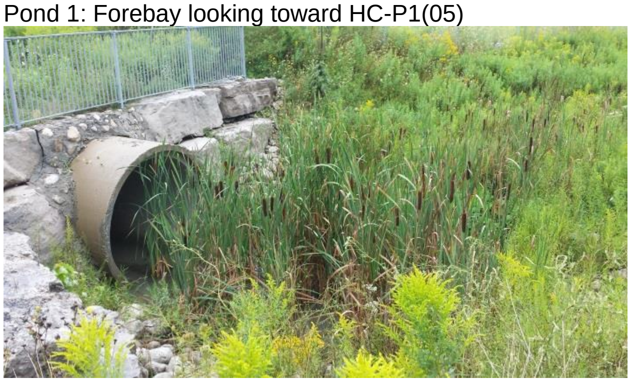
Site: Pond 4
- HC-P4(04) was flowing. Sample and YSI were taken in channel.
- HC-P4(05) was flowing. Sample and YSI were taken at outlet.
- Pictures not available.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing


Pond 1: Forebay looking toward HC-P1(05)


Pond 1: Forebay looking toward HC-P1(04)

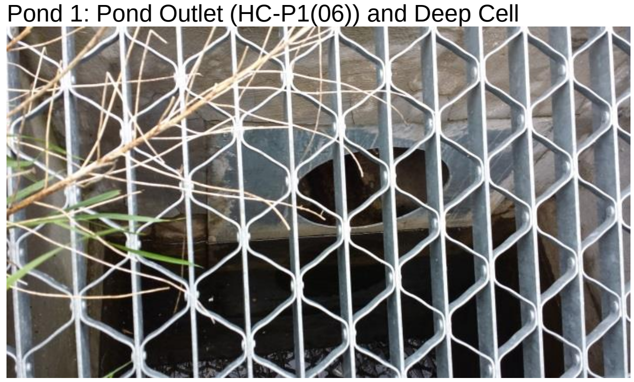

Pond 1: HC-P1(05) flowing


Pond 1: Drainage Swale (HC-P1(05))


Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell

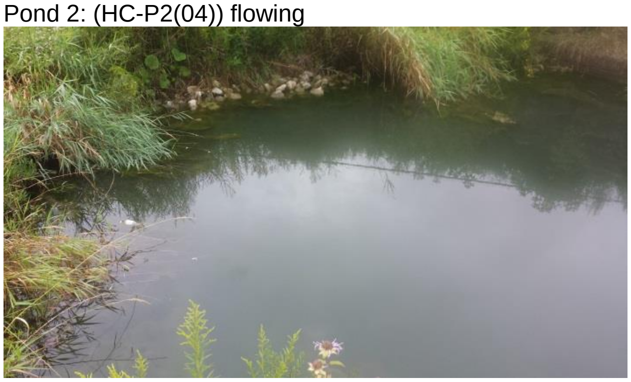

Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell


Pond 1: Pond Outlet (HC-P1(06)) Not Flowing


Pond 1: Pond Outlet (HC-P1(06)) Not Flowing


Pond 2: (HC-P2(04)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: HC-P2(05)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: HC-P2(06) looking toward forebay


Pond 2: Drainage Swale (HC-P2(06))


Pond 2: Deep Cell


Pond 2: Deep Cell


Pond 4: HC-P4(04) looking upstream

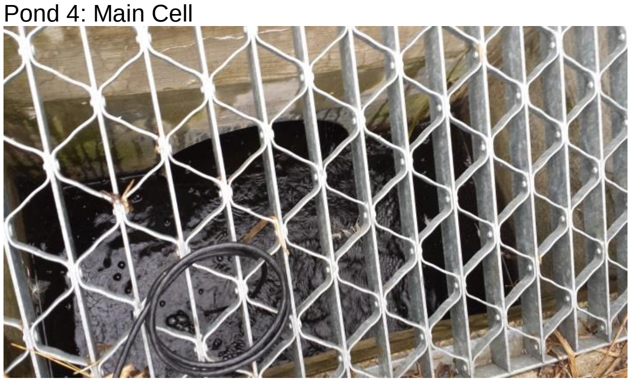

Pond 4: HC-P4(04) looking downstream


Pond 4: HC-P4(04) looking across


Pond 4: Main Cell


Pond 4: Main Cell


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(06)) flowing


Pond 4: Pond Outlet (HC-P4(06)) flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Base flow measurements		
Date	September 1, 2015	Project Number	60265453

Weather: Clear with a high of 28.3 °C (recorded in Guelph).

Tasks:

- Flow Measurements
- YSI measurements
- Photos

Field Crew: Andrew Minielly and Sachet Siwakoti

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	9/1/2015 11:02	14.47	615	8.11	6.34	9.3
HC-A(04)	9/1/2015 11:35	19.48	774	4.97	6.36	9.2
HC-A(06)	9/1/2015 12:06	19.91	784	6.78	6.63	-1.8
HC-A(10)	9/1/2015 13:26	18.44	1100	7.93	6.57	0.6
HC-A(11)	9/1/2015 13:51	18.67	1090	6.6	6.78	-7.8
HC-A(12)	9/1/2015 14:55	19.66	1088	6.34	7.02	-17.6
HC-A(13)	9/1/2015 15:37	20.57	750	6.07	6.8	-8.8
HC-A(14)	9/1/2015 11:02	14.47	615	8.11	6.34	9.3

Weather, General Conditions
Site: HC-A(03)
Time: 2015/09/01 11:02:40
Comments: Low flow

Flow Tracker Filename: HC-A(03) 2015-09-01.WAD
Measured Flow: Q= 0.0014 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.45	0.07
0.20	0.04	0.50	0.05
0.25	0.08	0.55	0.05
0.30	0.08	0.60	0
0.35	0.09		
0.40	0.08		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/09/01 11:30:34
Comments: None

Flow Tracker Filename: HC-A(04) 2015-09-01.WAD
Measured Flow: Q= 0.0097 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.50	0.09
0.20	0.10	0.55	0.09
0.25	0.12	0.60	0.09
0.30	0.11	0.70	0.60
0.35	0.10	0.90	0
0.40	0.10		
0.45	0.10		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/09/01 12:04:20
Comments: Photos missing

Flow Tracker Filename: HC-A(06) 2015-09-01.WAD
Measured Flow: Q= 0.0046 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.65	0.05
0.20	0.05	0.70	0.06
0.30	0.05	0.80	0.04
0.40	0.05	0.90	0.07
0.50	0.05	1.00	0.04
0.60	0.05	1.10	0

Weather, General Conditions
Site: HC-A(10)
Time: 2015/09/01 13:26:16
Comments: Increased watercress growth

Flow Tracker Filename: HC-A(10) 2015-09-01.WAD
Measured Flow: Q= 0.0110 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.09
0.10	0.12	0.80	0.08
0.20	0.11	0.90	0.08
0.30	0.10	1.00	0.07
0.40	0.10	1.10	0.07
0.50	0.09	1.40	0
0.60	0.09		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/09/01 13:48:41
Flow Tracker Filename: HC-A(11) 2015-09-01.WAD
Measured Flow: Q= 0.0121 m^3/s
Comments: Increased watercress growth around cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.4	0.18
0.8	0.14	1.5	0.18
0.9	0.15	1.6	0.18
1.0	0.16	1.7	0.18
1.1	0.16	1.8	0.18
1.2	0.17	2.5	0
1.3	0.18		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/09/01 14:40:42
Comments: none

Flow Tracker Filename: HC-A(12) 2015-09-01.WAD
Measured Flow: Q= 0.0095 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.22
0.30	0.24	0.75	0.22
0.40	0.23	0.80	0.22
0.50	0.22	0.85	0.22
0.55	0.22	0.90	0.20
0.60	0.22	0.10	0
0.65	0.22		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Comments: Missing flow tracker data – power issues. Increased watercress growth downstream of cross section.


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Comments: Missing flow tracker data – power issues. Increased watercress growth around cross section.


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1
- HC-P1(04) was not flowing.
- HC-P1(05) was not flowing.
- Pond outlet (HC-P1(06)) was not flowing.

Site: Pond 2
- Pond outlet (HC-P2(07)) was not flowing.

Site: Pond 4
- HC-P4(05) was flowing. Sample and YSI were taken at outlet.


Pond 1: HC-P1(04) dry


Pond 1: Forebay looking toward HC-P1(05)

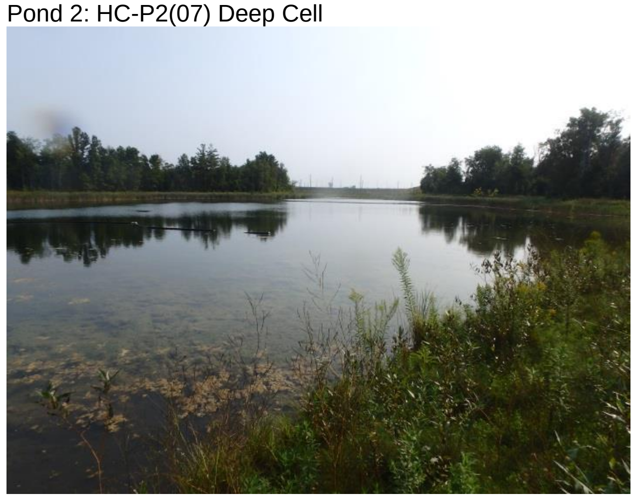

Pond 1: Main cell – access algae presense


Pond 1: HC-P1(05) Dry


Pond 2: HC-P2(07) Deep cell


Pond 2: HC-P2(07) Deep Cell


Pond 2: HC-P2(07) Not flowing


Pond 2: HC-P4(05) Deep Cell


Pond 4: HC-P4(05) Flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2013, High flow measurements		
Date	September 16, 2015	Project Number	60265453

Weather: Clear sky with a high of 27.3°C (recorded in Guelph).

Tasks:
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Andrew Minielly and Casey O'Driscoll

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	9/16/2015 10:16	17.2	805	4.28	7.04	-4.8
HC-A(04)	9/16/2015 10:22	13.06	540	8	7.13	-7.3
HC-A(06)	9/16/2015 10:34	16.99	747	2.1	7.57	-19.5
HC-A(10)	9/16/2015 11:33	14.54	1121	4.03	7.47	-16.7
HC-A(11)	9/16/2015 11:53	14.9	1149	7.22	7.43	-15.6
HC-A(12)	9/16/2015 12:57	16.35	1111	10.43	7.17	-8.5
HC-A(13)	9/16/2015 13:31	17.58	1160	7.48	7.64	-21.4
HC-A(14)	9/16/2015 14:00	18.1	1152	6.9	7.67	-22.3

Weather, General Conditions
Site: HC-A(03) Flow Tracker Filename: HC-A(03) 2015-09-16.WAD
Time: 2015/09/16 09:43:34 Measured Flow: Q= 0.00 m^3/s
Comments: Could not complete flow measurement due to low flow in the creek

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0		
0.2	0.6		
0.3	0.6		
0.4	0		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/09/16 10:01:20
Comments: None

Flow Tracker Filename: HC-A(04) 2015-09-16.WAD
Measured Flow: Q= 0.0041 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.55	0.09
0.25	0.13	0.60	0.08
0.30	0.14	0.65	0.06
0.35	0.14	0.80	0
0.40	0.14		
0.45	0.14		
0.50	0.09		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/09/16 10:38:48
Comments: None

Flow Tracker Filename: HC-A(06) 2015-09-16.WAD
Measured Flow: Q= 0.0042 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.06
0.20	0.04	0.65	0.06
0.30	0.04	0.70	0.06
0.40	0.50	0.80	0.06
0.50	0.04	0.90	0.06
0.55	0.04	1.10	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(10)
Flow Tracker Filename: HC-A(10) 2015-09-16.WAD
Time: 2015/09/16 11:10:39
Measured Flow: Q= 0.007 m^3/s
Comments: Increased watercress growth around cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.90	0.08
0.20	0.10	0.95	0.07
0.60	0.08	1.00	0.07
0.70	0.08	1.10	0.07
0.75	0.08	1.20	0.06
0.80	0.08	1.40	0
0.85	0.08		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Flow Tracker Filename: HC-A(11) 2015-09-16.WAD
Time: 2015/09/16 11:42:32
Measured Flow: Q= 0.0095 m^3/s
Comments: Increased watercress growth around cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.30	0.20
0.80	0.18	1.40	0.20
0.90	0.19	1.50	0.20
1.00	0.19	1.60	0.20
1.10	0.20	1.70	0.20
1.20	0.20	2.30	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/09/16 12:35:52
Comments: none

Flow Tracker Filename: HC-A(12) 2014-09-16.WAD
Measured Flow: Q= 0.0068 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.55	0.12
0.30	0.11	0.60	0.10
0.35	0.13	0.65	0.10
0.40	0.12	0.70	0.08
0.45	0.13	1.00	0
0.50	0.12		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Flow Tracker Filename: HC-A(13) 2015-09-16.WAD
Time: 2015/09/16 13:17:58
Measured Flow: Q= 0.0081 m^3/s
Comments: Increased watercress growth around cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.55	0.13
0.30	0.14	0.60	0.13
0.35	0.14	0.65	0.13
0.40	0.14	0.70	0.13
0.45	0.14	1.00	0
0.50	0.13		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 2015/09/16 13:46:54
Comments: Increased watercress growth around cross section

Flow Tracker Filename: HC-A(14) 2015-09-16.WAD
Measured Flow: Q= 0.0056 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.50	0.25
0.20	0.24	0.55	0.24
0.25	0.24	0.60	0.24
0.30	0.24	0.65	0.24
0.35	0.24	0.70	0.24
0.40	0.25	0.90	0
0.45	0.25		


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1	• HC-P1(04) was not flowing. • HC-P1(05) was not flowing. • Pond outlet (HC-P1(06)) was not flowing. • Lowered water level
Site: Pond 2	• Pond outlet (HC-P2(07)) was not flowing. • Lowered water level
Site: Pond 4	• HC-P4(05) was flowing. Sample and YSI were taken at outlet.


Pond 4: HC-P1(06) – Looking towards Main Cell


Looking towards HC-P1(06)


Pond 2: HC-P2(07) Deep cell – Lowered water level


Pond 2: HC-P2(07) Deep Cell – Lowered water level


Pond 2: HC-P2(07) Not flowing


Pond 2: HC-P4(05) Deep Cell


Pond 2: HC-P2(05) Not Flowing –algae present


Pond 2: HC-P4(05) Deep Cell

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Field/Sampling Report

Client: City of Guelph | Page 1

Project: Hanlon Creek Monitoring 2015, Wet day Grab Samples

Date: October 9, 2015 | Project Number: 60265453

Weather: Overcast, low of 2.3°C. Precipitation event overnight triggering high flows in the morning with total precipitation of 10.5 mm (recorded in Kitchener/Waterloo station).

Tasks:
- Water Samples
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(04)	10/9/2015 9:10	13.52	847	5.18		
HC-A(13)	10/9/2015 7:34	11.44	1092	7.54		
HC-A(14)	10/9/2015 8:21	11.55	1089	7.18		

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	10/9/2015 7:05	12.23	299	6.72		
HC-P1(05)	10/9/2015 7:21	12.56	457	6.82		
HC-P1(06)	10/9/2015 7:13	13.71	1287	5.52		
HC-P2(04)	10/9/2015 8:31	13.93	300	5.07		
HC-P2(05)	10/9/2015 8:41	13.42	881	4.73		
HC-P2(06)	10/9/2015 8:47	13.94	487	6.82		
HC-P2(07)	10/9/2015 7:41	13.24	447	3.49		
HC-P4(04)	10/9/2015 6:53	12.39	200	6.51		
HC-P4(05)	10/9/2015 9:01	13.65	859	8.02		

* pH removed due to faulty sensor

Weather, General Conditions
Site: HC-A(04)
Time: 10/09/2015 09:10
Comments: None


Looking Upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 10/09/2015 07:34
Comments: Increased watercress growth around cross section.


Looking Upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 10/09/2015 08:21
Comments: Increased watercress growth around cross section.


Looking Upstream

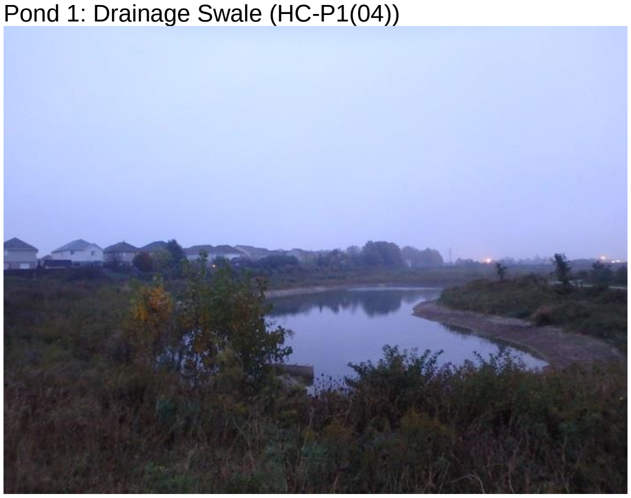

Looking downstream


Looking across stream

Site: Pond 1	• HC-P1(04) was flowing at inlet. Sample and YSI were taken at the inlet. • HC-P1(05) had some flow. Sample and YSI were taken in channel. • Pond outlet (HC-P1(06)) was not flowing. Samples and YSI were taken at pond.
Site: Pond 2	• Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond. • HC-P2(06) was not flowing. Sample and YSI were taken at pond. • HC-P2(05) was flowing. Sample and YSI were taken at inlet. • HC-P2(04) is backwatered. Sample and YSI were taken at inlet.
Site: Pond 4	• HC-P4(04) was flowing. Sample and YSI were taken in channel. • HC-P4(05) was flowing higher than normal. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing


Pond 1: Main cell looking toward HC-P1(04)


Pond 1: Main cell looking toward HC-P1(04) – lowered water level


Pond 1: Looking towards HC-P1(04)


Pond 1: Looking towards HC-P1(05)


Pond 2: Deep Cell looking from HC-P2(07)


Pond 2: HC-P2(07) not flowing


Pond 2: (HC-P2(04)) flowing


Pond 2: HC-P2(04) looking toward forebay

Pond 2: HC-P2(05)) flowing

Pond 2: HC-P2(05) looking toward forebay – lowered water level

Pond 2: Drainage Swale (HC-P2(06))

Pond 4: Pond Outlet (HC-P4(05)) flowing

Pond 4: Pond Outlet (HC-P4(05)) flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Wet day Grab Samples		
Date	October 28, 2015	Project Number	60265453

Weather: Overcast, low of 7.5°C. Precipitation event triggering high flows in the morning with total rainfall of 29.9 mm (recorded at Kitchener/Waterloo station).

Tasks:

- Water Samples
- YSI measurements
- Photos

Field Crew: Steven Scott and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(04)	10/28/2015 14:48	9.84	731	10.31	7.26	-39
HC-A(13)	10/28/2015 15:32	8.74	791	10.06	7.28	-39.9
HC-A(14)	10/28/2015 15:43	8.79	776	9.76	7.31	-41.9

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	10/28/2015 15:07	9.72	161	9.31	7.22	-36.7
HC-P1(05)	10/28/2015 15:23	10.2	207	9.71	7.27	-39.6
HC-P1(06)	10/28/2015 15:16	9.07	1062	10.4	7.39	-46.2
HC-P2(04)	10/28/2015 15:54	11.41	75	11.08	6.84	-14.7
HC-P2(05)	10/28/2015 16:02	10.04	453	8.5	6.77	-10.8
HC-P2(06)	10/28/2015 16:11	9.48	431	10.98	7.77	-68.3
HC-P2(07)	10/28/2015 15:37	9.69	256	10.98	7.36	-44.8
HC-P4(04)	10/28/2015 14:27	10.11	106	11.44	7.12	-30.9
HC-P4(05)	10/28/2015 14:38	9.58	765	13.46	7.74	-66.2

Weather, General Conditions
Site: HC-A(04)
Time: 10/28/2015 15:49:28
Comments: None


Looking Upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Time: 10/28/2015 16:44:42
Comments: None


Looking Upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 10/28/2015 16:32:32
Comments: None


Looking Upstream


Looking downstream


Looking across stream

Site: Pond 1
- HC-P1(04) was flowing at inlet. Sample and YSI were taken at the inlet.
- HC-P1(05) was flowing. Sample and YSI were taken in channel.
- Pond outlet (HC-P1(06)) was not flowing. Samples and YSI were taken at pond.

Site: Pond 2
- Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond.
- HC-P2(06) was flowing. Sample and YSI were taken in channel.
- HC-P2(05) was flowing. Sample and YSI were taken at inlet.
- HC-P2(04) is backwatered. Sample and YSI were taken at inlet.

Site: Pond 4
- HC-P4(04) was flowing. Sample and YSI were taken in channel.
- HC-P4(05) was flowing higher than normal. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) flowing


Pond 1: Forebay looking toward HC-P1(04)


Pond 1: Main cell looking toward HC-P1(04)


Pond 1: Drainage swale HC-P1(05)


Pond 1: Looking towards HC-P1(05)


Pond 2: Deep Cell looking from HC-P2(07)


Pond 2: Deep Cell


Pond 2: (HC-P2(04)) flowing


Pond 2: HC-P2(04) looking toward forebay


Pond 2: HC-P2(05)) flowing


Pond 2: HC-P2(05) looking toward forebay


Pond 2: Drainage Swale (HC-P2(06))


Pond 4: Pond Outlet (HC-P4(05)) flowing


Pond 4: Pond Outlet (HC-P4(05)) flowing

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Baseflow and Dry Samples		
Date	November 4, 2015	Project Number	60265453

Weather: Clear day with a high of 21.0°C and a low of 2.6°C. No rainfall recorded in the last 72 hours of the sampling day (recorded in Guelph Turfgrass station).

Tasks:

- Flow Measurements
- YSI measurements
- Water Samples
- Photos
- Loggers download

Field Crew: Andrew Minielly and Angus Keir

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	11/4/2015 10:56	7.91	666	9.7	6.34	14.8
HC-A(04)	11/4/2015 11:44	9.82	780	8.71	6.53	4.2
HC-A(06)	11/4/2015 12:17	9.92	799	10.34	7.02	-22.9
HC-A(10)	11/4/2015 12:49	9.11	1050	10.01	7.22	-33.8
HC-A(11)	11/4/2015 13:29	9.53	1049	9.1	7.39	-43.2
HC-A(12)	11/4/2015 14:41	9.89	1007	10.45	7.31	-39.1
HC-A(13)	11/4/2015 16:18	10.19	1051	10.19	7.29	-38.1
HC-A(14)	11/4/2015 16:38	10.2	1052	10.51	7.43	-45.9

Weather, General Conditions
Site: HC-A(03) Flow Tracker Filename: HC-A(03) 2015-11-04.WAD
Time: 2015/11/04 10:49:41 Measured Flow: Q= 0.0019 m^3/s
Comments: Wires for HC-A(03)'s telemetry station were found to be cut. Depth data will be taken from the backup U20 logger present onsite.

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.55	0.09
0.20	0.06	0.60	0.09
0.30	0.08	0.65	0.05
0.40	0.08	0.90	0
0.45	0.10		
0.50	0.11		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/11/04 11:27:41
Comments: None

Flow Tracker Filename: HC-A(04) 2015-11-04.WAD
Measured Flow: Q= 0.0107 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.55	0.16
0.20	0.12	0.60	0.16
0.30	0.15	0.65	0.16
0.40	0.16	0.70	0.16
0.45	0.17	0.80	0.11
0.50	0.16	1.20	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/11/04 12:10:06
Comments:

Flow Tracker Filename: HC-A(06) 2015-11-04.WAD
Measured Flow: Q= 0.0119 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.65	0.10
0.15	0.08	0.75	0.10
0.25	0.08	0.85	0.09
0.35	0.08	0.95	0.09
0.45	0.08	1.15	0
0.55	0.08		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(10)
Time: 2015/11/04 12:40:23
Comments: None

Flow Tracker Filename: HC-A(10) 2015-11-04.WAD
Measured Flow: Q= 0.0174 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.85	0.16
0.25	0.16	0.95	0.14
0.35	0.17	1.05	0.14
0.45	0.17	1.15	0.14
0.55	0.16	1.25	0.14
0.65	0.16	1.35	0
0.75	0.16		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/11/04 13:14:33
Flow Tracker Filename: HC-A(11) 2015-11-04.WAD
Measured Flow: Q= 0.0183 m^3/s
Comments: Cross section moved to culvert opening due to watercress growth at previous cross section location

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.80	0.21
0.20	0.23	2.00	0.21
0.40	0.22	2.20	0.22
0.60	0.19	2.40	0.22
0.80	0.20	2.60	0.22
1.00	0.20	2.80	0.22
1.20	0.20	3.00	0.18
1.40	0.20	3.20	0.16
1.60	0.21	3.80	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/11/04 14:33:23
Comments: none

Flow Tracker Filename: HC-A(12) 2015/11/04.WAD
Measured Flow: Q= 0.0177 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.40	0.34
0.10	0.20	0.45	0.33
0.15	0.20	0.50	0.34
0.20	0.26	0.55	0.34
0.25	0.32	0.80	0.14
0.30	0.32	1.10	0
0.35	0.33		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 2015/11/04 15:57:08
Comments: Pictures not available

Flow Tracker Filename: HC-A(13) 2015-11-04.WAD
Measured Flow: Q= 0.0172 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.80	0.22
0.50	0.18	0.85	0.20
0.55	0.18	0.90	0.20
0.60	0.20	0.95	0.20
0.65	0.21	1.00	0.20
0.70	0.21	1.60	0
0.75	0.21		

Weather, General Conditions
Site: HC-A(14)
Time: 2015/11/04 16:24:35
Comments: none

Flow Tracker Filename: HC-A(14) 2015-11-04.WAD
Measured Flow: Q= 0.0197 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.85	0.28
0.50	0.28	0.90	0.29
0.60	0.30	0.95	0.29
0.65	0.29	1.00	0.29
0.70	0.30	1.05	0.27
0.75	0.30	1.10	0.26
0.80	0.30	1.50	0


Looking upstream


Looking downstream


Looking across stream

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Site: Pond 1
- HC-P1(04) was not flowing. Sample taken in the pond.
- HC-P1(05) was flowing. Sample taken in the pond.
- Pond outlet (HC-P1(06)) was not flowing.

Site: Pond 2
- Pond outlet (HC-P2(07)) was not flowing.

Site: Pond 4
- HC-P4(05) was flowing.
- Sample taken at the inlet.


Pond 1: Drainage Swale (HC-P1(04))

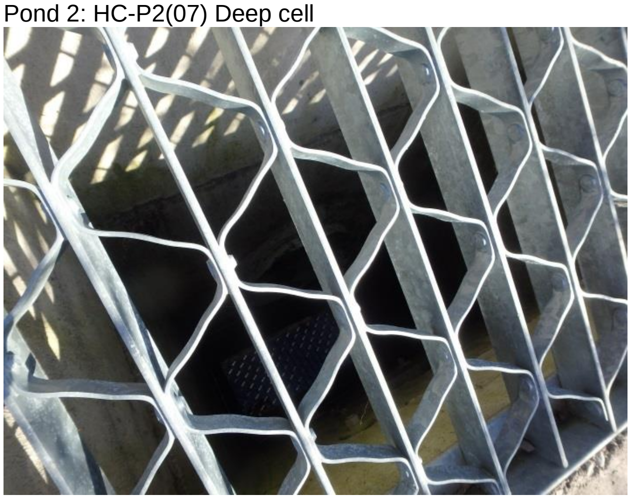

Pond 1: HC-P1(04) not flowing


Pond 1: HC-P1(05) flowing


Pond 1: Drainage Swale (HC-P1(05))


Pond 2: HC-P2(07) Deep cell


Pond 2: HC-P2(07) Deep Cell


Pond 2: HC-P2(07) Not flowing


Pond 2: HC-P4(05) Deep Cell


Pond 4: HC-P4(05) Flowing


Pond 4: Cooling Trench

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Field/Sampling Report

Client	City of Guelph	Page	1
Project	Hanlon Creek Monitoring 2015, Base flow measurements		
Date	November 18, 2015	Project Number	60265453

Weather: Clear with a high of 14.7°C and low of 7.0°C (recorded in Guelph).

Tasks:
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Andrew Minielly and Sachet Siwakoti

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond* (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	11/18/15 11:23:17	8.85		10.23	7.59	-33.0
HC-A(04)	11/18/15 11:48:31	8.68		8.84	7.46	-25.4
HC-A(06)	11/18/15 12:36:03	8.90		11.56	7.51	-28.6
HC-A(10)	11/18/15 14:41:00	9.63		10.79	7.68	-38.0
HC-A(11)	11/18/15 15:09:53	9.48		10.98	7.46	-25.6
HC-A(12)	11/18/15 15:42:15	9.42		11.10	7.49	-27.2
HC-A(13)	11/18/15 16:16:42	9.48		11.04	7.56	-31.0
HC-A(14)	11/18/15 16:41:58	9.50		10.93	7.56	-31.5

*Conductivity removed due to calibration issue

Weather, General Conditions
Site: HC-A(03)
Time: 2015/11/18 11:21:02
Comments: None

Flow Tracker Filename: HC-A(03) 2015-11-18.WAD
Measured Flow: Q= 0.0015 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.40	0.08
0.10	0.05	0.45	0.09
0.20	0.06	0.50	0.09
0.25	0.06	0.55	0.09
0.30	0.06	0.60	0.08
0.35	0.07	0.80	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/11/18 11:47:47
Comments: None

Flow Tracker Filename: HC-A(04) 2015-11-18.WAD
Measured Flow: Q= 0.0119 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.14
0.40	0.15	0.75	0.14
0.45	0.15	0.80	0.10
0.50	0.15	0.85	0.09
0.55	0.16	0.90	0.05
0.60	0.16	0.95	0
0.65	0.14		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/11/18 12:38:14
Comments: none

Flow Tracker Filename: HC-A(06) 2015-11-18.WAD
Measured Flow: Q= 0.0089 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.09
0.20	0.07	0.80	0.08
0.30	0.07	0.90	0.09
0.40	0.07	1.00	0.08
0.50	0.07	1.05	0.08
0.60	0.08	1.15	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(10)
Flow Tracker Filename: HC-A(10) 2015-11-18.WAD
Time: 2015/11/18 14:43:11
Measured Flow: Q= 0.0134 m^3/s
Comments: Cross section shifted 1 m up stream due to watercress

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.10	0.12
0.30	0.13	1.20	0.10
0.40	0.12	1.30	0.10
0.50	0.12	1.40	0.10
0.60	0.12	1.50	0.10
0.70	0.10	1.60	0.09
0.80	0.10	1.70	0.07
0.90	0.10	1.80	0.06
1.00	0.11	2.00	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Time: 2015/11/18 15:07:58
Flow Tracker Filename: HC-A(11) 2015-11-18.WAD
Measured Flow: Q= 0.0152 m^3/s
Comments: Cross section taken at culvert due to watercress

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	2.10	0.18
0.30	0.22	2.40	0.18
0.60	0.20	2.70	0.20
0.90	0.18	3.00	0.18
1.20	0.17	3.30	0.16
1.50	0.17	3.60	0
1.80	0.19		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/11/18 15:35:12
Comments: none

Flow Tracker Filename: HC-A(12) 2015-11-18.WAD
Measured Flow: Q= 0.0186 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.45	0.31
0.15	0.34	0.55	0.26
0.20	0.30	0.65	0.14
0.25	0.34	0.75	0.10
0.30	0.33	0.85	0.12
0.35	0.33	1.05	0
0.40	0.30		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13)
Time: 2015/11/18 16:16:14
Comments: Pictures not available

Flow Tracker Filename: HC-A(12) 2015-11-18.WAD
Measured Flow: Q= 0.0098 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.65	0.20
0.20	0.16	0.70	0.20
0.40	0.18	0.75	0.20
0.45	0.18	0.80	0.20
0.50	0.18	1.00	0.18
0.55	0.19	1.40	0
0.60	0.19		

Weather, General Conditions
Site: HC-A(14)
Time: 2015/11/18 16:42:13
Comments: Pictures not available

Flow Tracker Filename: HC-A(14) 2015-11-18.WAD
Measured Flow: Q= 0.0181 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.28
0.40	0.24	0.75	0.28
0.45	0.27	0.80	0.28
0.50	0.28	0.85	0.27
0.55	0.28	0.90	0.27
0.60	0.28	1.50	0
0.65	0.29		

Site: Pond 1	• HC-P1(04) was not flowing. • HC-P1(05) was flowing. • Pond outlet (HC-P1(06)) was not flowing.
Site: Pond 2	• Pond outlet (HC-P2(07)) was not flowing.
Site: Pond 4	• HC-P4(05) was flowing.


Pond 1: HC-P1(04) drainage swale not flowing


Pond 1: HC-P1(04) not flowing


Pond 1: HC-P1(06) main cell


Pond 1: HC-P1(05) flowing


Pond 2: HC-P1(05) drainage swale


Pond 2: Looking towards HC-P1(04)


Pond 2: HC-P2(07) Deep cell


Pond 2: HC-P2(07) Deep Cell


Pond 4: HC-P4(05) deep cell


Pond 4: HC-P4(05) Flowing

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Field/Sampling Report

Client City of Guelph

Page 1

Project Hanlon Creek Monitoring 2015, High flow measurements

Date November 27, 2015

Project Number 60265453

Weather: Overcast/partial cloudiness, low of 0.4°C. Precipitation event triggering high flows in the morning of November 27, 2015 with total precipitation of 7.6 mm (recorded in Kitchener/Waterloo station).

Tasks:

- Water Samples
- Flow Measurements
- YSI measurements
- Photos

Field Crew: Sachet Siwakoti and Andrew Minielly

YSI Results:

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-A(03)	11/27/15 09:37:50	8.98	453	9.80	6.92	4.6
HC-A(04)	11/27/15 10:01:21	7.32	815	9.81	6.93	3.7
HC-A(06)	11/27/15 10:35:05	7.67	837	11.10	6.82	9.8
HC-A(10)	11/27/15 11:06:59	8.61	1068	10.23	6.93	4.1
HC-A(11)	11/27/15 11:19:34	8.33	1091	8.56	6.89	6.1
HC-A(12)	11/27/15 12:01:17	8.64	1060	10.92	6.95	2.9
HC-A(13)	11/27/15 12:37:33	8.42	1069	10.38	6.97	1.8
HC-A(14)	11/27/15 12:53:49	8.44	1058	10.46	6.89	6.3

Site	DateTime (M/D/Y H:M)	Temp (°C)	SpCond (uS/cm)	DO Conc (mg/L)	pH	pH (mV)
HC-P1(04)	11/27/15 12:14:03	8.53	2108	8.88	6.62	21.4
HC-P1(05)	11/27/15 11:44:26	9.69	1142	9.86	6.90	5.7
HC-P1(06)	11/27/15 11:53:35	6.89	1058	11.26	6.91	5.3
HC-P2(04)	11/27/15 13:10:14	8.16	483	9.30	6.98	0.9
HC-P2(05)	11/27/15 13:17:08	8.96	3142	15.97	6.76	13.3
HC-P2(06)	11/27/15 13:23:19	7.49	410	13.86	6.96	2.2
HC-P2(07)	11/27/15 12:28:22	8.92	215	10.89	6.96	2.2
HC-P4(04)	11/27/15 13:31:47	10.13	1354	10.21	7.03	-1.9
HC-P4(05)	11/27/15 10:20:09	5.42	862	14.22	6.94	3.4

Weather, General Conditions
Site: HC-A(03)
Time: 2015/11/27 09:39:59
Comments: None

Flow Tracker Filename: HC-A(03) 2015-11-27.WAD
Measured Flow: Q= 0.0029 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.40	0.11
0.10	0.08	0.45	0.10
0.20	0.08	0.50	0.10
0.25	0.07	0.55	0.09
0.30	0.08	0.60	0.07
0.35	0.09	0.75	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(04)
Time: 2015/11/27 10:01:02
Comments: None

Flow Tracker Filename: HC-A(04) 2015-11-27.WAD
Measured Flow: Q= 0.0131 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.17
0.30	0.12	0.80	0.15
0.40	0.14	0.90	0.14
0.50	0.14	1.00	0.10
0.60	0.14	1.10	0.09
0.65	0.16	1.20	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(06)
Time: 2015/11/27 10:36:25
Comments: None

Flow Tracker Filename: HC-A(06) 2015-11-27.WAD
Measured Flow: Q= 0.0090 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.65	0.10
0.25	0.08	0.75	0.10
0.35	0.08	0.85	0.10
0.45	0.08	0.95	0.11
0.50	0.08	1.05	0.10
0.55	0.08	1.20	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(10)
Time: 2015/11/27 11:02:07
Comments: None

Flow Tracker Filename: HC-A(10) 2015-11-27.WAD
Measured Flow: Q= 0.0166 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	1.00	0.12
0.30	0.12	1.20	0.12
0.50	0.12	1.40	0.10
0.70	0.11	1.60	0.10
0.80	0.11	1.80	0.08
0.90	0.10	2.10	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(11)
Flow Tracker Filename: HC-A(11) 2015-11-27.WAD
Time: 2015/11/27 11:19:24
Measured Flow: Q= 0.0219 m^3/s
Comments: Cross section taken at culvert due to watercress downstream

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	2.20	0.20
0.20	0.26	2.60	0.23
0.60	0.21	3.00	0.22
1.00	0.20	3.40	0.18
1.40	0.20	3.60	0.20
1.80	0.21	3.80	0


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(12)
Time: 2015/11/27 11:51:17
Comments: Inundation occurring

Flow Tracker Filename: HC-A(12) 2015-11-27.WAD
Measured Flow: Q= 0.0199 m^3/s

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.60	0.24
0.30	0.36	0.65	0.24
0.35	0.36	0.70	0.21
0.40	0.36	0.90	0.15
0.45	0.36	1.10	0.15
0.50	0.36	1.20	0
0.55	0.34		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(13) Flow Tracker Filename: HC-A(13) 2015-11-27.WAD
Time: 2015/11/27 12:29:43 Measured Flow: Q= 0.0165 m^3/s
Comments: Large watercress population along both banks of cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.55	0.22
0.25	0.20	0.60	0.23
0.30	0.19	0.65	0.23
0.35	0.22	0.70	0.23
0.40	0.22	1.00	0.21
0.45	0.22	1.40	0
0.50	0.22		


Looking upstream


Looking downstream


Looking across stream

Weather, General Conditions
Site: HC-A(14)
Flow Tracker Filename: HC-A(14) 2015-11-27.WAD
Time: 2015/11/27 10:49:41
Measured Flow: Q= 0.0019 m^3/s
Comments: Large watercress population along both banks of cross section

Distance from Edge of Creek (m)	Water Depth (m)	Distance from Edge of Creek (m)	Water Depth (m)
0	0	0.70	0.32
0.30	0.24	0.75	0.32
0.40	0.29	0.80	0.32
0.50	0.31	1.00	0.28
0.55	0.31	1.20	0.26
0.60	0.32	1.70	0
0.65	0.32		


Looking upstream


Looking downstream


Looking across stream

Site: Pond 1
- HC-P1(04) was not flowing. Samples and YSI were taken at the pond.
- HC-P1(05) was flowing. Samples and YSI were taken in channel.
- Pond outlet (HC-P1(06)) was not flowing. Samples and YSI were taken at the pond.

Site: Pond 2
- Pond outlet (HC-P2(07)) was not flowing. Samples and YSI were taken at pond.
- HC-P2(04) had visible flow (normally backwatered/stagnant). Sample and YSI were taken at inlet.
- HC-P2(05) had visible flow (normally backwatered/stagnant). Sample and YSI were taken at inlet.
- HC-P2(06) was not flowing. Small pocket of water pool in the channel. Sample and YSI were taken at pond.

Site: Pond 4
- HC-P4(04) was flowing. Sample and YSI were taken in channel.
- HC-P4(05) was flowing. Sample and YSI were taken at outlet.


Pond 1: Drainage Swale (HC-P1(04))


Pond 1: HC-P1(04) not flowing


Pond 1: Forebay looking toward HC-P1(04)


Pond 1: Forebay looking toward HC-P1(05)

Pond 1: Drainage Swale (HC-P1(05))

Pond 1: HC-P1(05) flowing

Pond 1: Pond Outlet (HC-P1(06)) not flowing

Pond 1: Pond Outlet (HC-P1(06)) and Deep Cell

Pond 2: HC-P2(04)) backwatered - flowing

Pond 2: HC-P2(04) looking toward forebay


Pond 2: Inlet (HC-P2(05)) flowing


Pond 2: Deep Cell


Pond 2: Drainage swale (HC-P2(06)) not flowing


Pond 4: HC-P4(04) looking upstream


Pond 4: HC-P4(04) looking downstream


Pond 4: HC-P4(04) looking across


Pond 4: HC-P4(06)) drainage swale outlet flowing

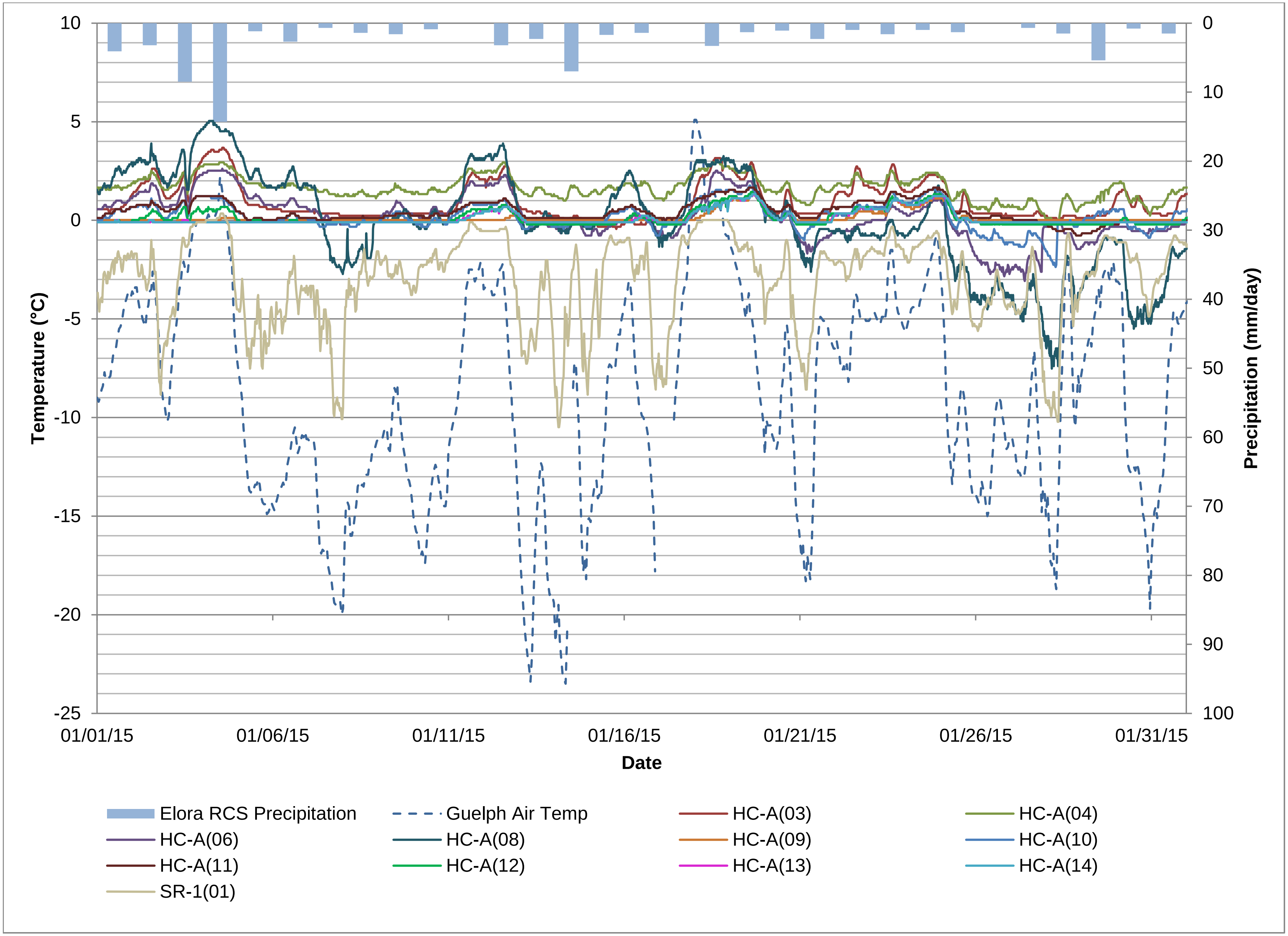

Pond 4: Cooling trench – looking towards HC-P4(06)


Pond 4: Pond Outlet (HC-P4(05)) flowing

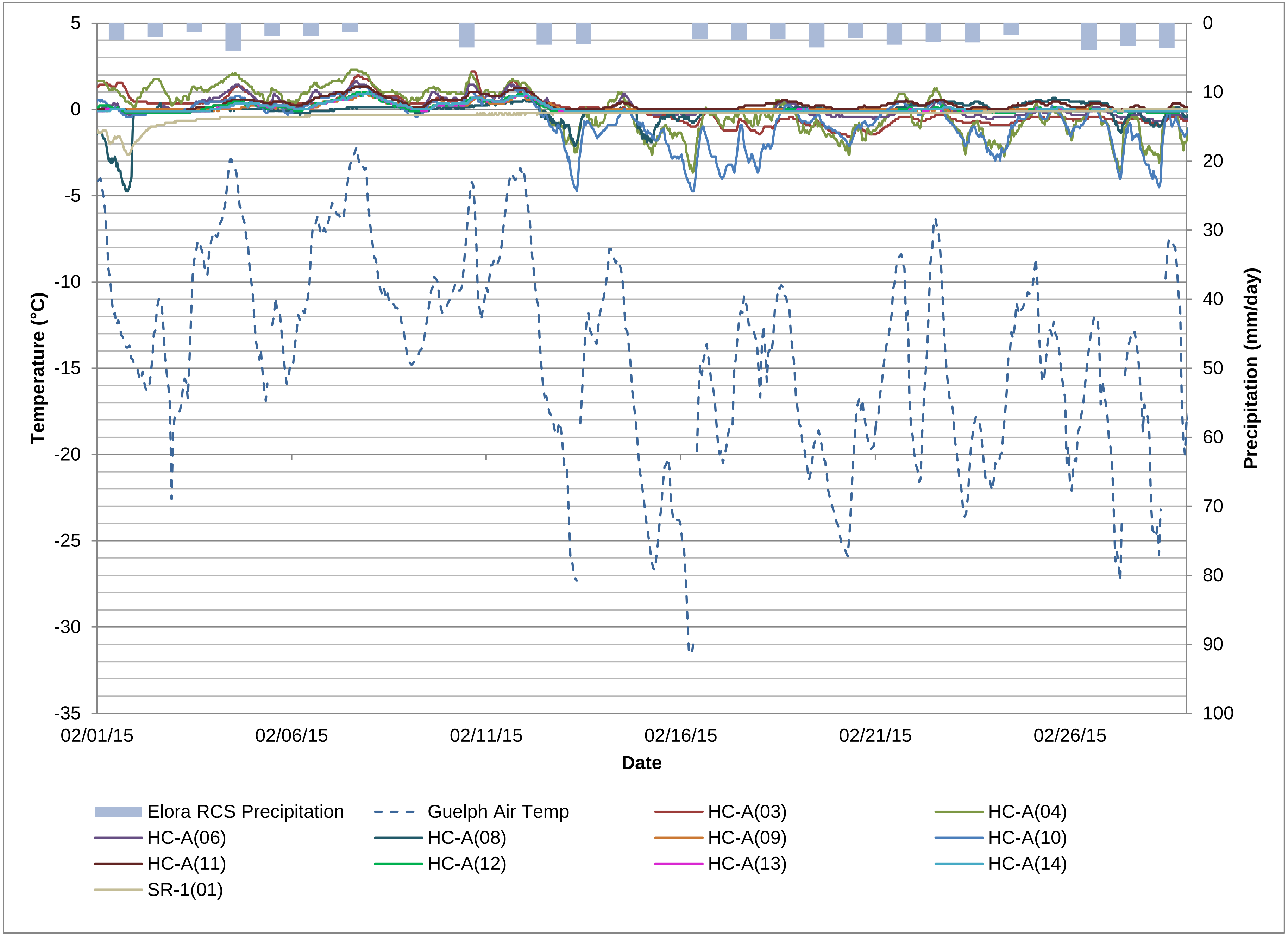

Pond 4: Main cell looking toward HC-P4(04)

Appendix B

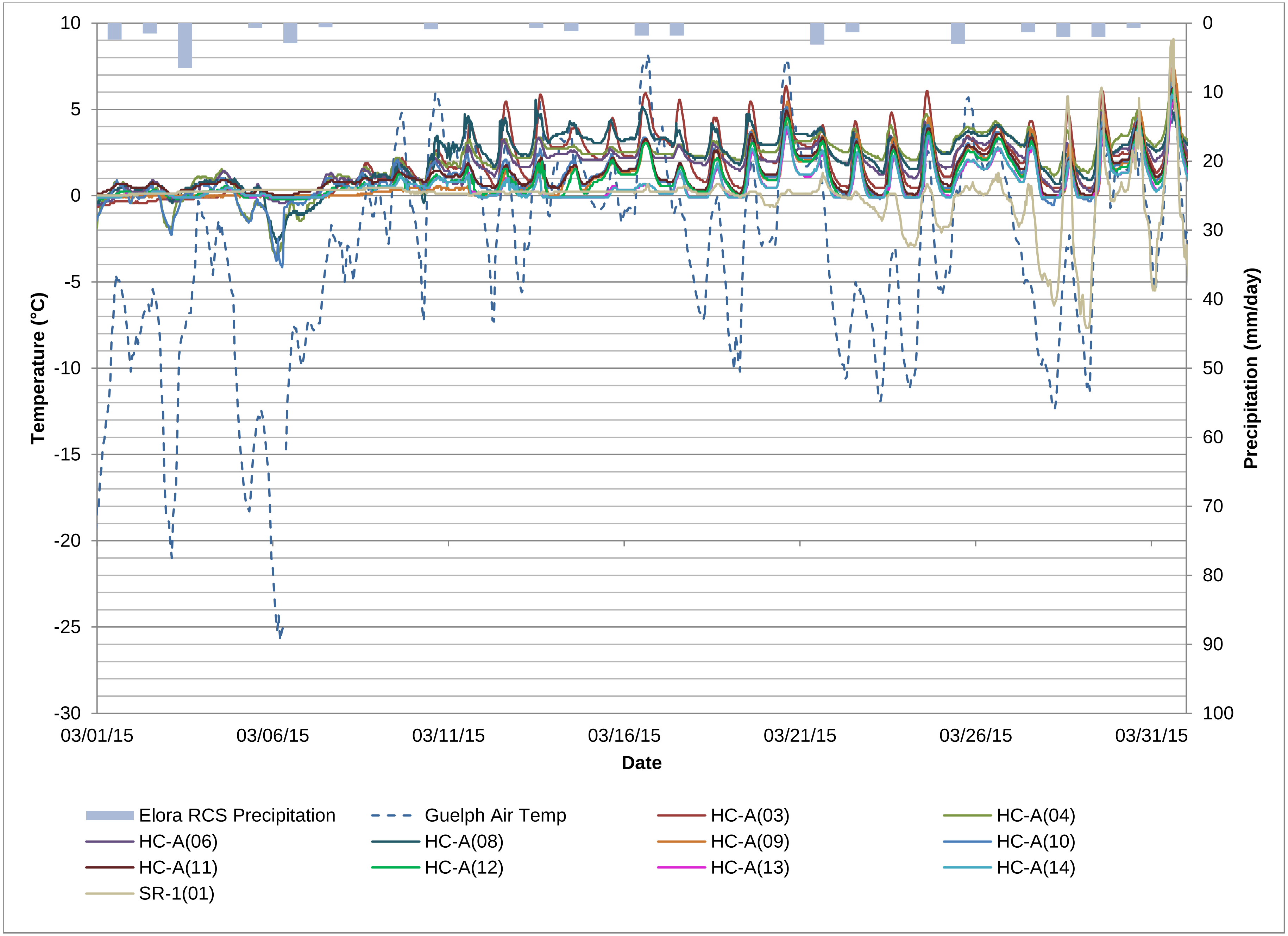
Monthly Temperature Plots



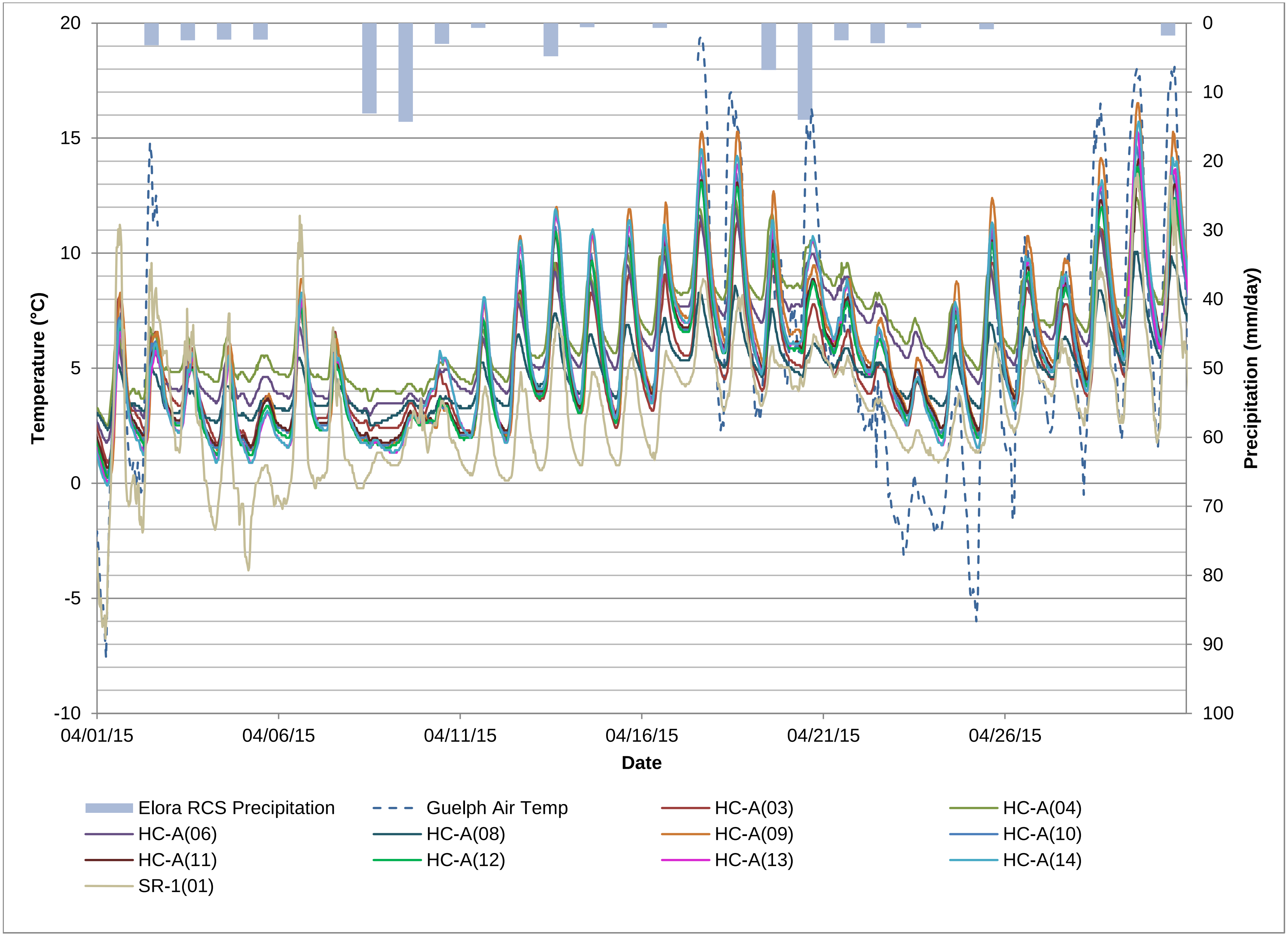
10
5
0
-5
-10
-15
-20
-25
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
100
Precipitation (mm/day)
01/01/15
01/06/15
01/11/15
01/16/15
01/21/15
01/26/15
01/31/15
Date
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)



5
0
-5
-10
-15
-20
-25
-30
-35
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
100
Precipitation (mm/day)
02/01/15
02/06/15
02/11/15
02/16/15
02/21/15
02/26/15
Date
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)



10
5
0
-5
-10
-15
-20
-25
-30
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
100
Precipitation (mm/day)
03/01/15
03/06/15
03/11/15
03/16/15
03/21/15
03/26/15
03/31/15
Date
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)



Temperature (°C)
Precipitation (mm/day)
Date
20
15
10
5
0
-5
-10
0
10
20
30
40
50
60
70
80
90
100
04/01/15
04/06/15
04/11/15
04/16/15
04/21/15
04/26/15
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
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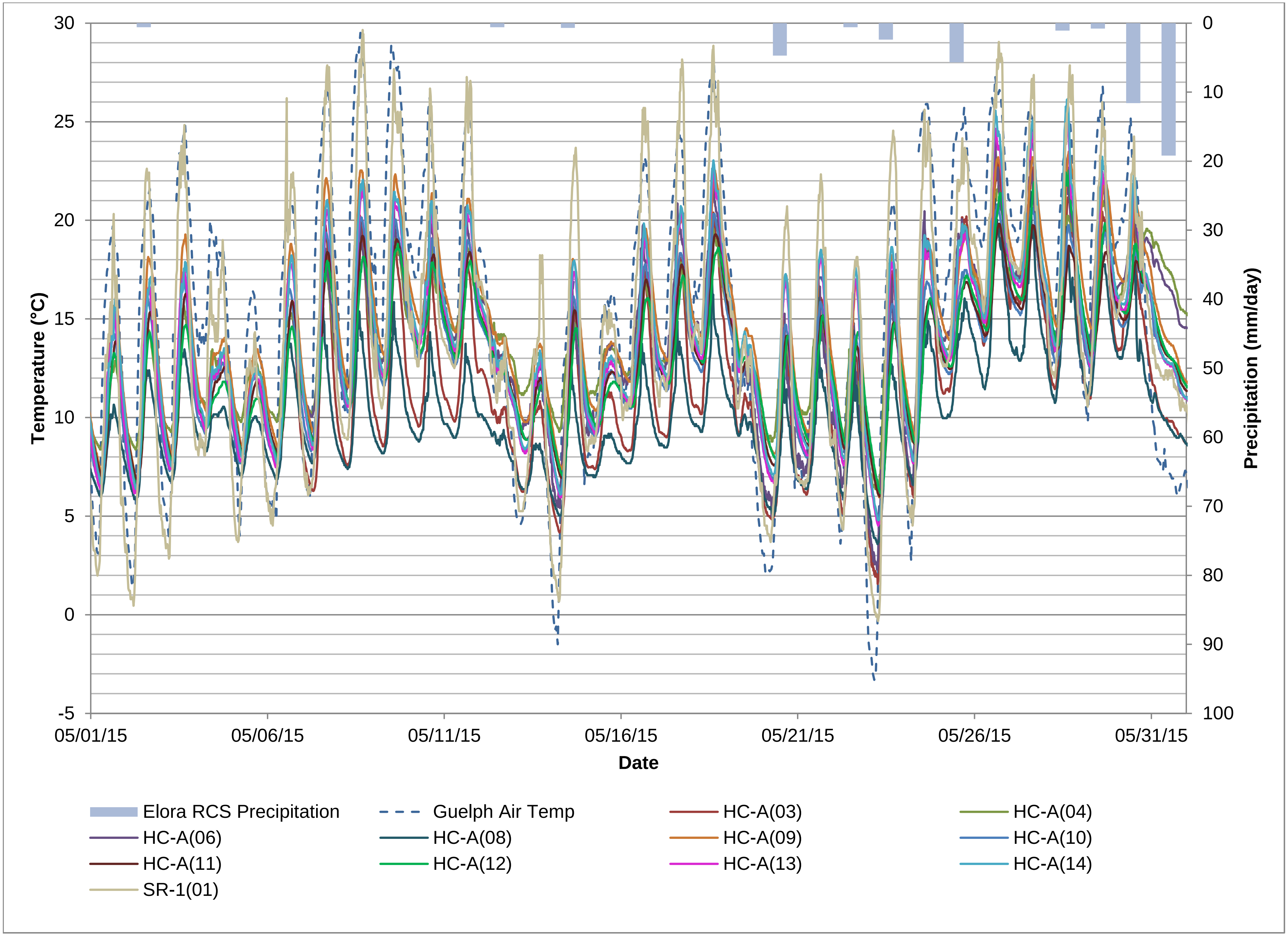
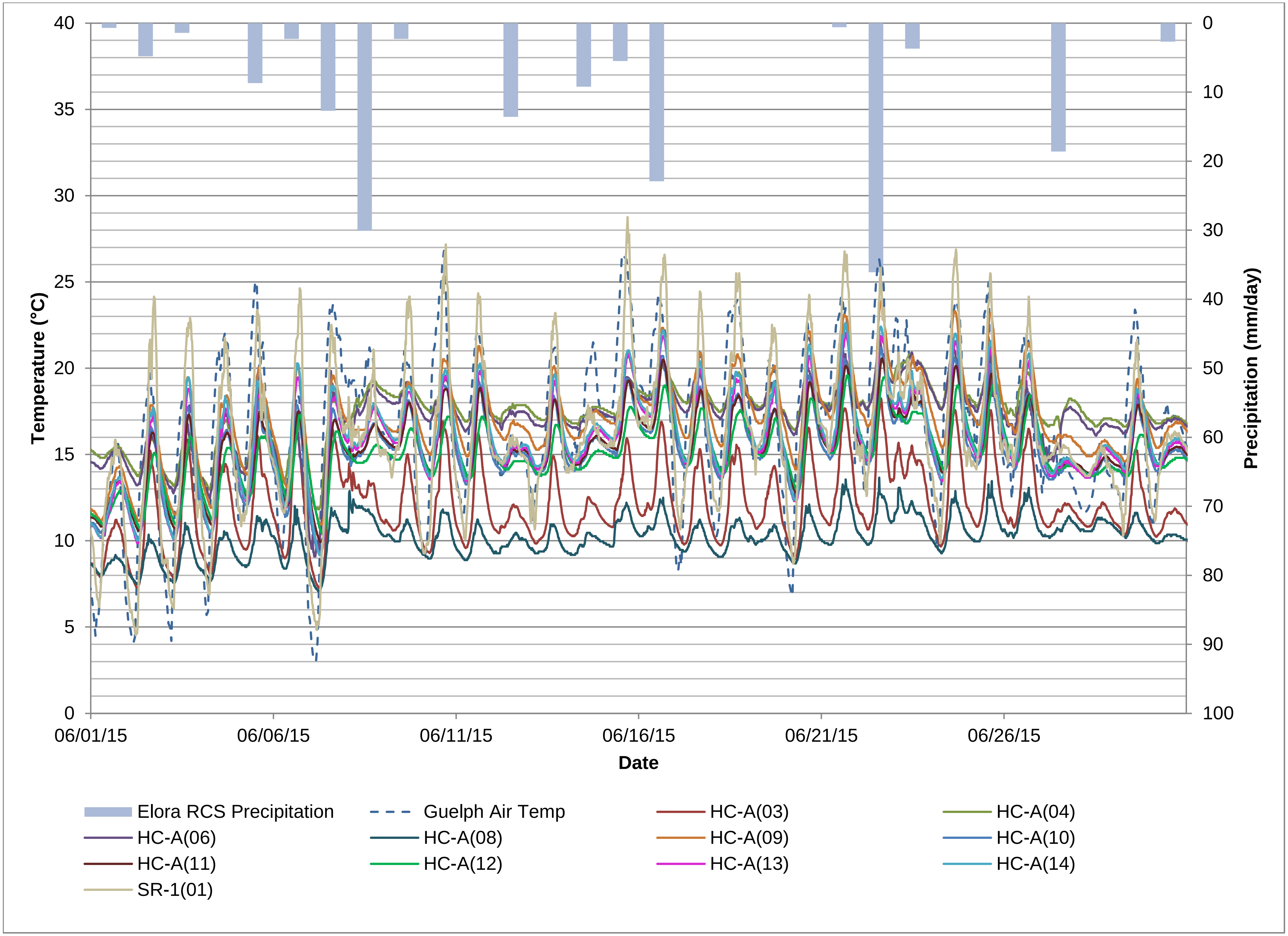
HC-A(14)
SR-1(01)



Temperature (°C)
Precipitation (mm/day)
Date
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
60
70
80
90
100
05/01/15
05/06/15
05/11/15
05/16/15
05/21/15
05/26/15
05/31/15
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)



Temperature (°C)
Precipitation (mm/day)
Date
06/01/15
06/06/15
06/11/15
06/16/15
06/21/15
06/26/15
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
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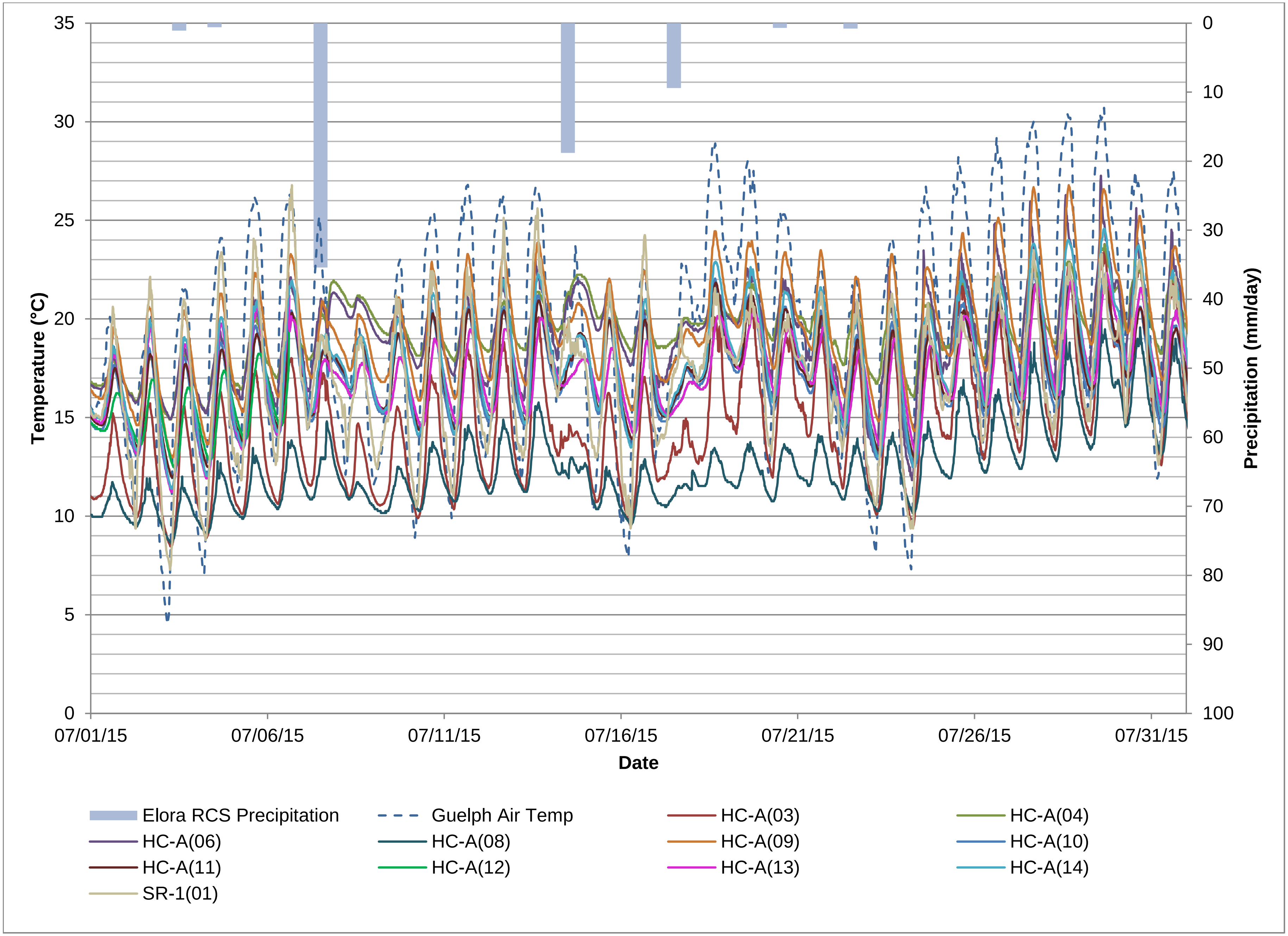
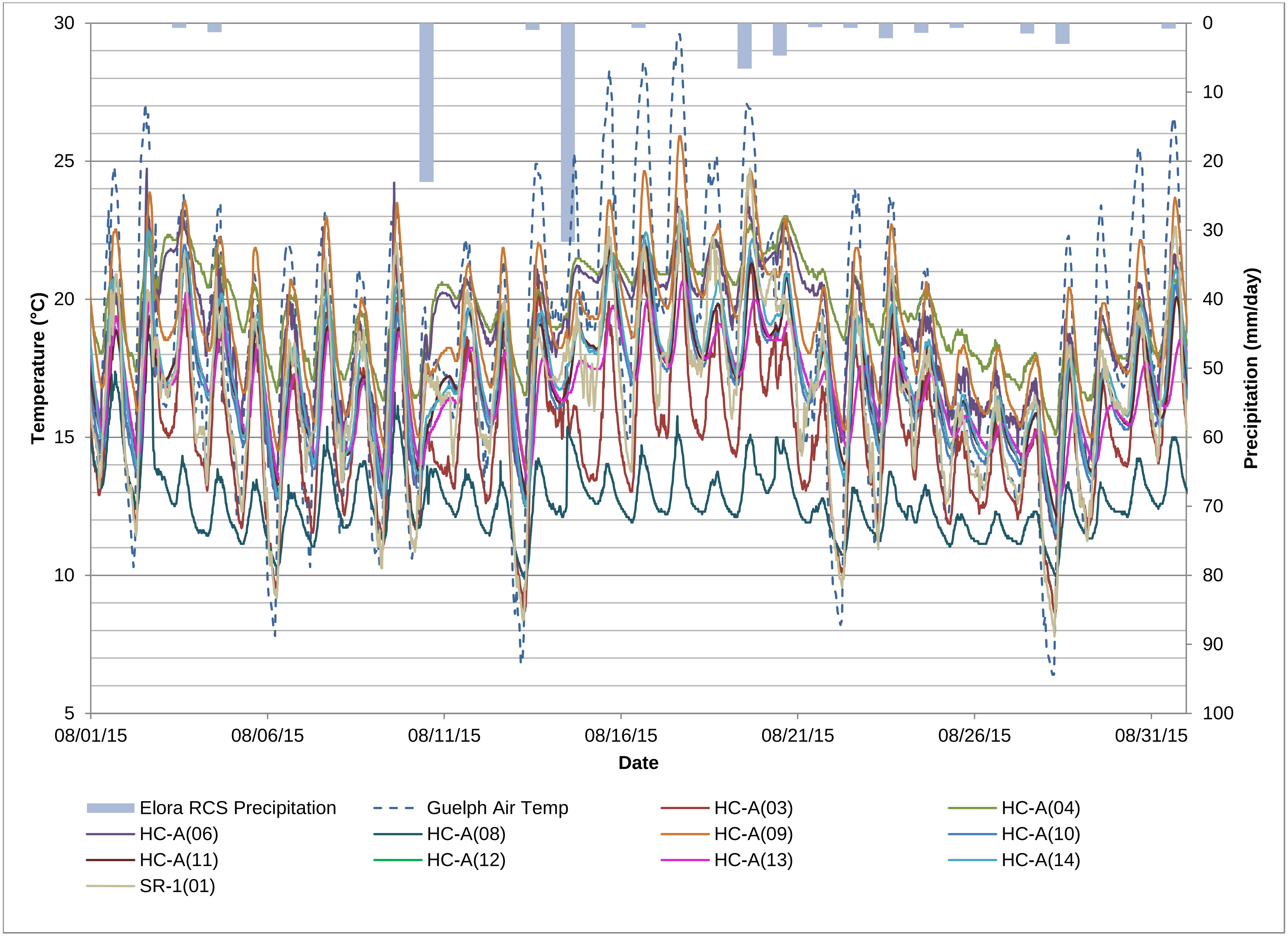
HC-A(14)
SR-1(01)



Temperature (°C)
Precipitation (mm/day)
Date
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
07/01/15
07/06/15
07/11/15
07/16/15
07/21/15
07/26/15
07/31/15
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)



Temperature (°C)
Precipitation (mm/day)
Date
30
25
20
15
10
5
0
10
20
30
40
50
60
70
80
90
100
08/01/15
08/06/15
08/11/15
08/16/15
08/21/15
08/26/15
08/31/15
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
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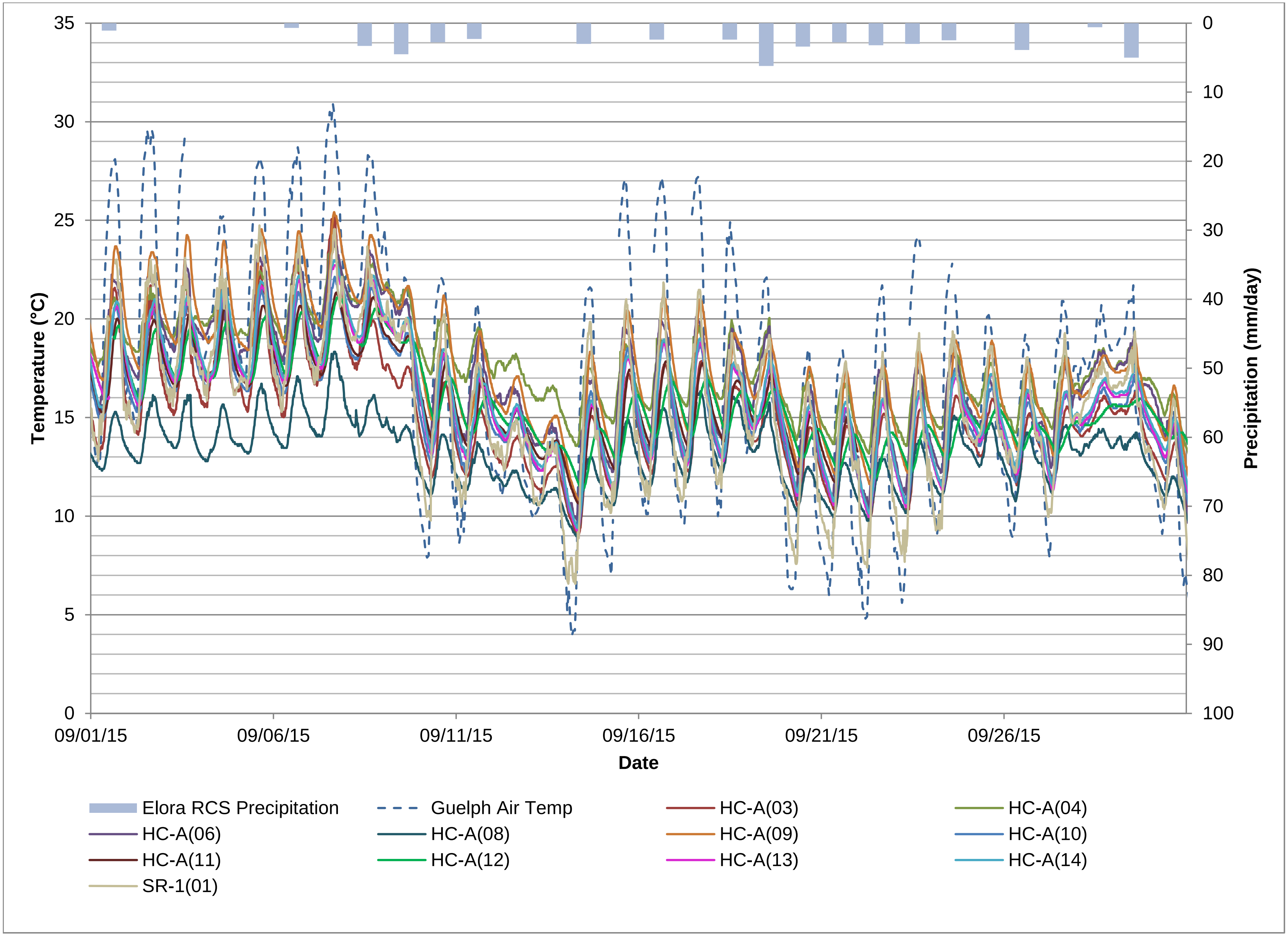
HC-A(14)
SR-1(01)



35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Temperature (°C)
Precipitation (mm/day)
09/01/15
09/06/15
09/11/15
09/16/15
09/21/15
09/26/15
Date
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
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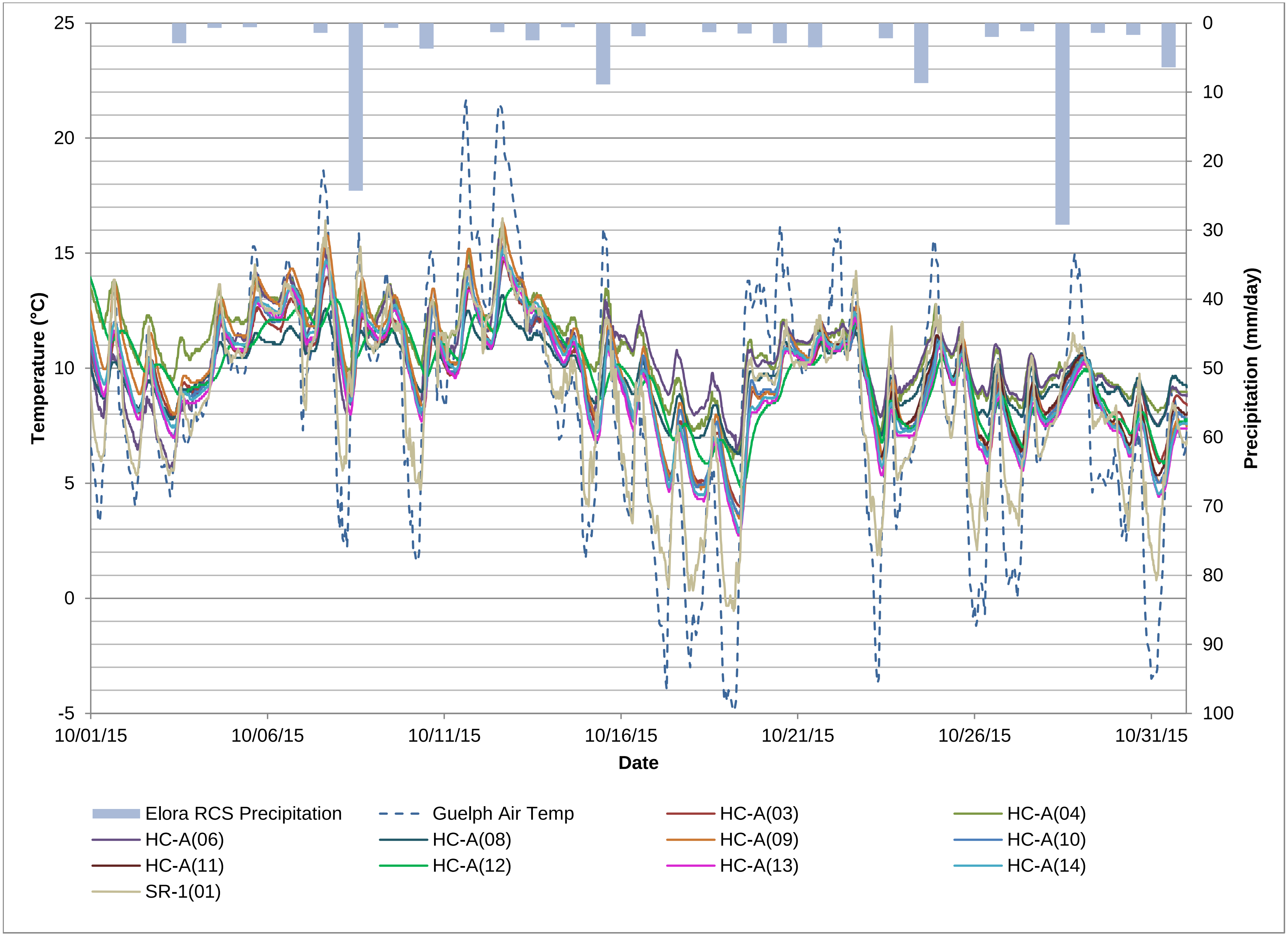
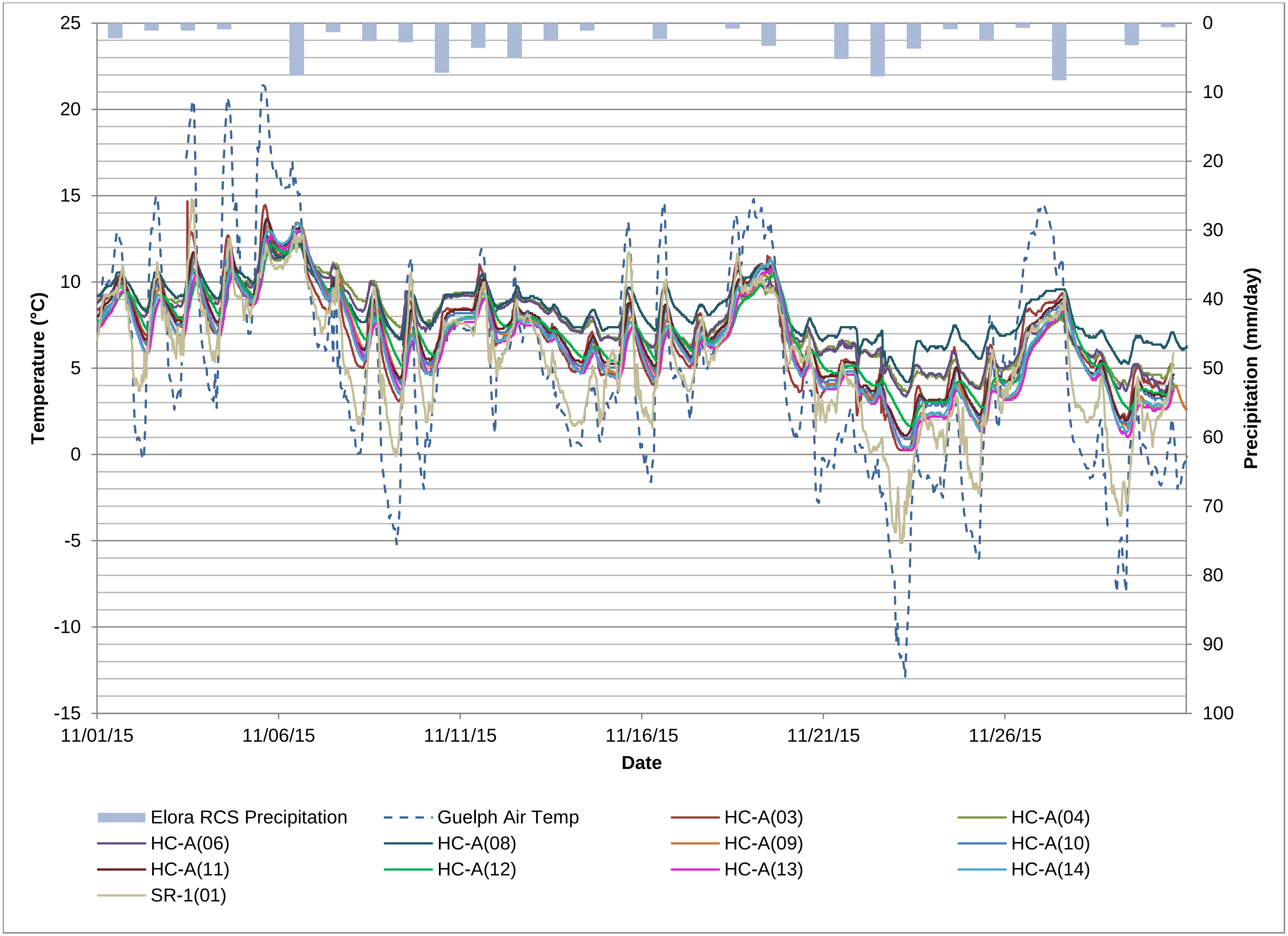
HC-A(14)
SR-1(01)



Temperature (°C)
25
20
15
10
5
0
-5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
10/01/15
10/06/15
10/11/15
10/16/15
10/21/15
10/26/15
10/31/15
Date
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)



25
20
15
10
5
0
-5
-10
-15
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
100
Precipitation (mm/day)
11/01/15
11/06/15
11/11/15
11/16/15
11/21/15
11/26/15
Date
Elora RCS Precipitation
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
SR-1(01)

AECOM

Appendix C

Historical Comparison of Statistical Stream Temperatures

Station	HC-A(03)					
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011***
Summer (July-August) average maximum	14.5 - 19.9	18.03	15.68	15.60	19.34	19.01
Summer (July-August) average	12.5 - 14.5	14.56	13.13	13.59	18.00	18.28
Summer (July-August) average minimum	9.0 - 12.0	11.83	11.23	12.02	16.66	16.67
Maximum 3-day mean	14.0 - 19.0	17.27	14.72	16.03	20.39	21.50
Maximum 7-day mean	13.0 - 17.0	16.69	14.28	15.09	19.38	20.77
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.05	16.88	18.05	20.81	21.94
Hours over 19°C	15.4	84.25	0.00	5.00	384.50	237.50
Percent of Time over 19°C	1%	5.66%	0.00%	0.34%	25.84%	41.00%
Frequency of Exceedance over 19°C (Days/yr)	4.1	19.00	0.00	1.00	40.00	17.00
Average Duration of Event Over 19°C (h)	3.1	4.01	0.00	5.00	9.86	14.84
Hours over 22°C		0.25	0.00	0.00	4.25	32.00
Percent of Time over 22°C		0.02%	0.00%	0.00%	0.29%	6.00%
Frequency of Exceedance over 22°C (Days/yr)		1.00	0.00	0.00	1.00	6.00
Average Duration of Event Over 22°C (h)		0.25	0.00	0.00	1.81	5.33
Hours over 24°C	0	0.00	0.00	0.00	0.00	4.25
Percent of Time over 24°C	0	0.00%	0.00%	0.00%	0.00%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	0.00	0.00	1.00
Average Duration of Event Over 24°C (h)		0.00	0.00	0.00	0.00	4.25

*Based off of 25 day sample size

Station	HC-A(04)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	20.91	20.03	20.52	23.56	19.63	18.30	15.50
Summer July-August) average	12.5 - 14.5	19.54	19.02	19.55	22.41	17.74	15.50	13.80
Summer (July-August) average minimum	9.0 - 12.0	18.21	18.06	18.66	21.29	16.10	13.40	12.60
Maximum 3-day mean	14.0 - 19.0	21.73	20.27	23.23	24.18	21.45	15.00	13.20
Maximum 7-day mean	13.0 - 17.0	21.47	19.61	22.36	23.53	19.77	14.50	12.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.83	21.05	23.35	25.65	21.57	16.80	14.80
Hours over 19°C	51.1	920.00	771.00	924.00	1477.50	452.50	101.50	0.00
Percent of Time over 19°C	3%	61.83%	51.81%	62.10%	99.39%	30.00%	8.80%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	9.4	55.00	53.00	55.00	62.00	40.00	19.00	0.00
Average Duration of Event Over 19°C (h)	5	21.90	16.76	27.18	295.50	14.60	5.30	0.00
Hours over 22°C		96.75	3.75	101.00	901.00	35.75	0.00	0.00
Percent of Time over 22°C		6.50%	0.25%	6.79%	60.61%	2.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		16.00	2.00	6.00	48.00	7.00	0.00	0.00
Average Duration of Event Over 22°C (h)		5.17	0.95	35.28	45.03	5.11	0.00	0.00
Hours over 24°C	0	0.00	0.00	20.50	182.25	4.50	0.00	0.00
Percent of Time over 24°C	0%	0.00%	0.00%	1.38%	12.26%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	2.00	24.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0.00	0.00	10.25	5.88	4.50	0.00	0.00

Station	HC-A(06)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	21.64	20.42	20.63	24.07	19.98	19.70	16.10
Summer July-August) average	12.5 - 14.5	18.86	18.95	19.48	21.88	18.02	16.70	13.90
Summer (July-August) average minimum	9.0 - 12.0	16.31	17.79	18.49	20.22	16.01	14.30	12.50
Maximum 3-day mean	14.0 - 19.0	21.39	20.10	23.12	24.18	21.65	16.00	13.30
Maximum 7-day mean	13.0 - 17.0	21.11	19.51	22.29	23.32	19.96	15.20	12.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	25.43	21.58	23.60	26.17	21.90	17.70	15.10
Hours over 19°C	0.9	753.25	728.75	902.25	1386.75	512.00	269.75	0.00
Percent of Time over 19°C	0.00%	50.62%	48.98%	60.64%	93.20%	35.00%	18.10%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	0.3	57.00	56.00	57.00	62.00	46.00	38.00	0.00
Average Duration of Event Over 19°C (h)	3	10.46	12.35	24.39	99.05	12.80	7.10	0.00
Hours over 22°C		107.00	5.00	99.25	685.25	55.50	19.25	0.00
Percent of Time over 22°C		7.19%	0.34%	6.67%	46.05%	4.00%	1.30%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		24.00	2.00	7.00	55.00	8.00	7.00	0.00
Average Duration of Event Over 22°C (h)		3.39	1.01	23.21	14.35	6.94	2.75	0.00
Hours over 24°C	0	14.75	0.00	12.50	193.50	6.50	0.00	0.00
Percent of Time over 24°C	0.00%	0.99%	0.00%	0.84%	13.00%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		8.00	0.00	2.00	35.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		1.64	0.00	6.25	5.23	6.50	0.00	0.00

Station	HC-A(08)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	14.45	8.55	18.16	15.00	14.40	14.10	13.90
Summer July-August) average	12.5 - 14.5	12.60	12.21	16.03	13.56	12.56	13.00	13.00
Summer (July-August) average minimum	9.0 - 12.0	11.28	6.17	14.37	12.40	11.21	12.10	12.20
Maximum 3-day mean	14.0 - 19.0	16.18	13.38	20.82	16.57	14.43	12.40	12.60
Maximum 7-day mean	13.0 - 17.0	15.48	12.95	20.23	15.46	13.42	12.00	12.30
Maximum 7-day mean of daily maximums	15.0 - 23.5	19.12	15.53	22.42	17.28	16.00	12.90	12.30
Hours over 19°C		3.75	0.00	393.25	8.50	0.00	19.25	0.00
Percent of Time over 19°C		0.25%	0.00%	26.43%	0.57%	0.00%	1.60%	0.00%
Frequency of Exceedance over 19°C (Days/yr)		5.00	0.00	38.00	2.00	0.00	3.00	0.00
Average Duration of Event Over 19°C (h)		0.63	0.00	10.63	4.25	0.00	6.40	0.00
Hours over 22°C		0.00	0.00	41.75	0.00	0.00	0.00	0.00
Percent of Time over 22°C		0.00%	0.00%	2.81%	0.00%	0.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	0.00	9.00	0.00	0.00	0.00	0.00
Average Duration of Event Over 22°C (h)		0.00	0.00	2.69	0.00	0.00	0.00	0.00
Hours over 24°C		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Time over 24°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0.00	0.00	0.00	0.00	0.00	0.00	0.00

Station	HC-A(09)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	22.34	21.80	21.75	23.70	20.72	19.70	17.20
Summer July-August) average	12.5 - 14.5	19.18	18.62	19.24	20.33	18.85	17.90	15.00
Summer (July-August) average minimum	9.0 - 12.0	16.76	16.36	17.31	17.57	17.11	16.30	13.10
Maximum 3-day mean	14.0 - 19.0	21.97	20.43	23.46	23.92	22.26	17.10	n/a
Maximum 7-day mean	13.0 - 17.0	21.31	19.47	22.63	22.45	20.67	16.20	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	25.49	23.03	25.67	26.75	23.00	18.90	n/a
Hours over 19°C	10	742.25	621.50	784.00	1014.75	701.00	506.25	11.75
Percent of Time over 19°C	1%	49.88%	41.77%	52.69%	68.20%	47.00%	34.00%	2.00%
Frequency of Exceedance over 19°C (Days/yr)	2.8	58.00	60.00	59.00	62.00	54.00	28.00	3.00
Average Duration of Event Over 19°C (h)	3.4	14.55	10.90	16.33	23.06	17.10	18.10	3.90
Hours over 22°C		223.75	106.25	171.25	417.50	115.50	52.00	0.00
Percent of Time over 22°C		15.04%	7.14%	11.51%	28.06%	8.00%	3.40%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		38.00	26.00	22.00	46.00	13.00	6.00	0.00
Average Duration of Event Over 22°C (h)		3.90	2.66	8.22	7.90	8.88	8.70	0.00
Hours over 24°C	0	47.50	13.50	41.75	169.00	10.75	5.50	0.00
Percent of Time over 24°C	0	3.19%	0.91%	2.81%	11.36%	1.00%	0.40%	0.00%
Frequency of 24°C Exceedance (Days/yr)		10.00	6.00	6.00	26.00	1.00	2.00	0.00
Average Duration of Event Over 24°C (h)		4.75	2.25	6.96	6.50	10.75	2.75	0.00

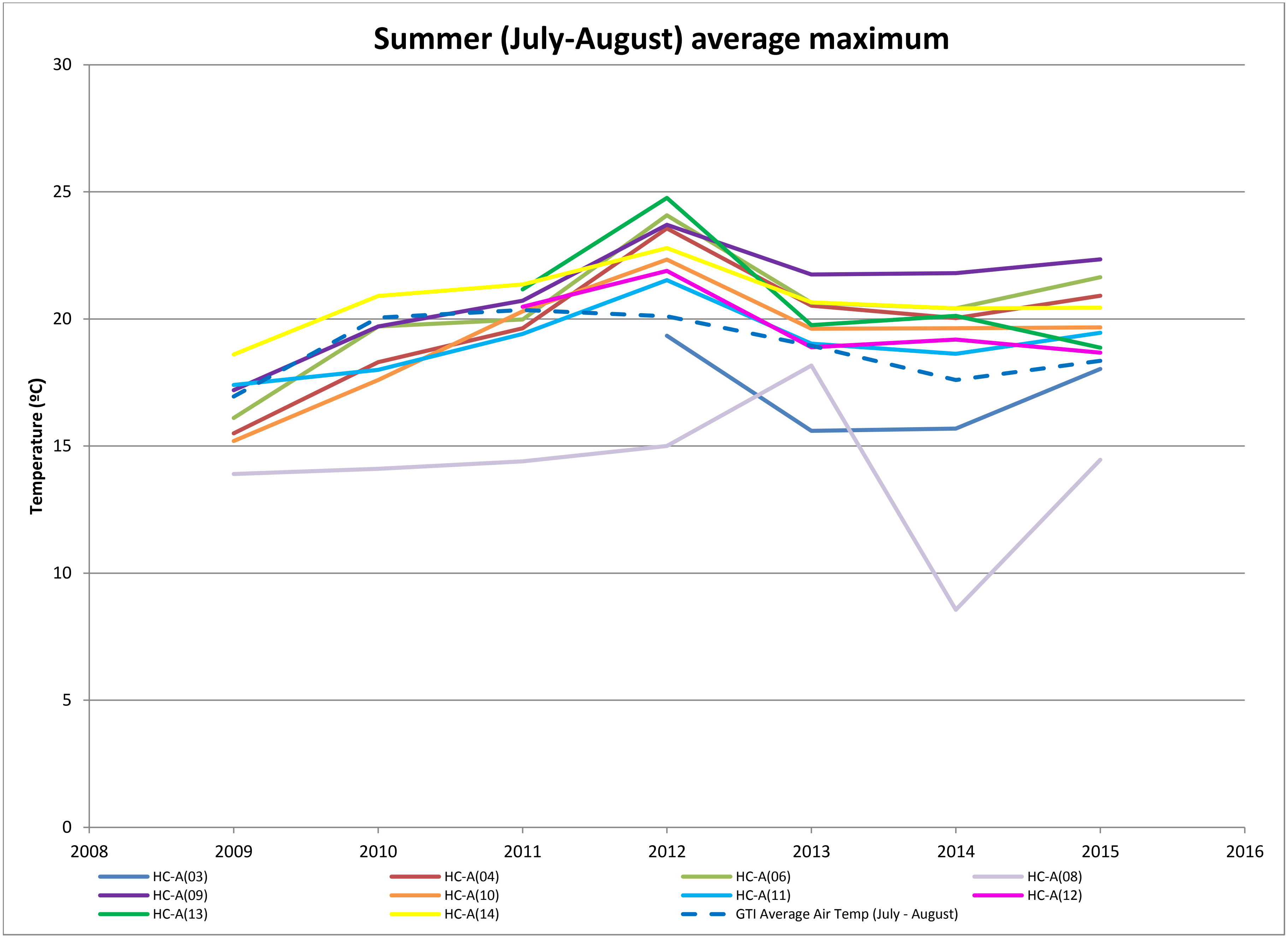
Station	HC-A(10)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	19.66	19.63	19.62	22.33	20.30	17.60	15.20
Summer July-August) average	12.5 - 14.5	16.89	16.88	17.34	18.00	18.28	14.70	13.70
Summer (July-August) average minimum	9.0 - 12.0	14.81	14.82	15.59	14.99	16.47	12.50	12.70
Maximum 3-day mean	14.0 - 19.0	19.34	18.74	21.06	20.64	21.93	14.00	n/a
Maximum 7-day mean	13.0 - 17.0	18.85	17.76	20.31	19.48	20.26	13.40	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.31	21.20	23.20	29.53	22.67	14.80	n/a
Hours over 19°C	58.4	260.25	221.75	295.00	513.50	573.75	18.75	0.00
Percent of Time over 19°C	4%	17.49%	14.90%	19.83%	34.67%	39.00%	1.20%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	10.3	44.00	40.00	33.00	53.00	50.00	7.00	0.00
Average Duration of Event Over 19°C (h)	5.2	5.66	5.28	9.52	9.01	13.99	2.70	0.00
Hours over 22°C		12.50	9.50	36.00	121.25	92.50	0.00	0.00
Percent of Time over 22°C		0.84%	0.64%	2.42%	8.19%	6.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		6.00	4.00	6.00	25.00	14.00	0.00	0.00
Average Duration of Event Over 22°C (h)		1.40	1.97	3.27	3.28	6.61	0.00	0.00
Hours over 24°C	0.4	0.00	0.00	2.00	46.75	9.50	0.00	0.00
Percent of Time over 24°C	0%	0.00%	0.00%	0.13%	3.16%	1.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	2.00	12.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0.00	0.00	1.00	3.60	9.50	0.00	0.00

Station	HC-A(11)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	19.45	18.63	19.03	21.53	19.41	18.00	17.40
Summer July-August) average	12.5 - 14.5	17.06	16.97	17.39	18.43	18.09	13.10	14.50
Summer (July-August) average minimum	9.0 - 12.0	15.19	15.60	16.10	16.04	16.84	15.10	12.30
Maximum 3-day mean	14.0 - 19.0	19.40	18.89	20.67	21.09	20.96	14.40	n/a
Maximum 7-day mean	13.0 - 17.0	18.94	17.87	20.00	19.90	19.97	13.80	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.00	19.88	21.69	23.43	20.79	15.30	n/a
Hours over 19°C	57.8	259.00	135.50	264.25	587.75	457.25	61.50	11.75
Percent of Time over 19°C	4%	17.41%	9.11%	17.76%	39.50%	31.00%	4.10%	2.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	43.00	23.00	30.00	56.00	37.00	12.00	6.00
Average Duration of Event Over 19°C (h)	5.6	5.89	5.89	9.44	11.09	9.33	5.10	2.00
Hours over 22°C		3.25	0.00	11.00	117.50	13.50	11.25	0.00
Percent of Time over 22°C		0.22%	0.00%	0.74%	7.90%	1.00%	0.80%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		1.00	0.00	4.00	26.00	3.00	4.00	0.00
Average Duration of Event Over 22°C (h)		1.75	0.00	1.77	3.40	4.50	2.80	0.00
Hours over 24°C	0.8	0.00	0.00	0.00	23.75	0.00	1.00	0.00
Percent of Time over 24°C	0.06%	0.00%	0.00%	0.00%	1.60%	0.00%	0.07%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	0.00	6.00	0.00	1.00	0.00
Average Duration of Event Over 24°C (h)		0.00	0.00	0.00	3.96	0.00	1.00	0.00

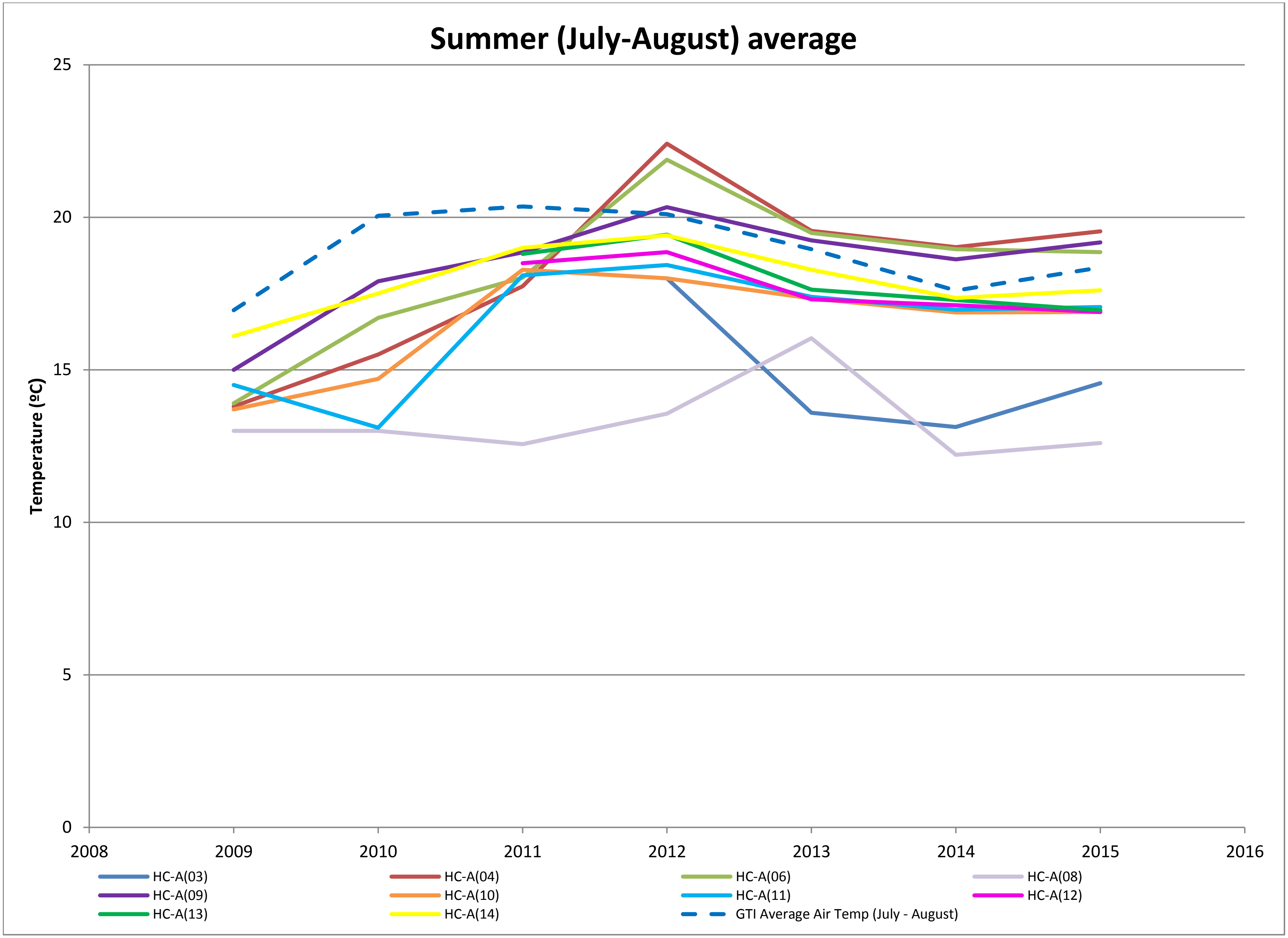
Station	HC-A(12)					
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**
Summer (July-August) average maximum	14.5 - 19.9	18.67	19.18	18.88	21.88	20.48
Summer July-August) average	12.5 - 14.5	16.89	17.11	17.31	18.86	18.49
Summer (July-August) average minimum	9.0 - 12.0	15.33	15.41	15.97	16.21	16.71
Maximum 3-day mean	14.0 - 19.0	19.23	19.36	21.53	22.40	22.02
Maximum 7-day mean	13.0 - 17.0	18.62	18.38	20.68	20.90	20.32
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.23	21.12	23.45	25.79	23.04
Hours over 19°C	57.8	184.00	218.00	226.75	636.50	597.25
Percent of Time over 19°C	4%	12.37%	14.65%	15.24%	42.89%	40.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	25.00	28.00	26.00	51.00	49.00
Average Duration of Event Over 19°C (h)	5.6	7.36	7.52	9.86	12.48	15.31
Hours over 22°C		2.50	10.75	43.00	205.00	105.00
Percent of Time over 22°C		0.17%	0.72%	2.89%	13.81%	7.00%
Frequency of Exceedance over 22°C (Days/yr)		1.00	3.00	6.00	30.00	15.00
Average Duration of Event Over 22°C (h)		1.38	2.06	4.05	4.66	7.00
Hours over 24°C	0.8	0.00	0.00	9.00	78.50	10.00
Percent of Time over 24°C	0.06%	0.00%	0.00%	0.60%	5.29%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	3.00	18.00	1.00
Average Duration of Event Over 24°C (h)		0.00	0.00	3.00	3.74	10.00

Station	HC-A(13)					
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**
Summer (July-August) average maximum	14.5 - 19.9	18.87	20.12	19.75	24.76	21.16
Summer July-August) average	12.5 - 14.5	16.95	17.29	17.63	19.43	18.80
Summer (July-August) average minimum	9.0 - 12.0	15.28	14.92	15.77	15.11	16.68
Maximum 3-day mean	14.0 - 19.0	19.23	19.52	21.93	23.42	22.30
Maximum 7-day mean	13.0 - 17.0	18.62	18.37	21.05	22.01	20.67
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.23	21.76	24.11	29.89	23.56
Hours over 19°C	57.8	198.50	350.00	365.75	713.50	690.75
Percent of Time over 19°C	4%	13.34%	23.52%	24.58%	48.20%	46.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	28.00	46.00	35.00	57.00	55.00
Average Duration of Event Over 19°C (h)	5.6	7.09	7.61	11.43	12.30	14.70
Hours over 22°C		2.50	28.00	62.25	352.00	138.50
Percent of Time over 22°C		0.17%	1.88%	4.18%	23.78%	9.00%
Frequency of Exceedance over 22°C (Days/yr)		1.00	6.00	9.00	41.00	18.00
Average Duration of Event Over 22°C (h)		1.38	2.87	4.45	4.90	7.69
Hours over 24°C	0.8	0.00	0.00	18.00	207.00	16.25
Percent of Time over 24°C	0.06%	0.00%	0.00%	1.21%	13.98%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	4.00	30.00	4.00
Average Duration of Event Over 24°C (h)		0.00	0.00	4.50	6.27	4.06

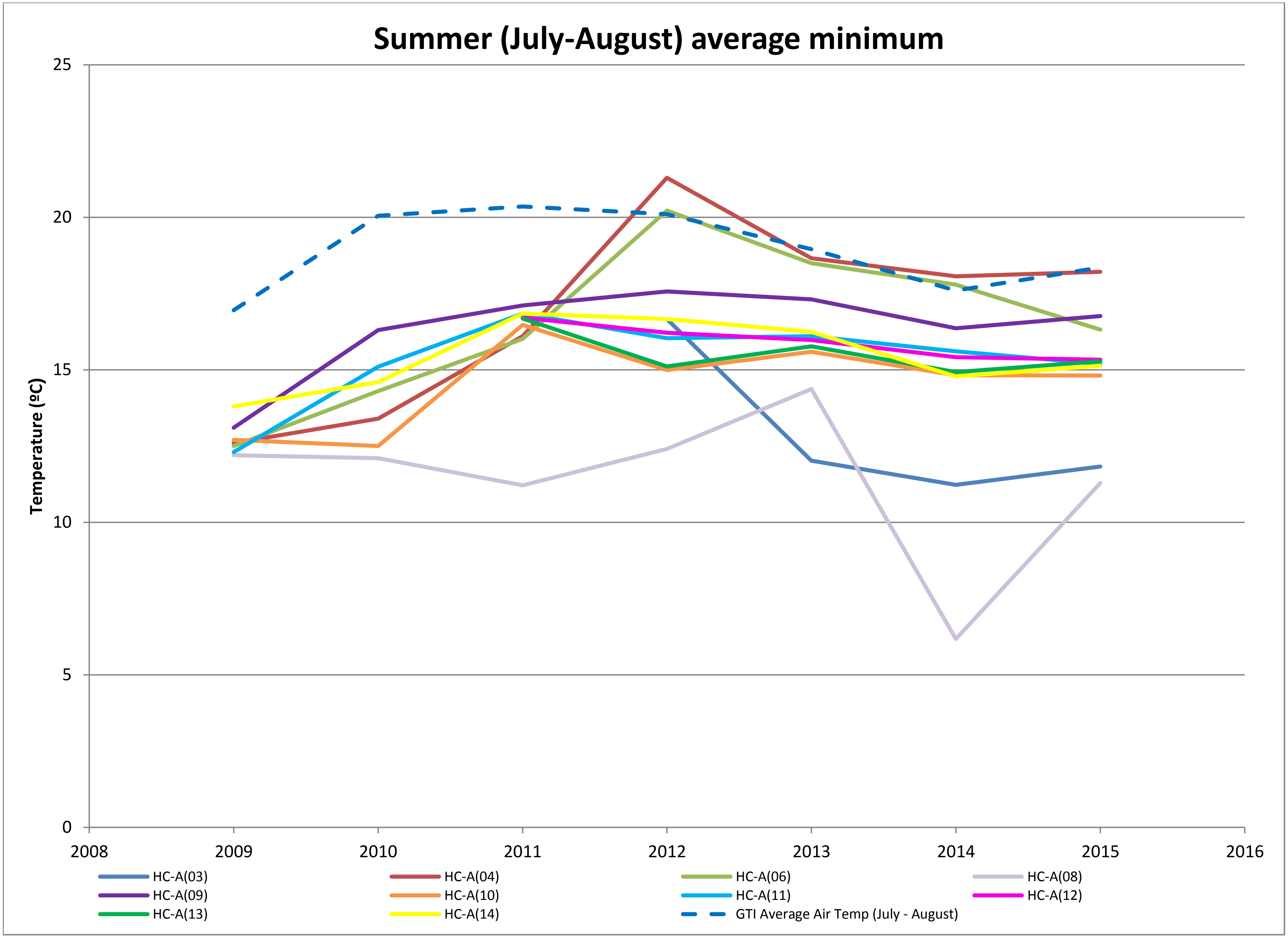
Station	HC-A(14)							
Year	**Modeled**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	20.44	20.41	20.65	22.79	21.36	20.90	18.60
Summer July-August) average	12.5 - 14.5	17.60	17.35	18.28	19.40	19.00	17.50	16.10
Summer (July-August) average minimum	9.0 - 12.0	15.13	14.78	16.24	16.66	16.84	14.60	13.80
Maximum 3-day mean	14.0 - 19.0	20.23	19.55	22.51	22.67	22.45	16.70	15.40
Maximum 7-day mean	13.0 - 17.0	19.57	18.46	21.65	21.45	20.86	15.80	14.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	23.31	22.43	24.66	26.40	23.78	18.30	17.80
Hours over 19°C	130.7	431.00	383.00	578.50	778.50	741.25	422.25	187.00
Percent of Time over 19°C	9%	28.97%	26.00%	38.88%	52.32%	50.00%	28.40%	12.00%
Frequency of Exceedance over 19°C (Days/yr)	26.8	49.00	50.00	50.00	55.00	56.00	49.00	29.00
Average Duration of Event Over 19°C (h)	4.3	8.98	7.37	13.15	16.56	12.15	8.60	6.20
Hours over 22°C		59.00	41.00	86.50	287.25	157.75	95.00	0.50
Percent of Time over 22°C		3.97%	3.00%	5.81%	19.30%	11.00%	6.40%	0.03%
Frequency of Exceedance over 22°C (Days/yr)		14.00	9.00	11.00	37.00	19.00	20.00	1.00
Average Duration of Event Over 22°C (h)		2.91	4.50	5.15	5.09	8.30	4.75	0.50
Hours over 24°C	3.2	3.25	3.00	26.75	113.50	28.00	25.75	0.00
Percent of Time over 24°C	0.21%	0.22%	0.00%	1.80%	7.63%	2.00%	0.30%	0.00%
Frequency of 24°C Exceedance (Days/yr)		1.00	1.00	5.00	24.00	9.00	5.00	0.00
Average Duration of Event Over 24°C (h)		3.25	1.50	5.35	4.37	2.15	5.15	0.00



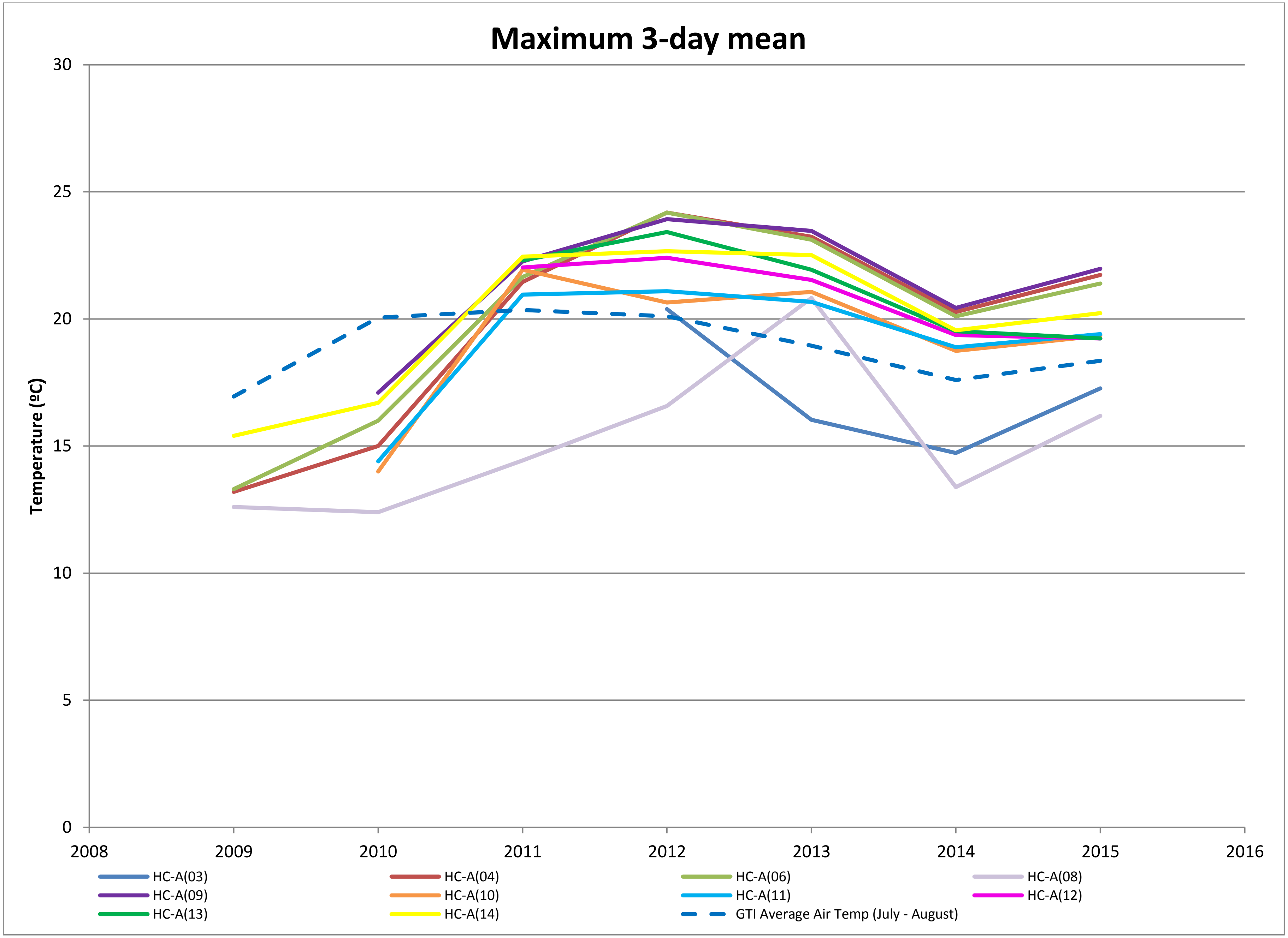
Summer (July-August) average maximum
Temperature (ºC)
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

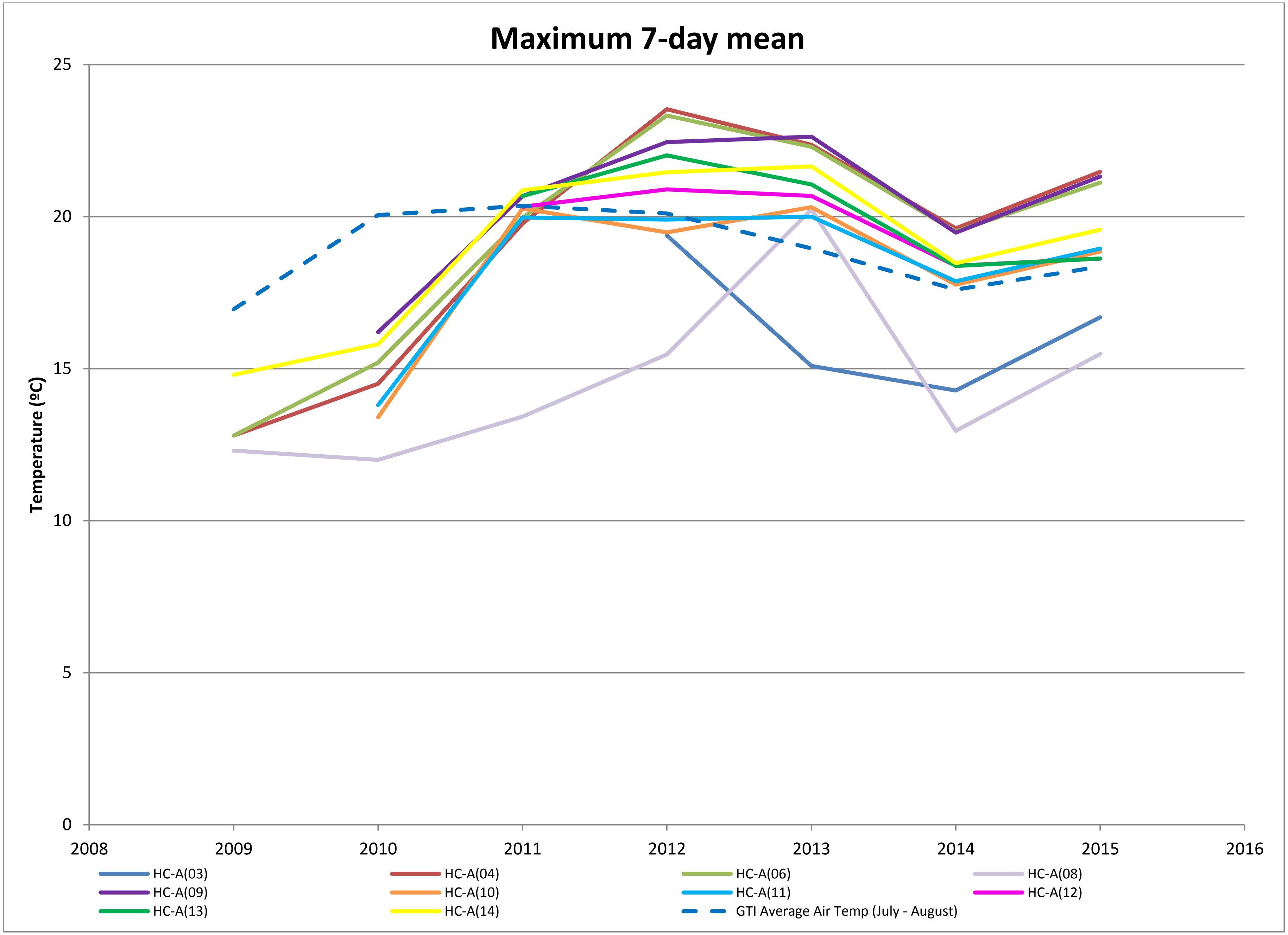


Summer (July-August) average
Temperature (ºC)
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

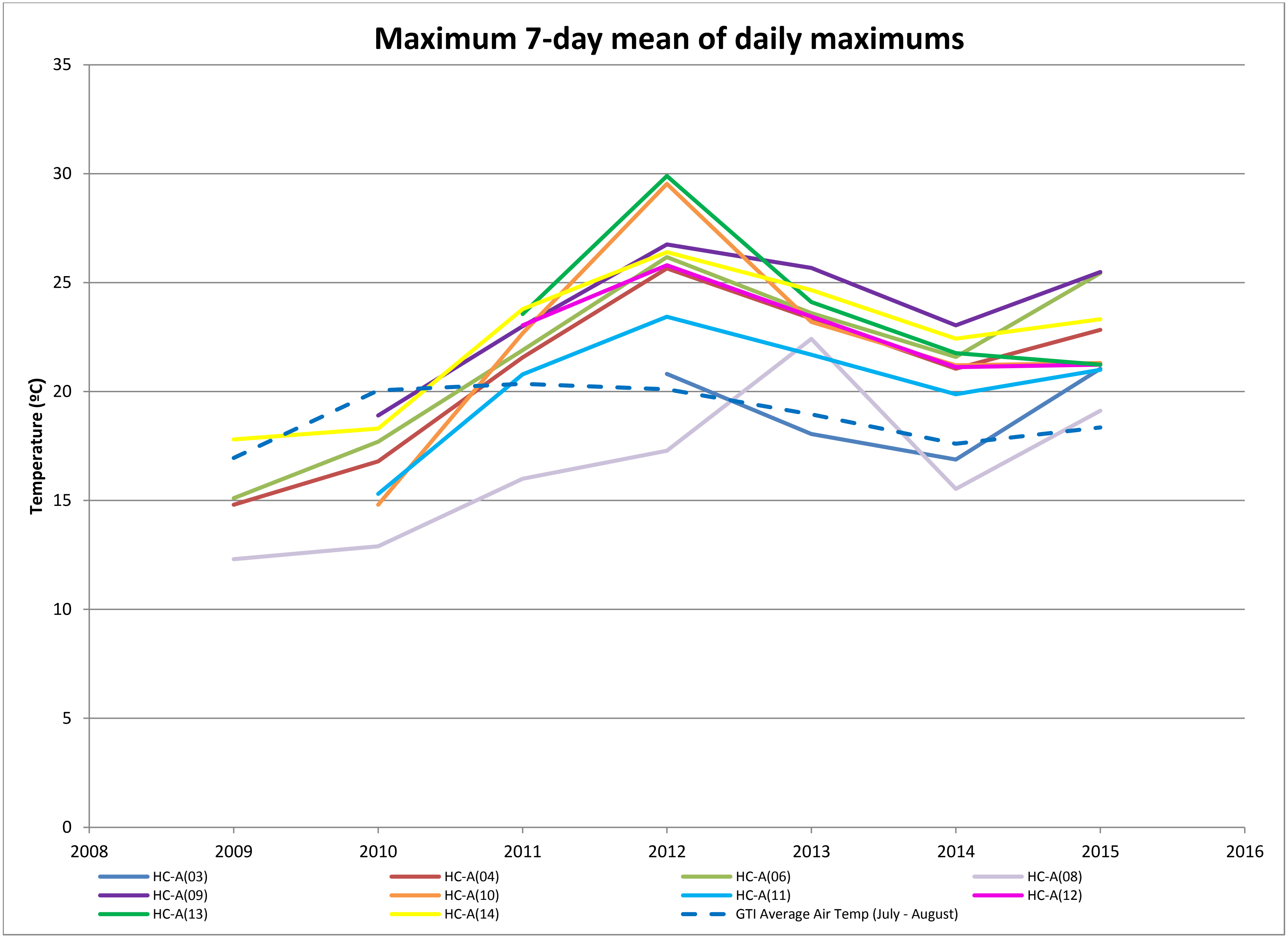


Summer (July-August) average minimum
Temperature (ºC)
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

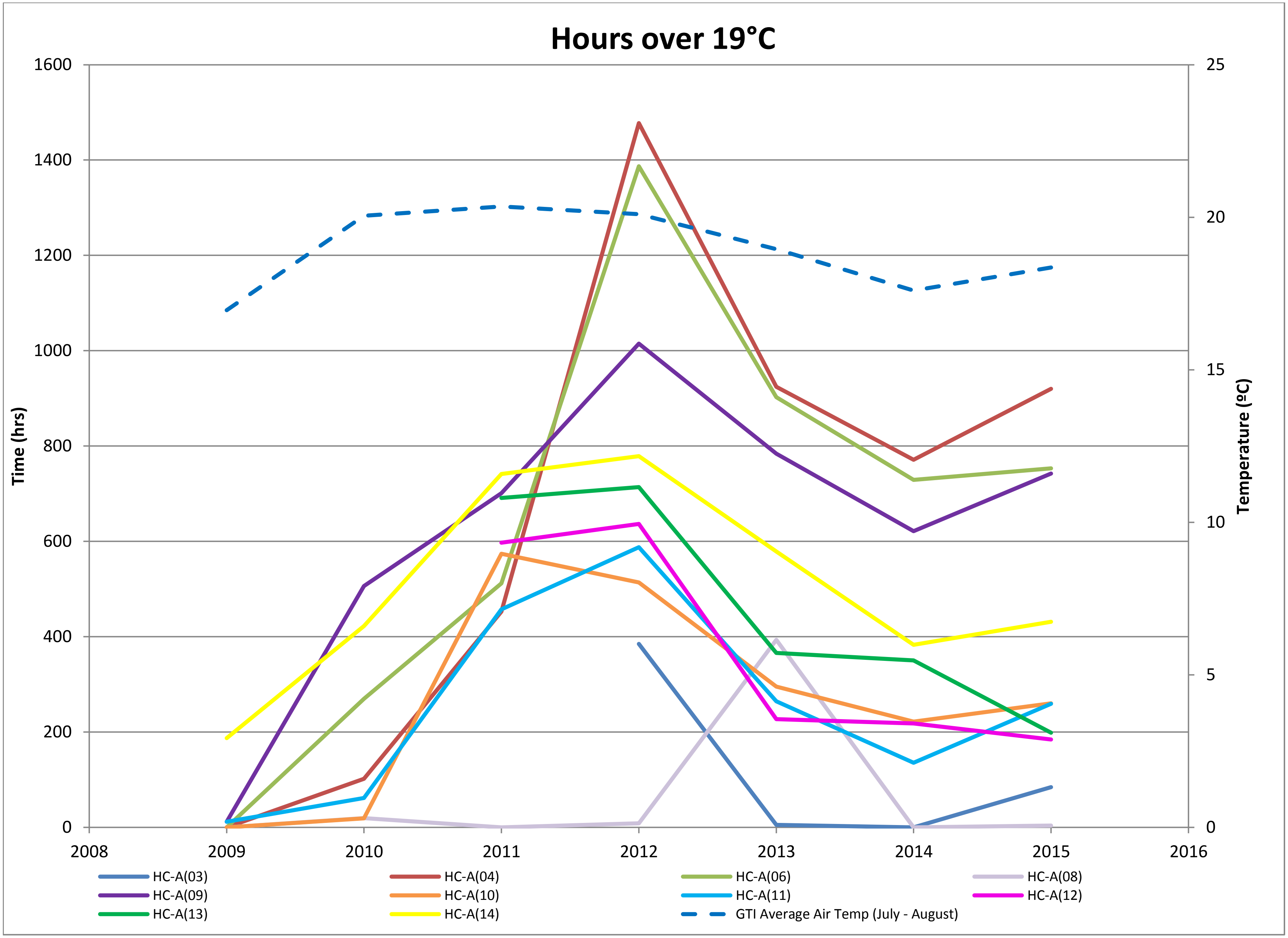

Maximum 3-day mean
Temperature (ºC)
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

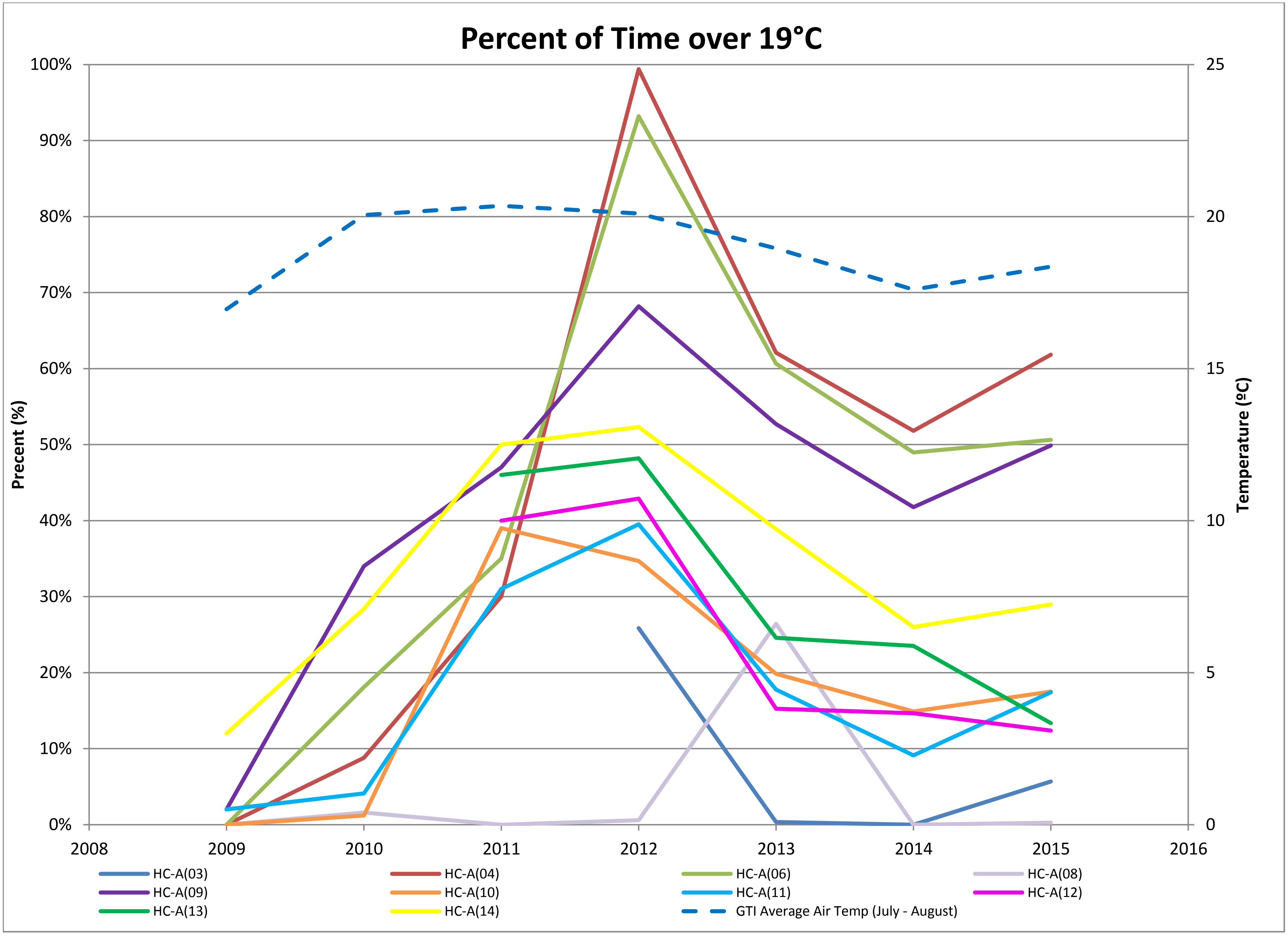


Maximum 7-day mean
Temperature (ºC)
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

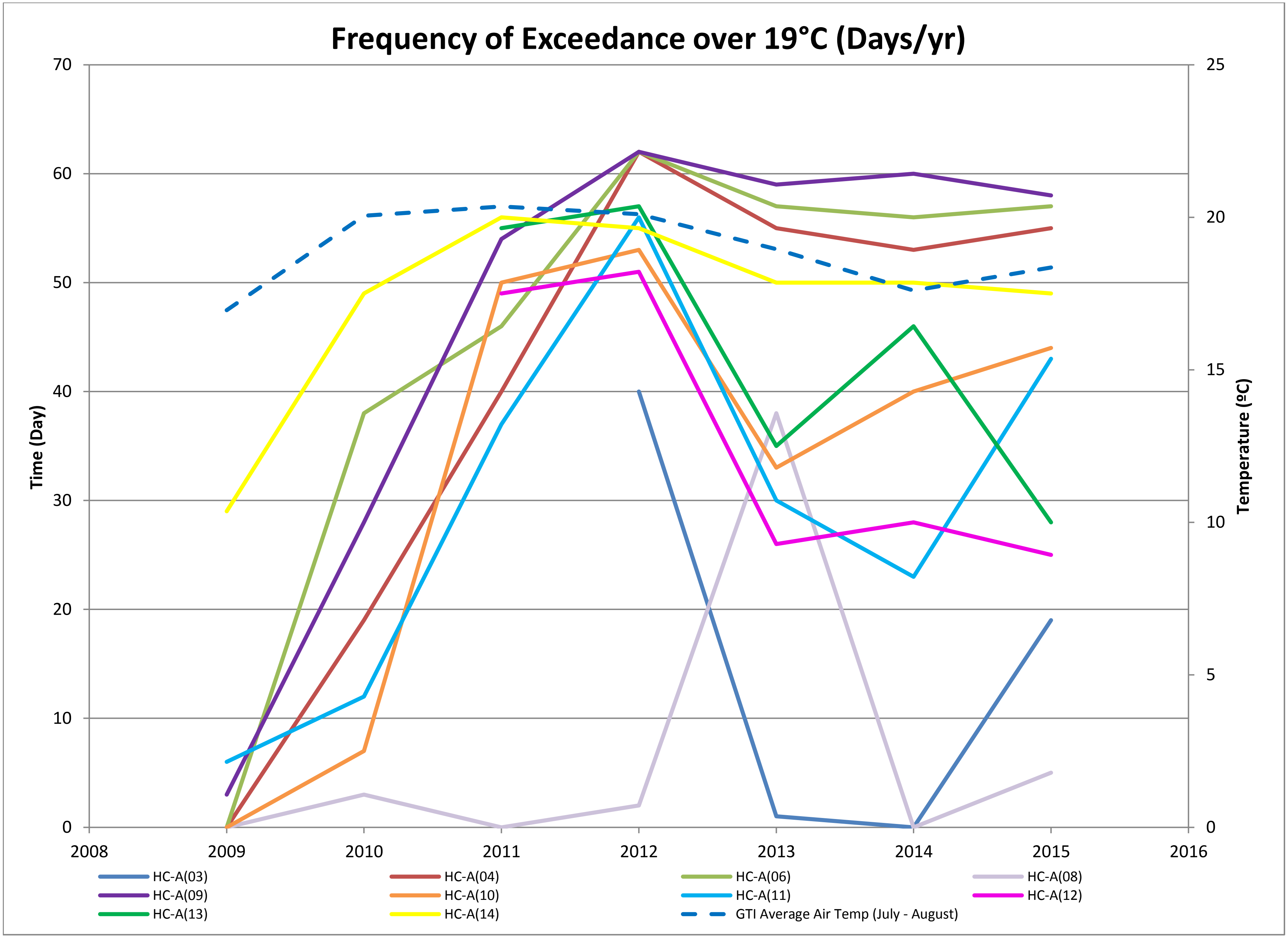


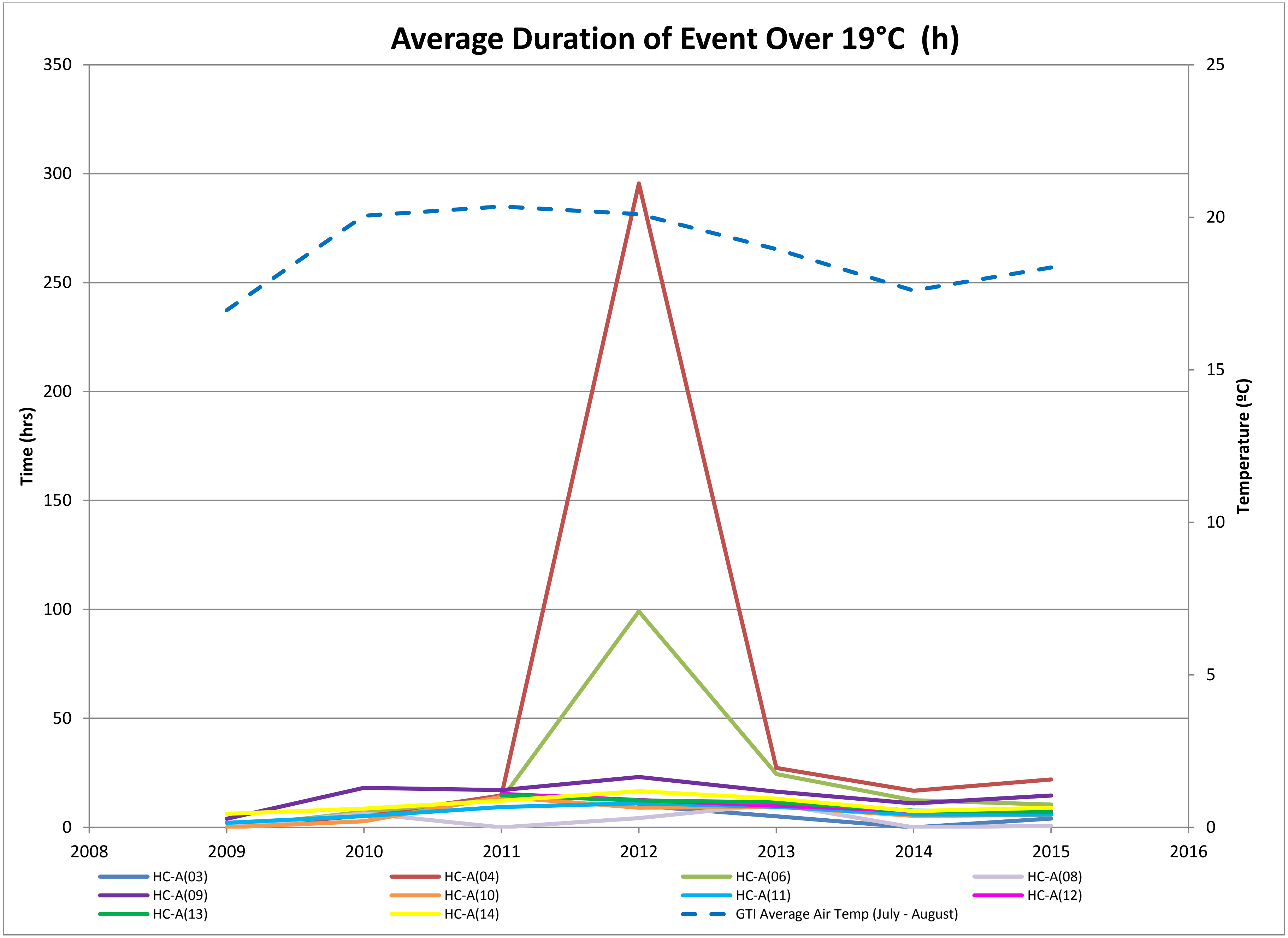
Maximum 7-day mean of daily maximums
Temperature (ºC)
35
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)


Hours over 19°C
Time (hrs)
Temperature (ºC)
1600
1400
1200
1000
800
600
400
200
0
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

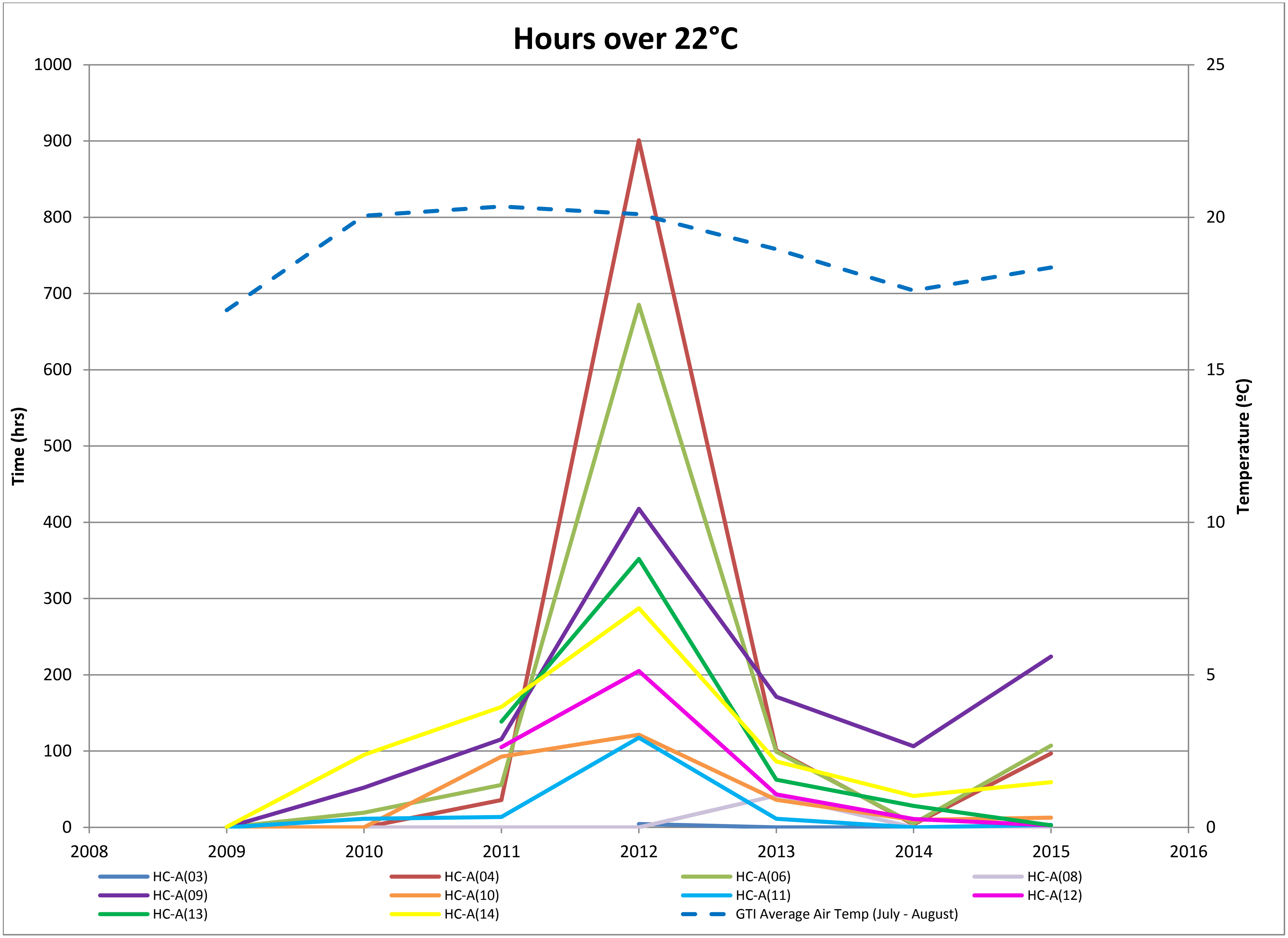


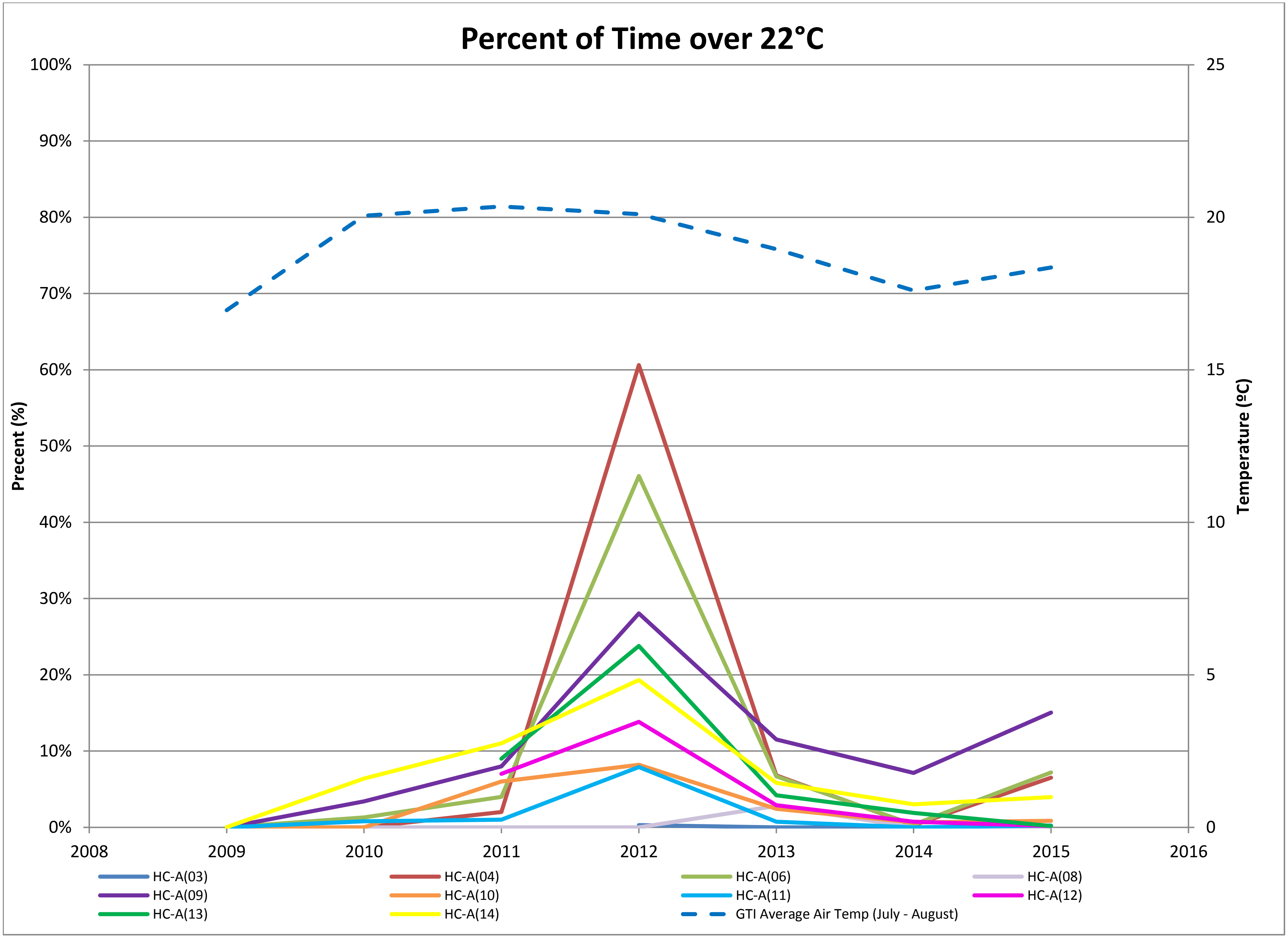
Percent of Time over 19°C
Precent (%)
Temperature (ºC)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)


Frequency of Exceedance over 19°C (Days/yr)
Time (Day)
Temperature (ºC)
70
60
50
40
30
20
10
0
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

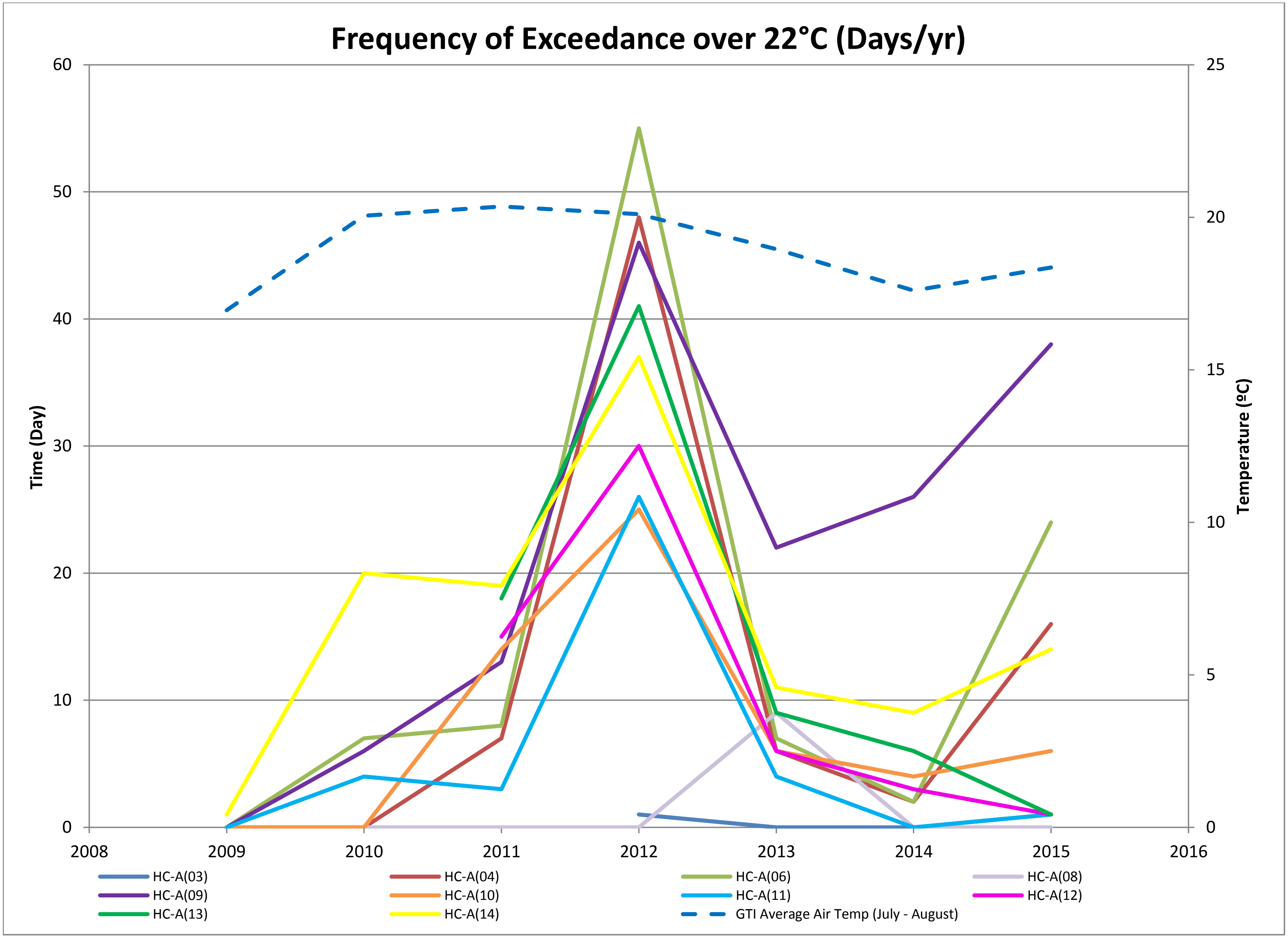


Average Duration of Event Over 19°C (h)
Time (hrs)
Temperature (ºC)
350
300
250
200
150
100
50
0
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

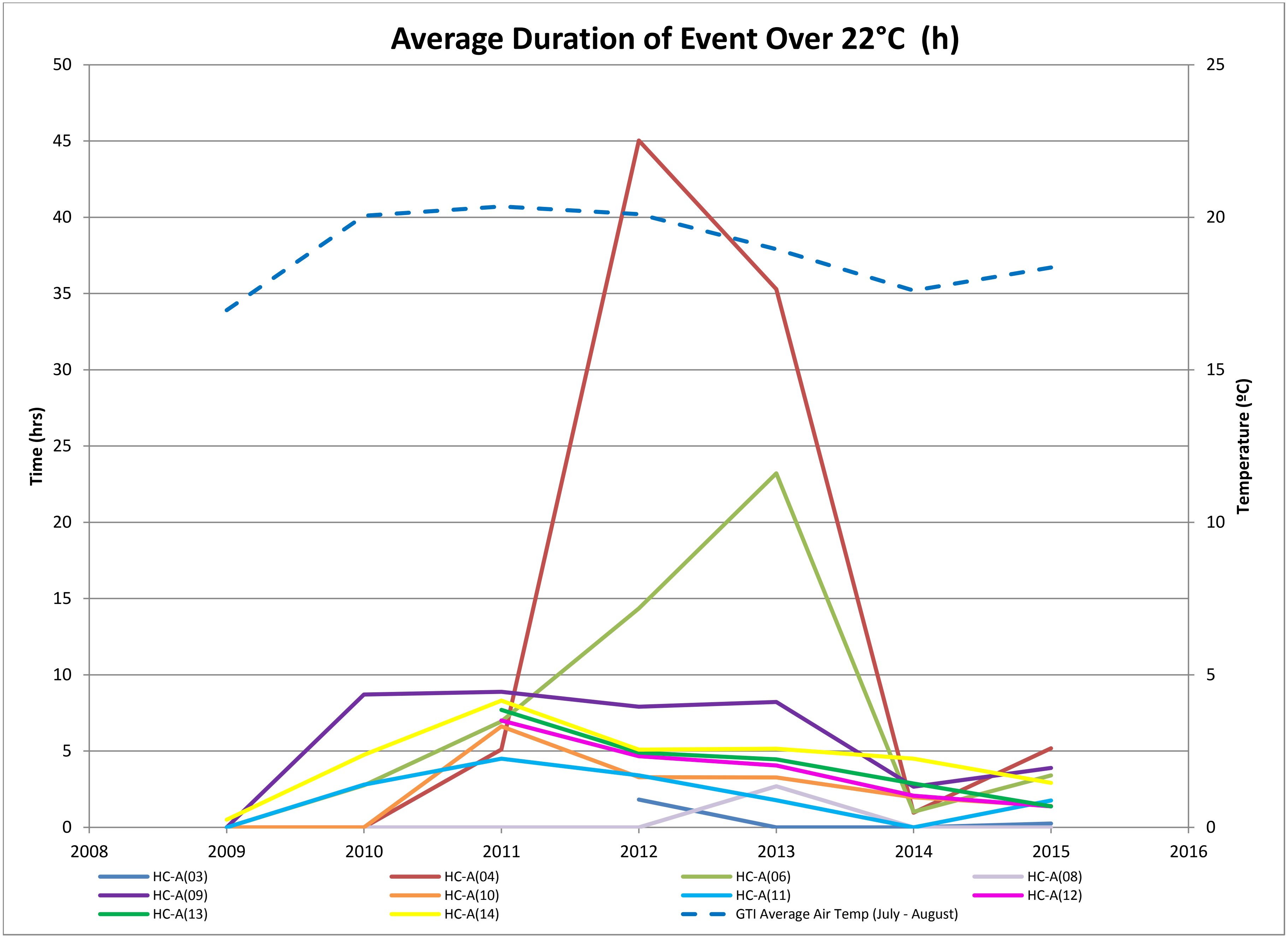

Hours over 22°C
Time (hrs)
Temperature (ºC)
1000
900
800
700
600
500
400
300
200
100
0
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



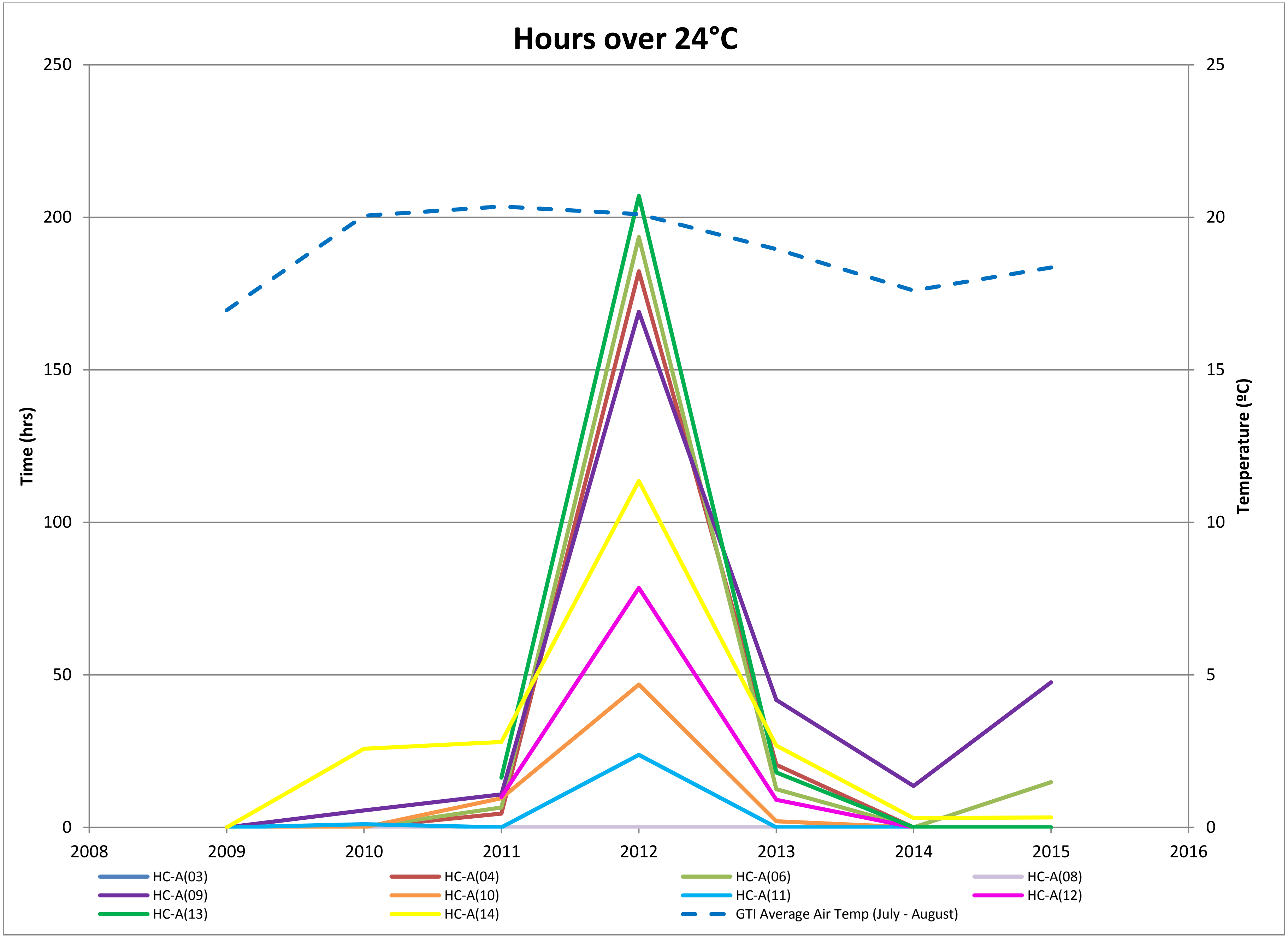
Percent of Time over 22°C
Precent (%)
Temperature (ºC)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

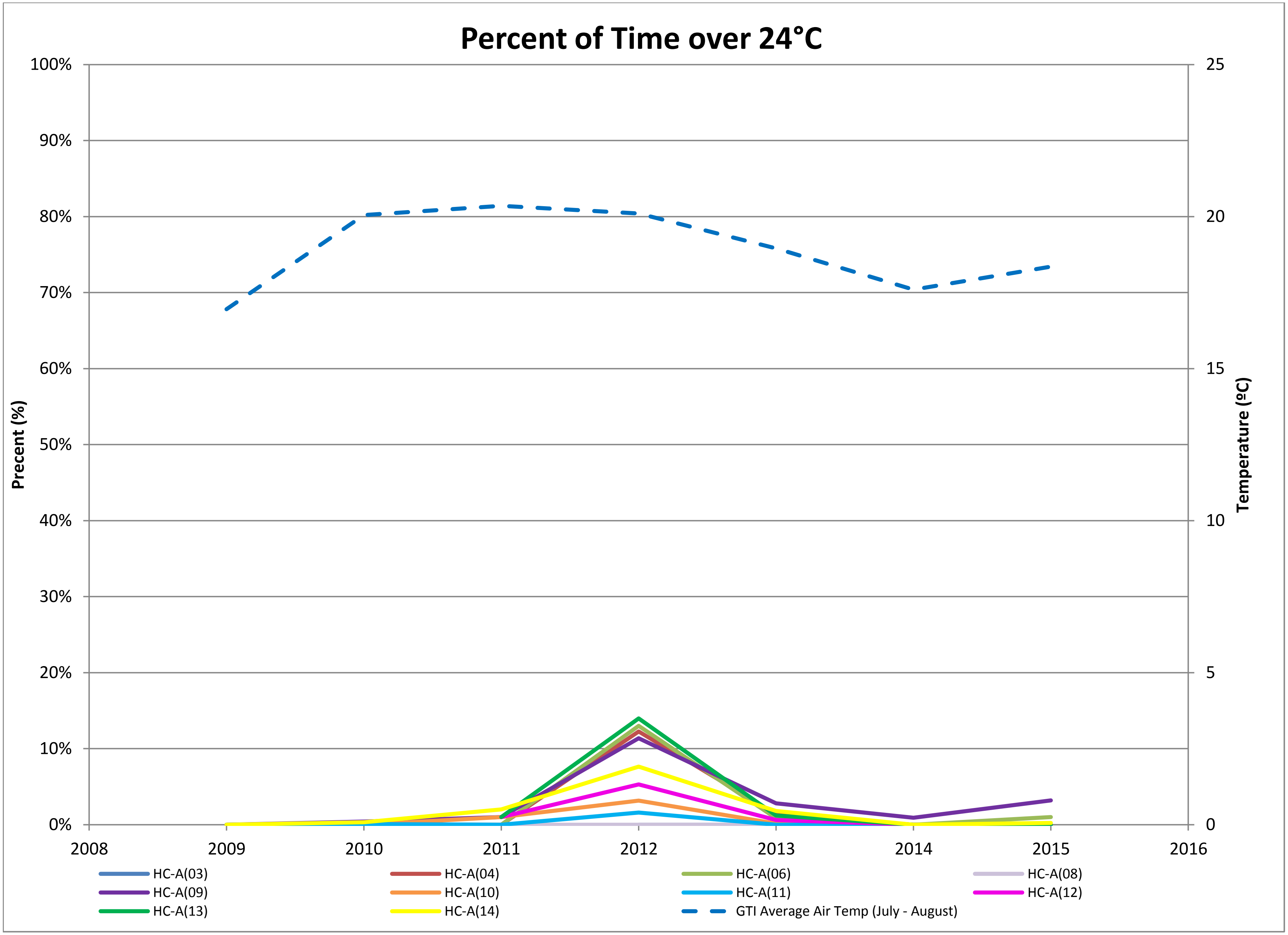


Frequency of Exceedance over 22°C (Days/yr)
Time (Day)
Temperature (ºC)
0
10
20
30
40
50
60
0
5
10
15
20
25
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

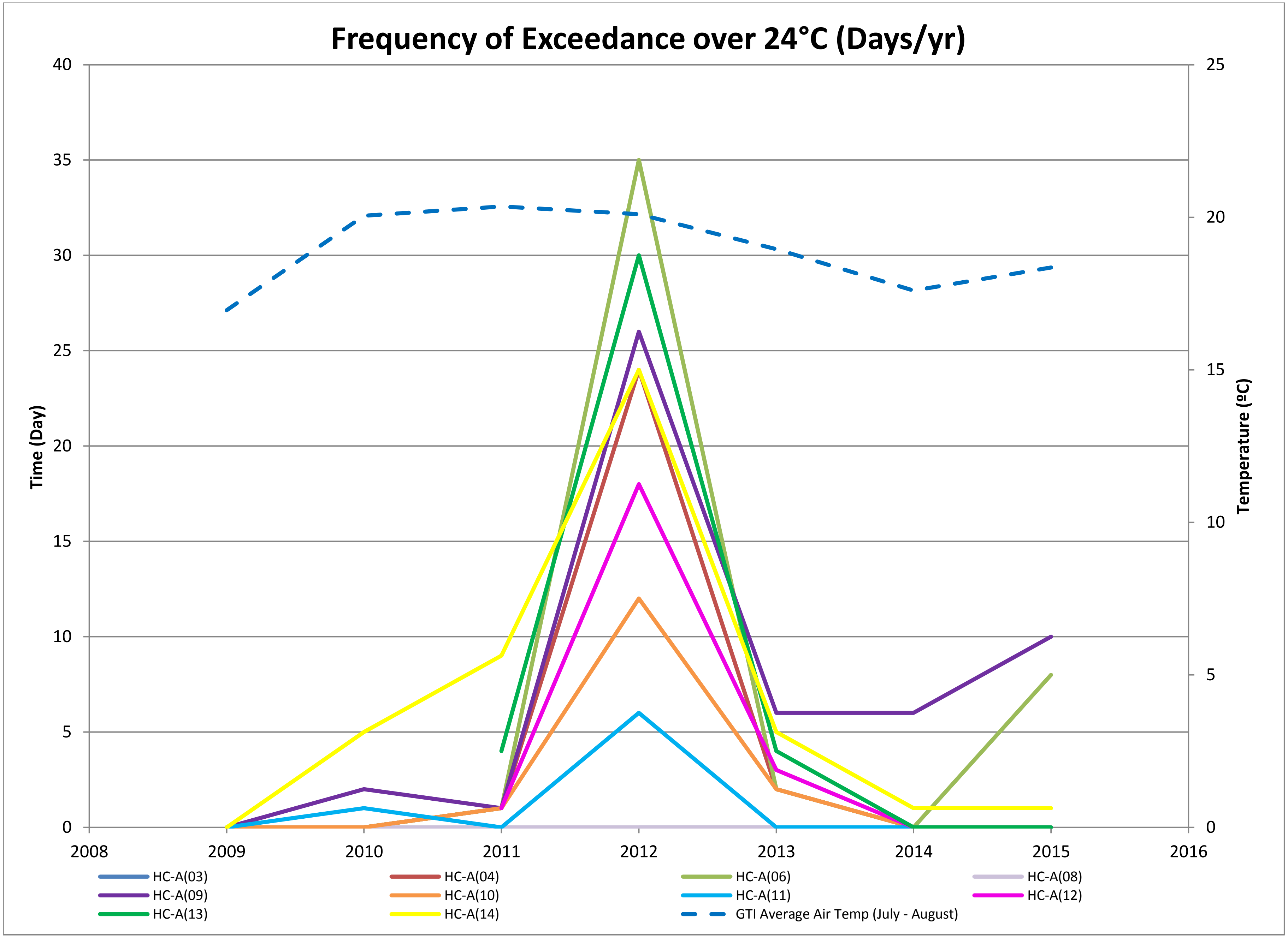


Average Duration of Event Over 22°C (h)
Time (hrs)
Temperature (ºC)
50
45
40
35
30
25
20
15
10
5
0
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

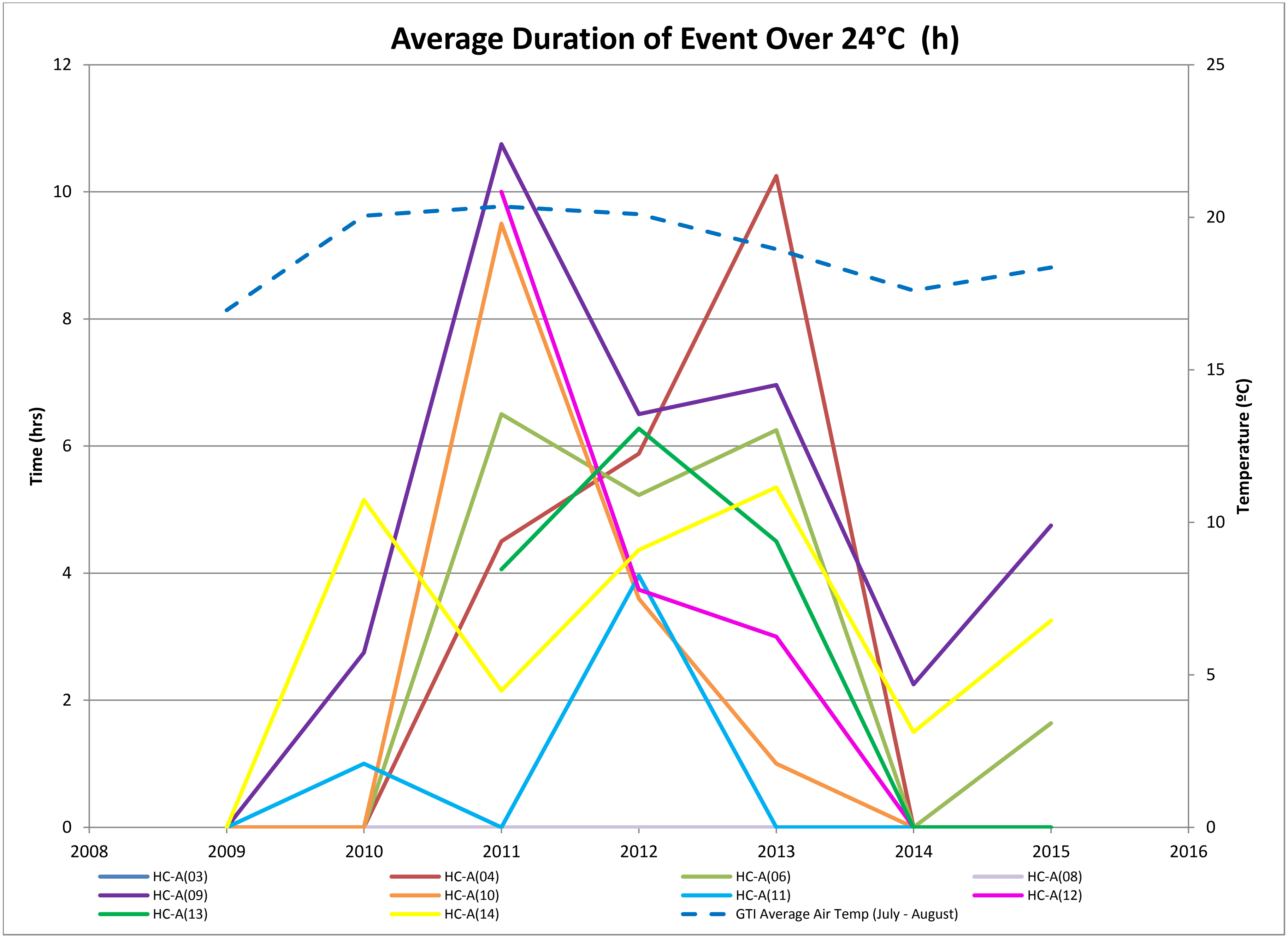

Hours over 24°C
Time (hrs)
Temperature (ºC)
250
200
150
100
50
0
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



Percent of Time over 24°C
Precent (%)
Temperature (ºC)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



Frequency of Exceedance over 24°C (Days/yr)
Time (Day)
Temperature (ºC)
0
5
10
15
20
25
30
35
40
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

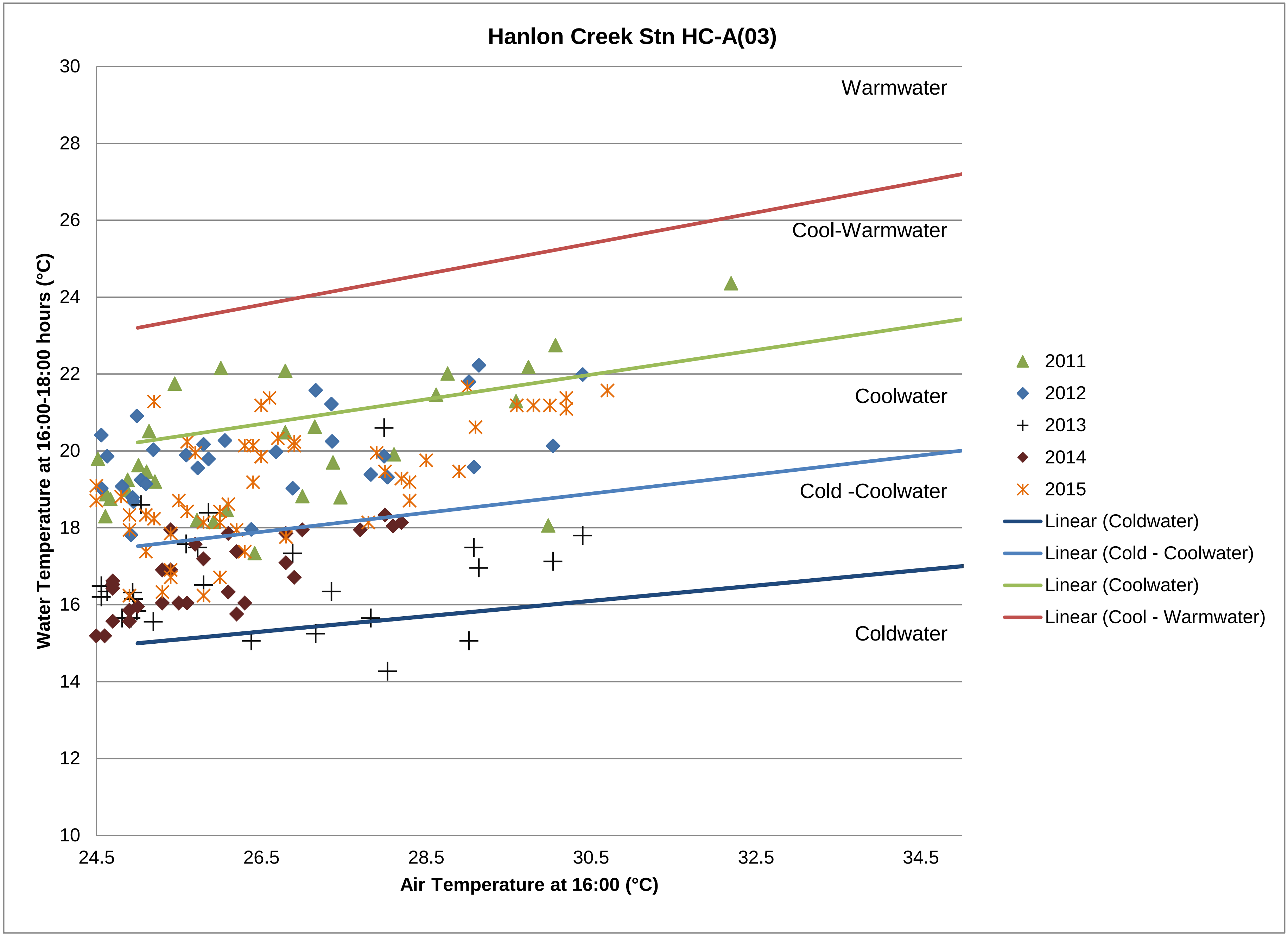


Average Duration of Event Over 24°C (h)
Time (hrs)
Temperature (ºC)
0
2
4
6
8
10
12
0
5
10
15
20
25
2008
2009
2010
2011
2012
2013
2014
2015
2016
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

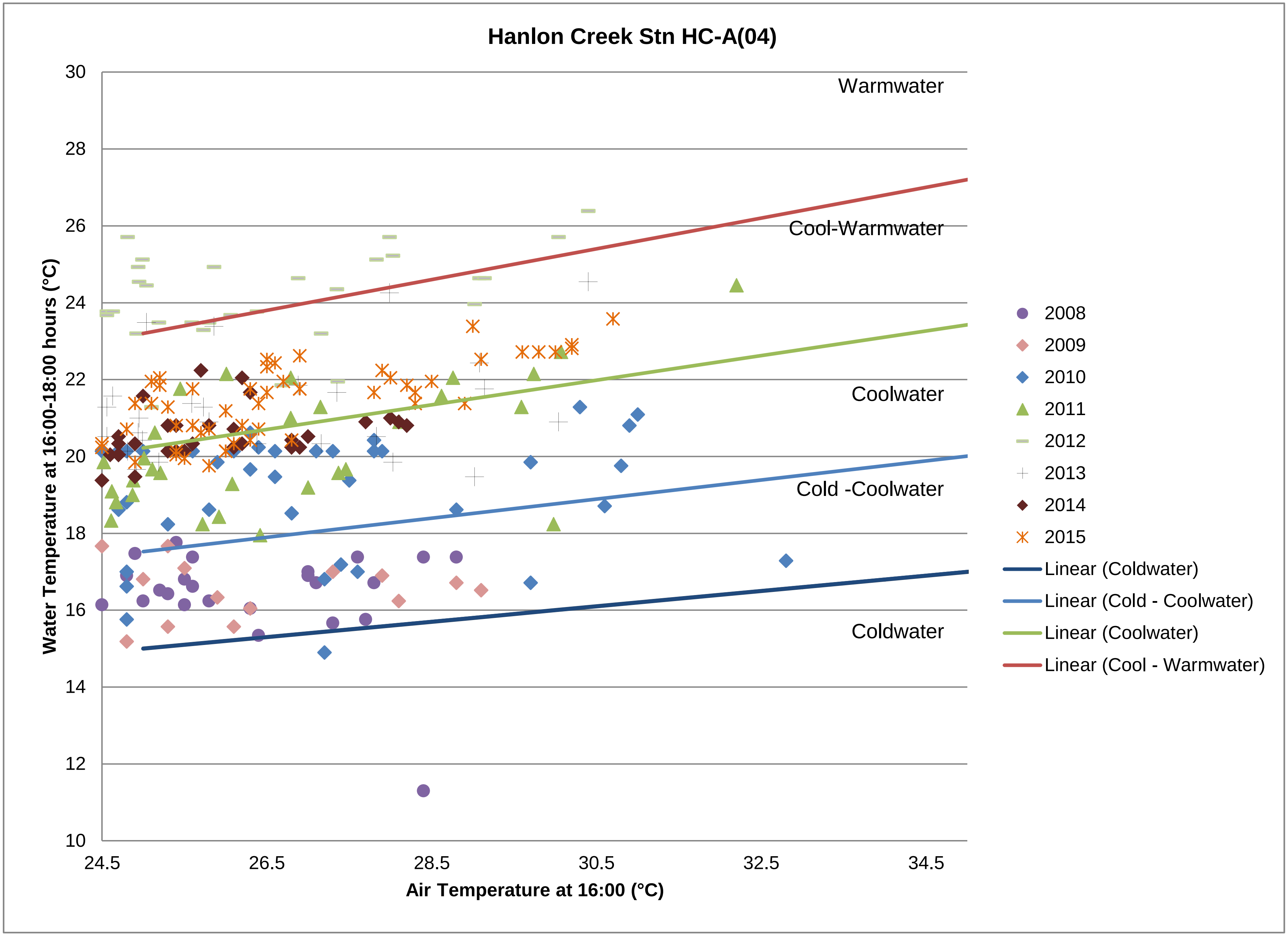
AECOM

Appendix D

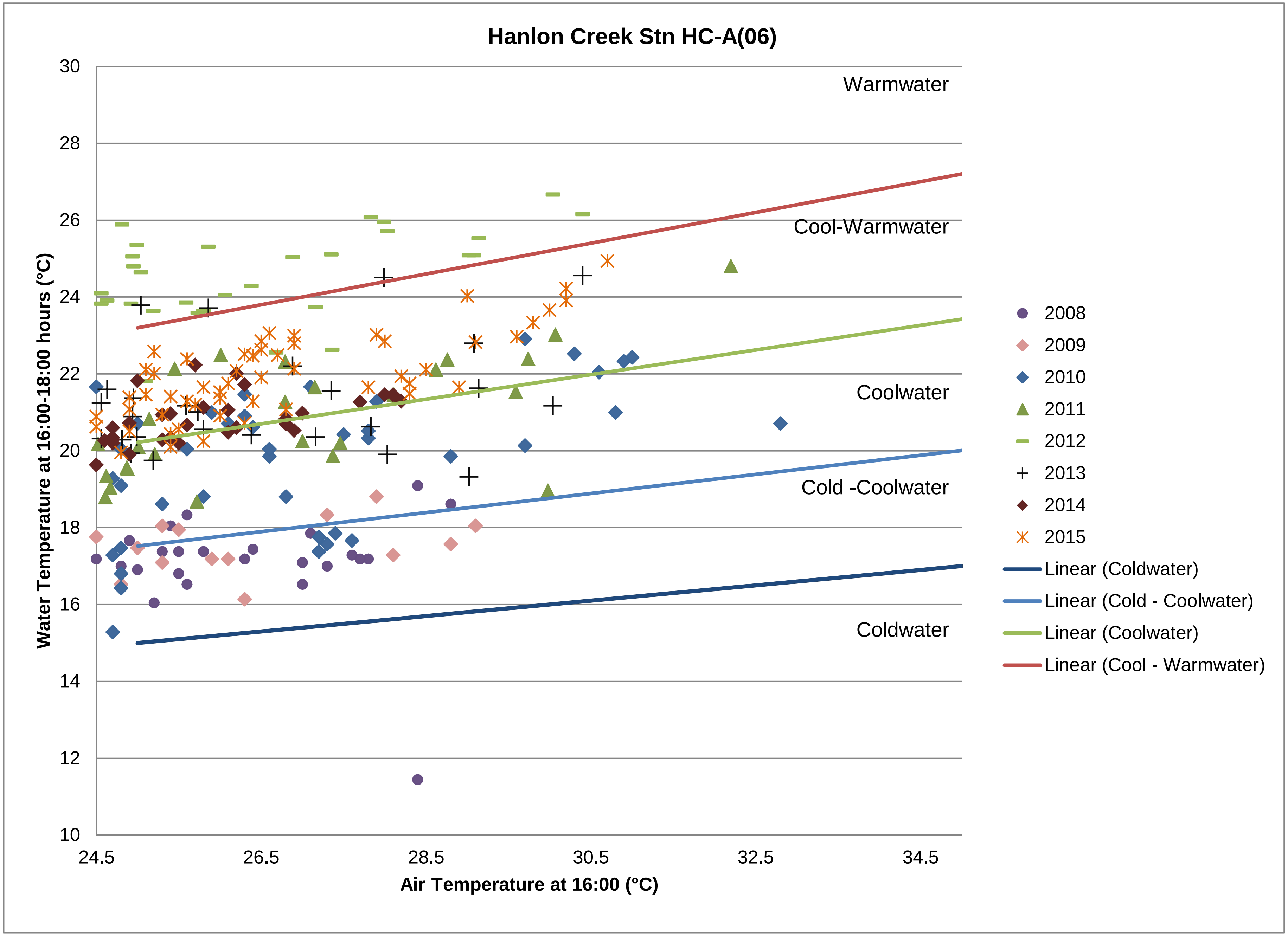
Thermal Regime Classification

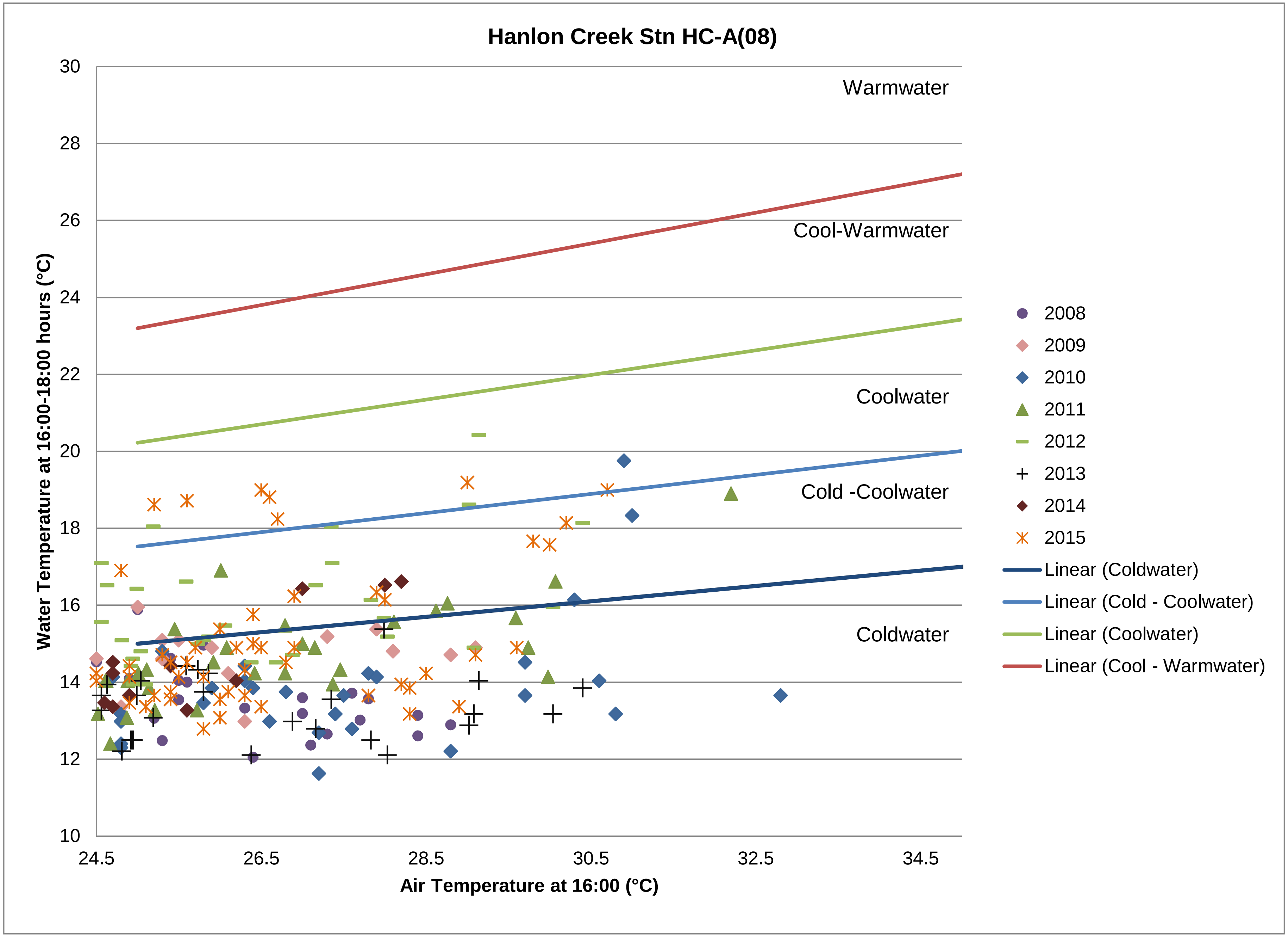


Hanlon Creek Stn HC-A(03)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

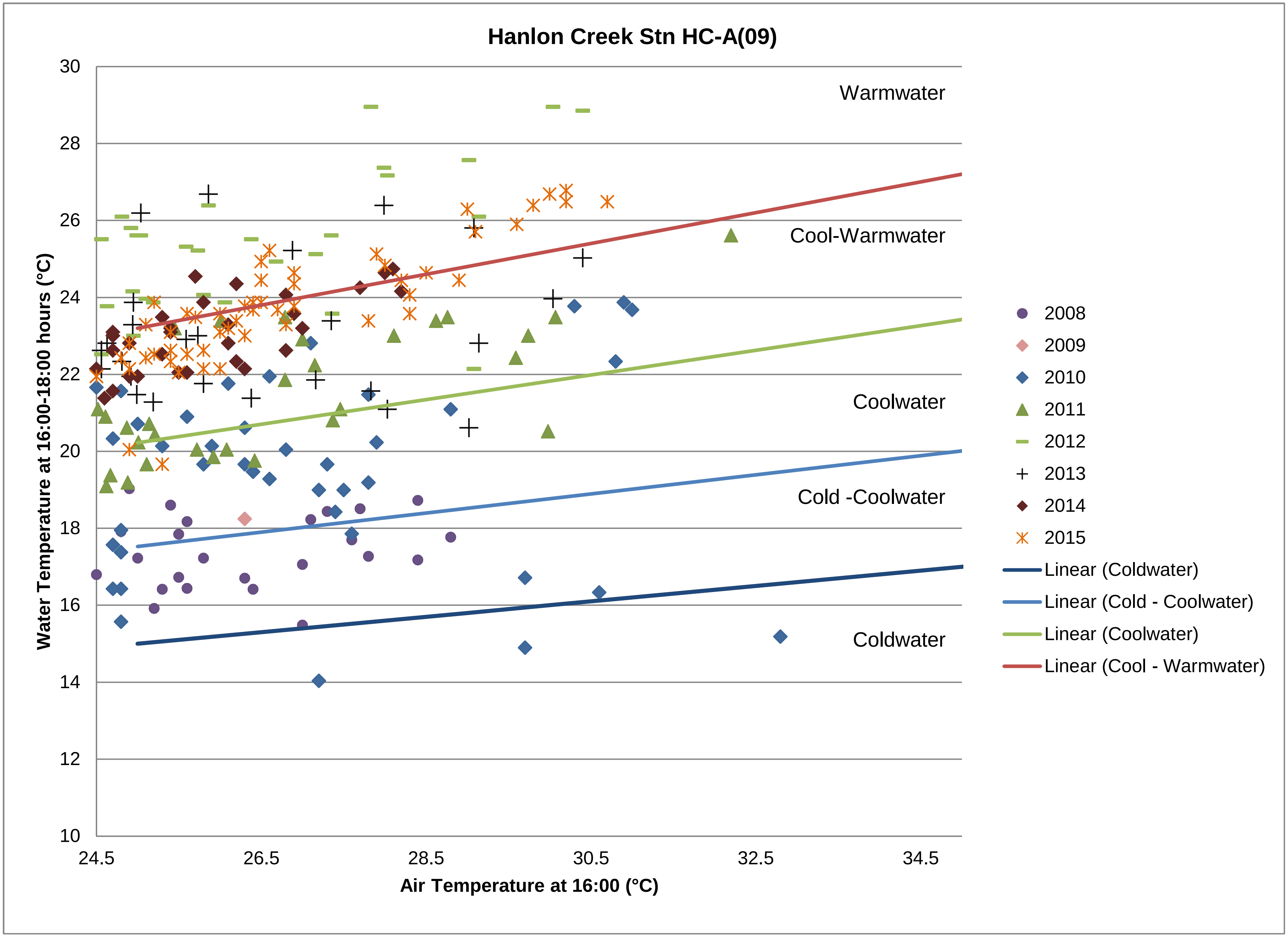


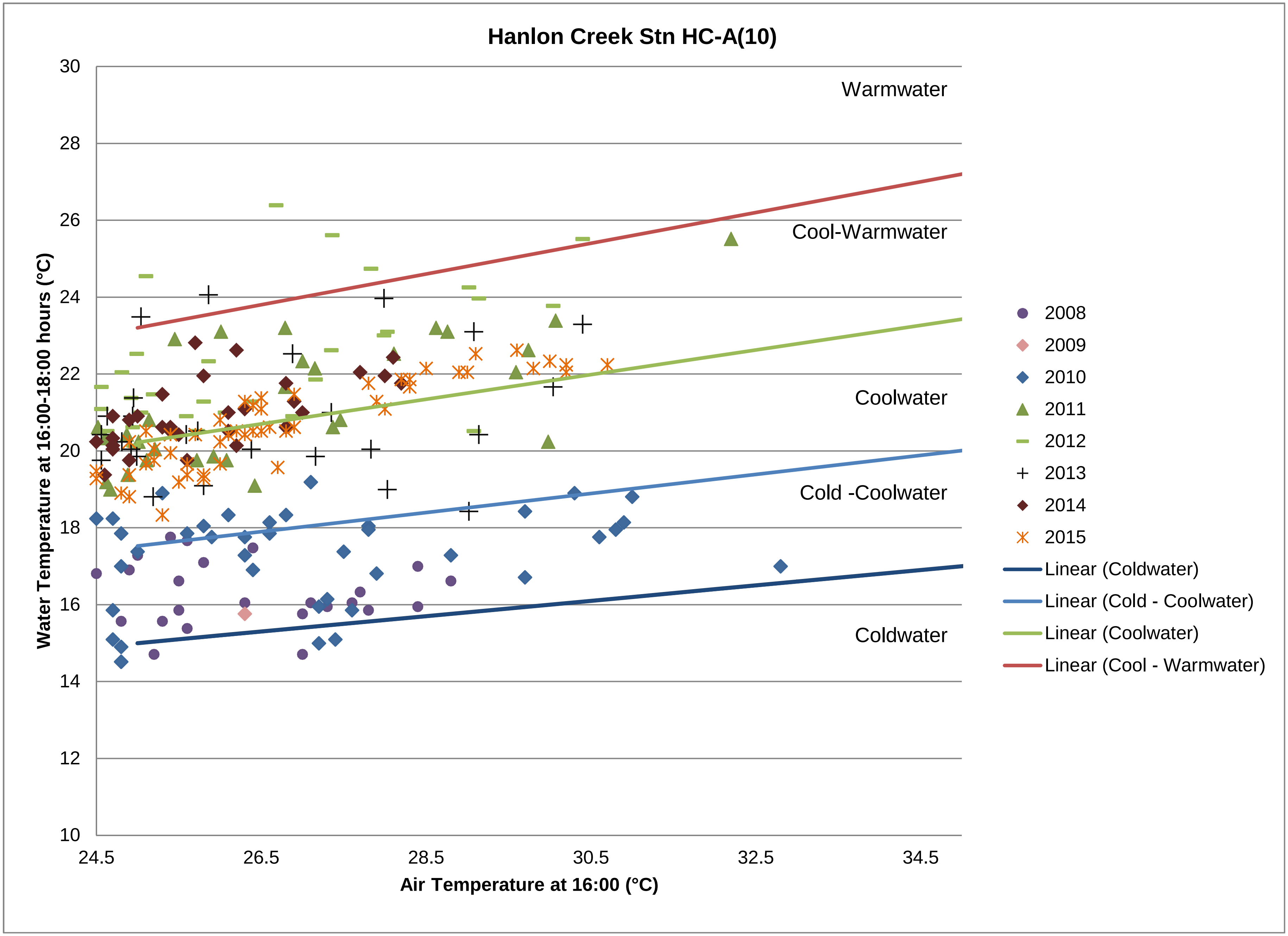
Hanlon Creek Stn HC-A(04)
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)


Hanlon Creek Stn HC-A(06)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

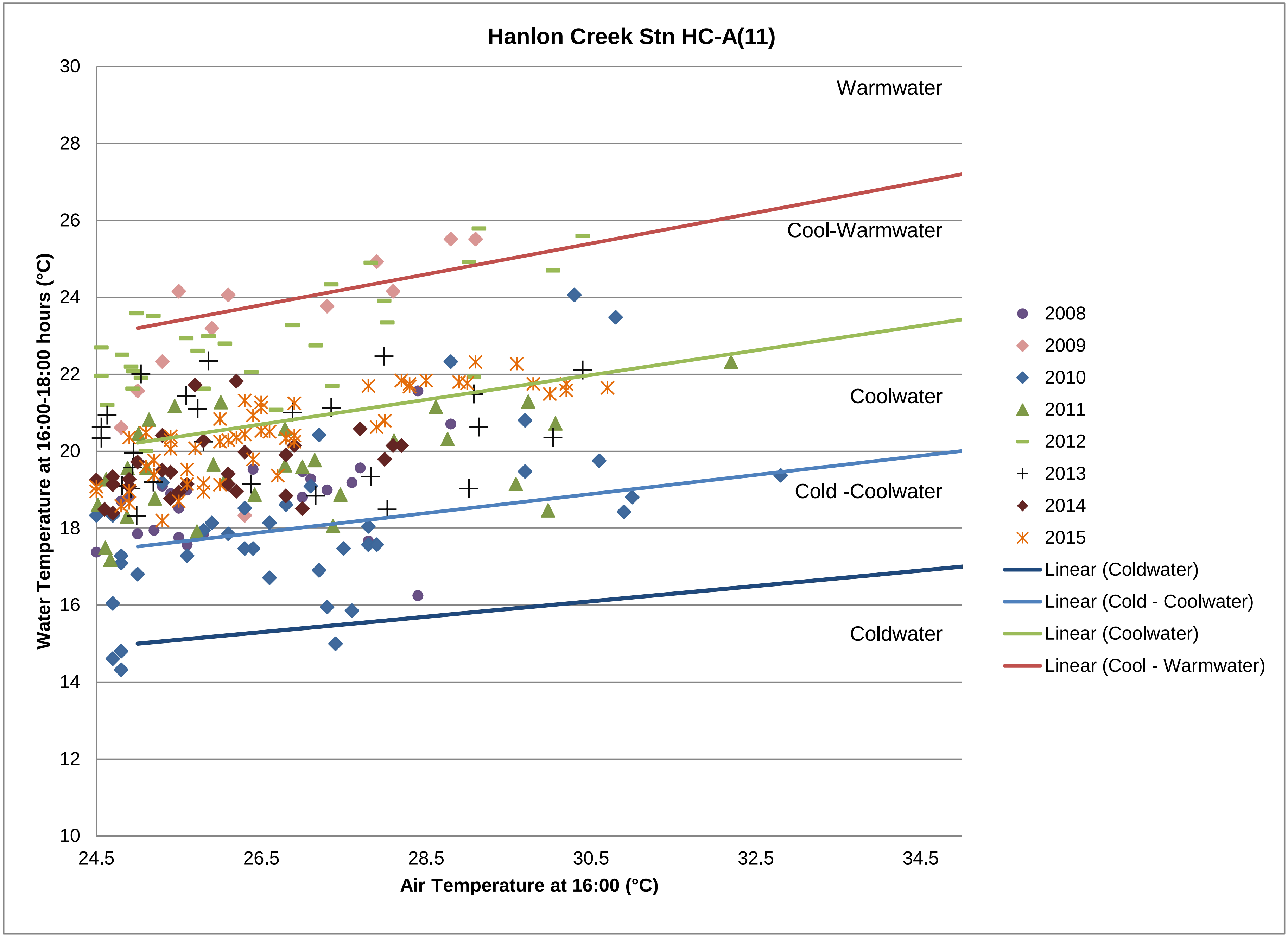


Hanlon Creek Stn HC-A(08)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
10
12
14
16
18
20
22
24
26
28
30
24.5
26.5
28.5
30.5
32.5
34.5
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

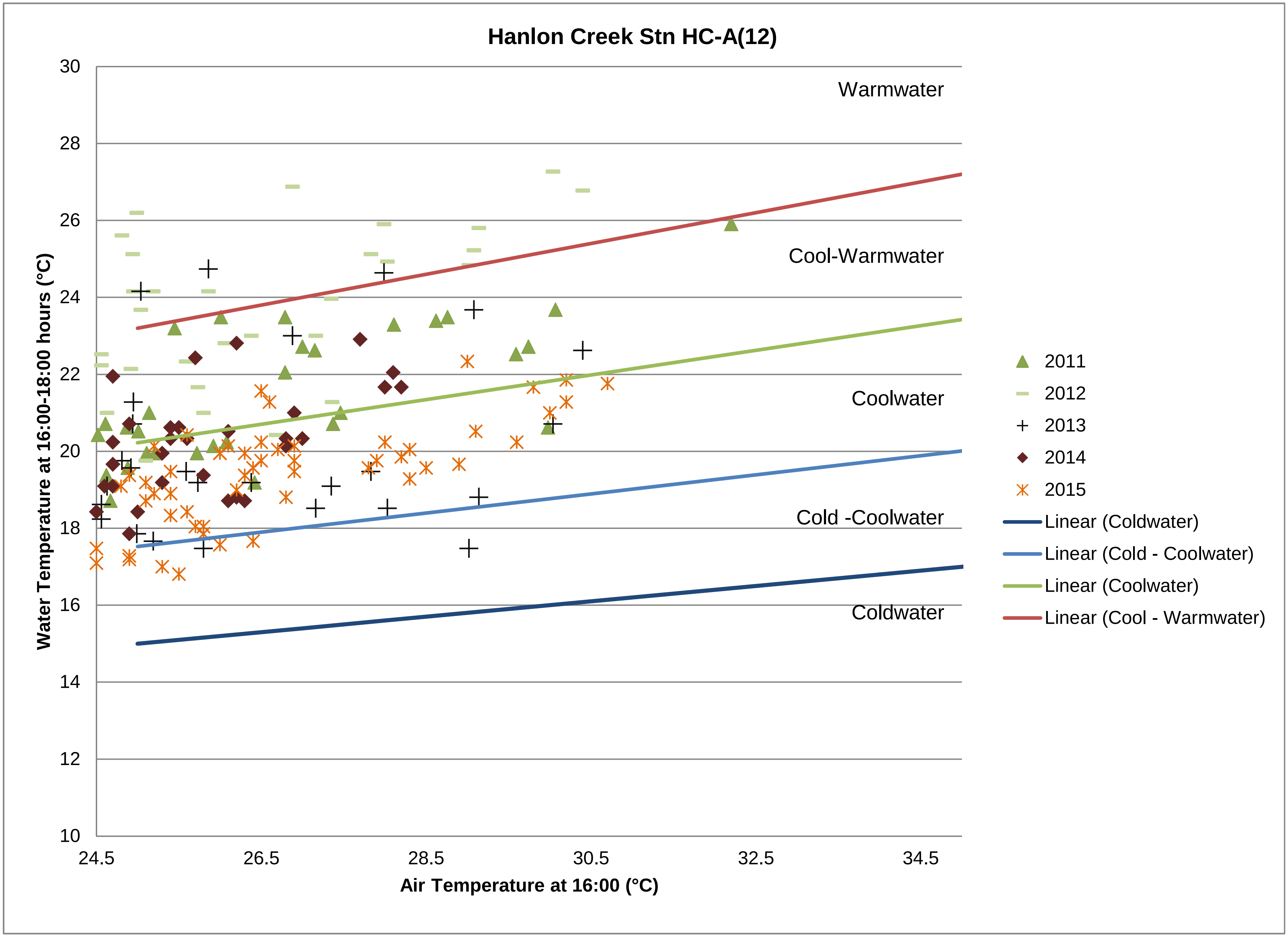

Hanlon Creek Stn HC-A(09)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

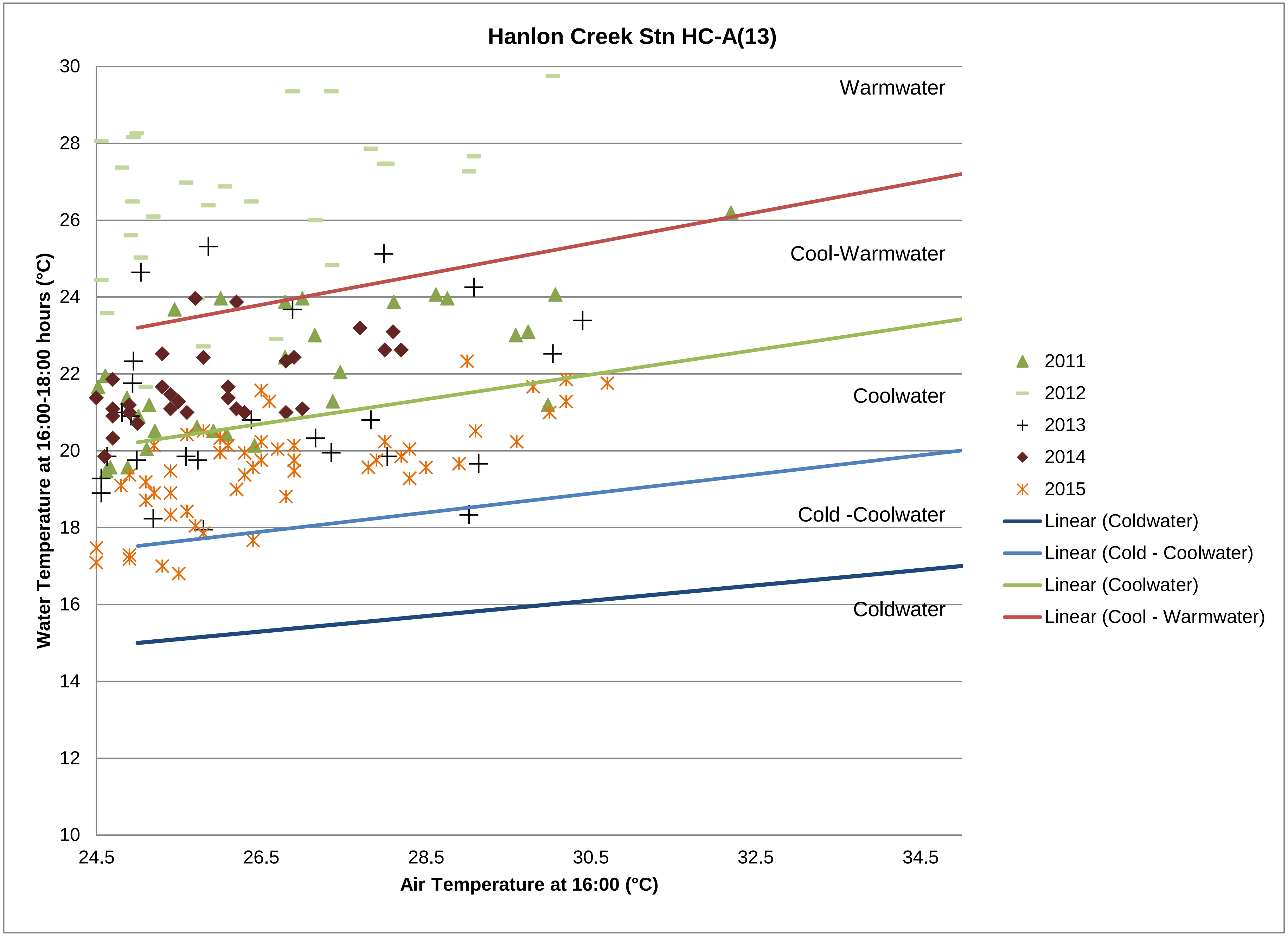


Hanlon Creek Stn HC-A(10)
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

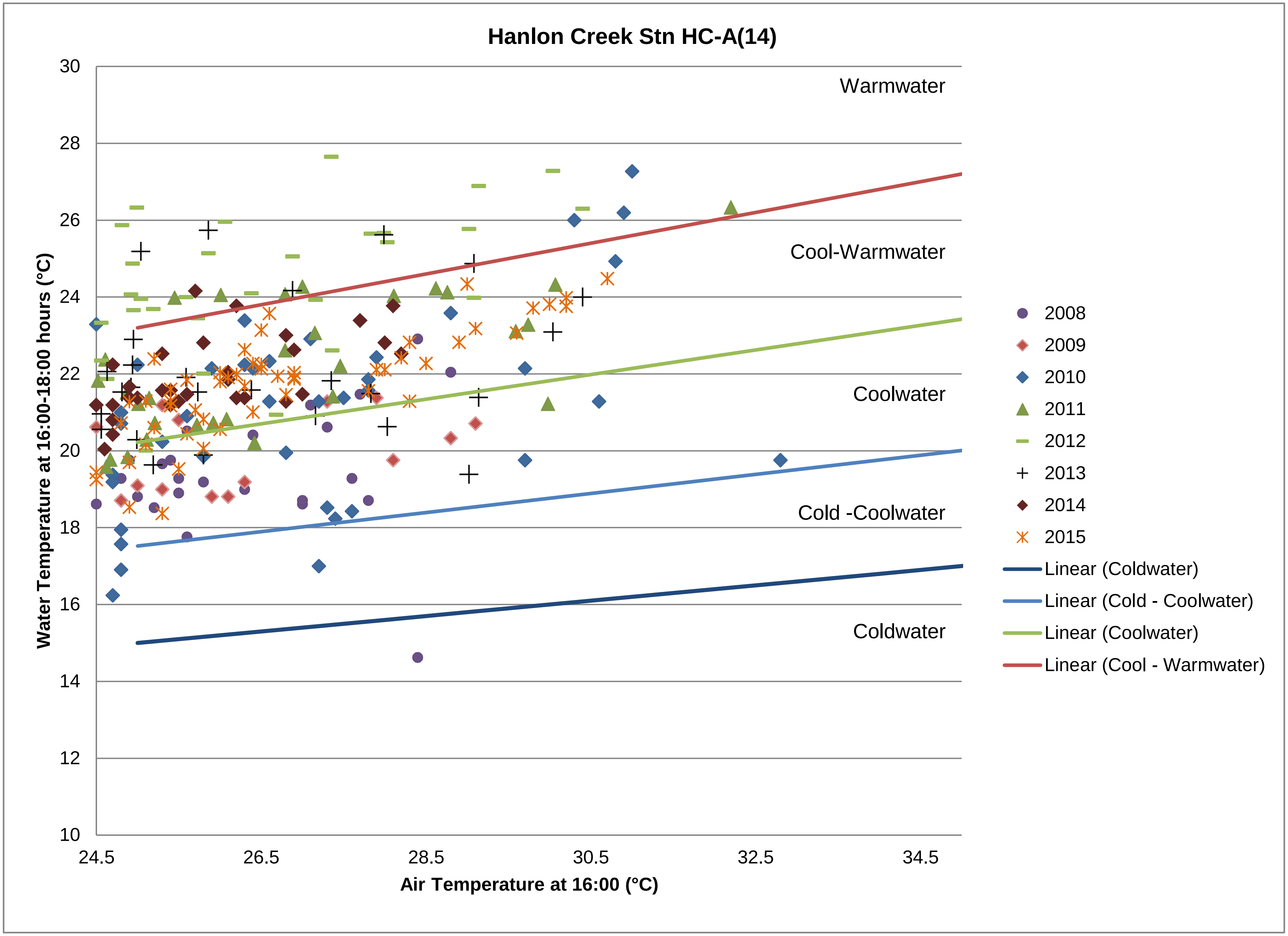


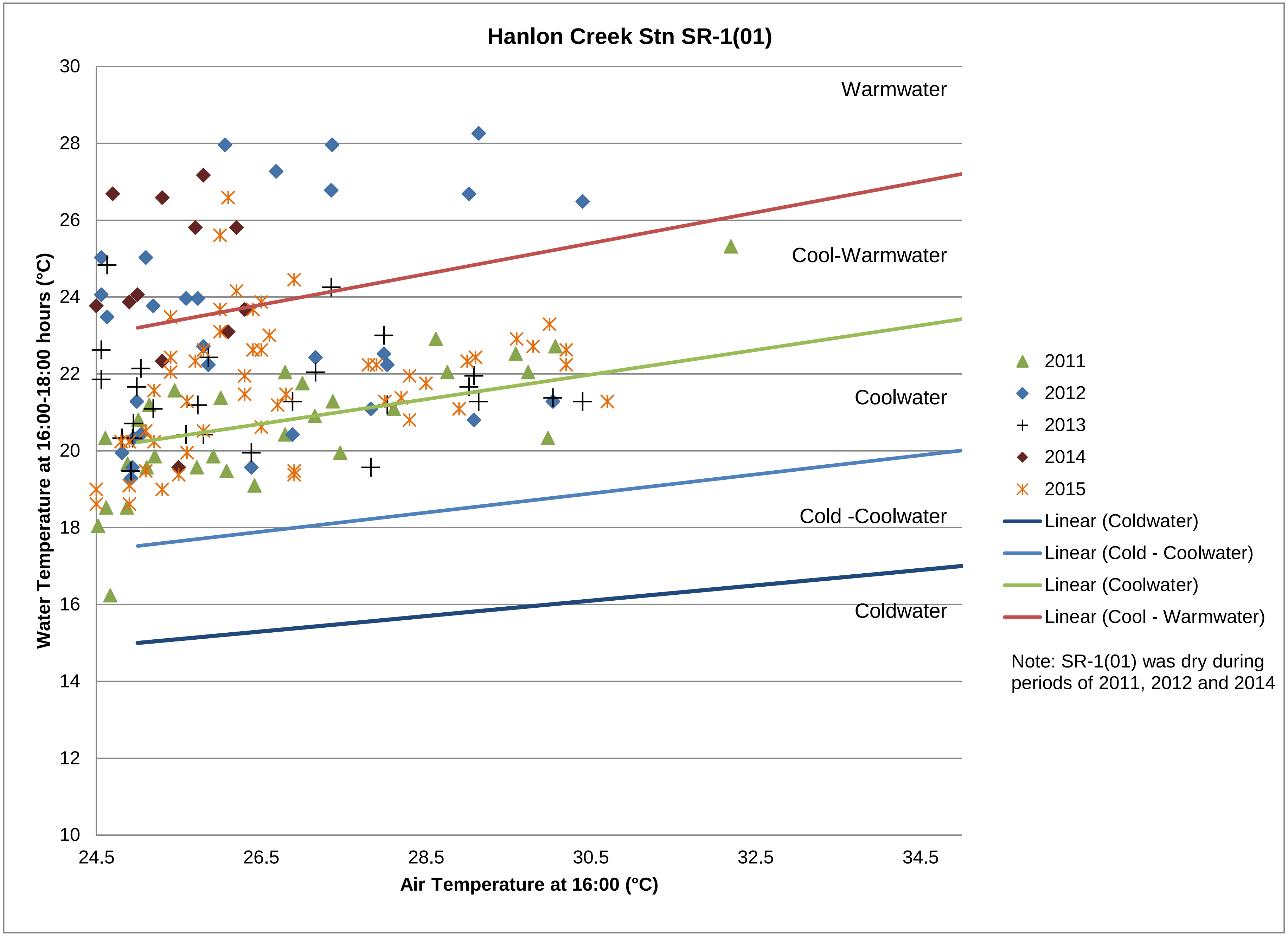
Hanlon Creek Stn HC-A(11)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)


Hanlon Creek Stn HC-A(12)
Water Temperature at 16:00-18:00 hours (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)



Hanlon Creek Stn HC-A(13)
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

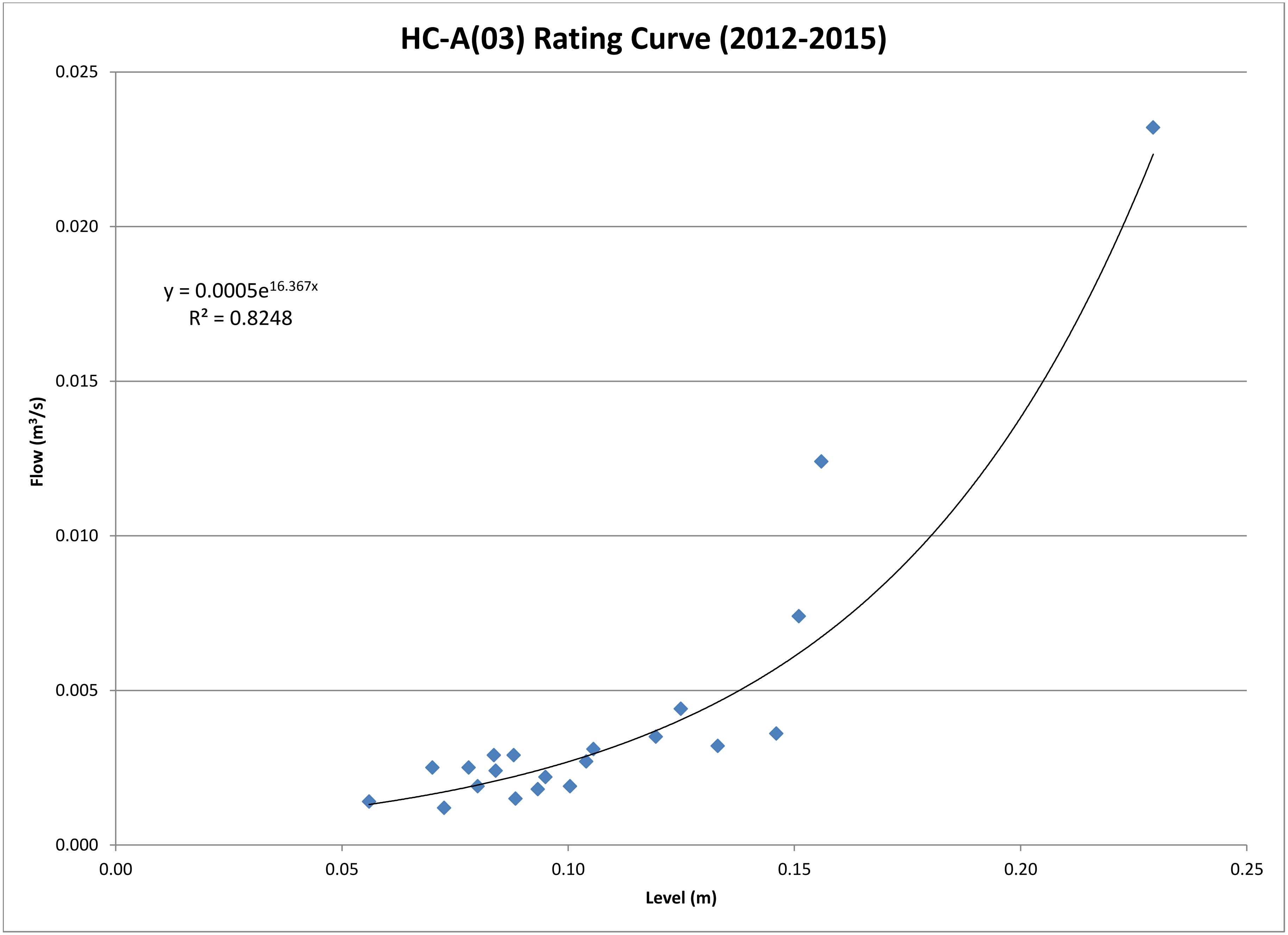

Hanlon Creek Stn HC-A(14)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
Water Temperature at 16:00-18:00 hours (°C)
Air Temperature at 16:00 (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
2008
2009
2010
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

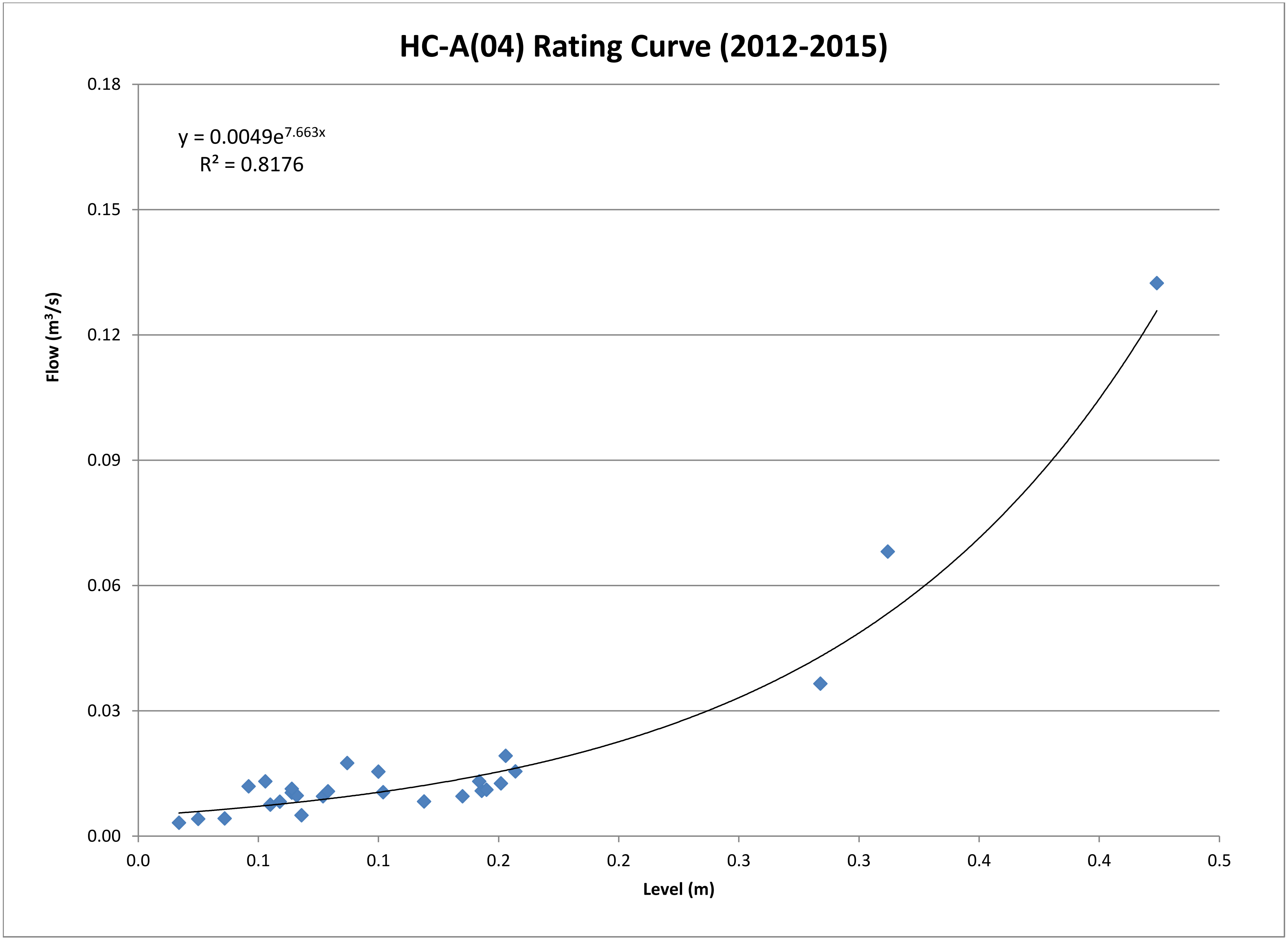

Hanlon Creek Stn SR-1(01)
Warmwater
Cool-Warmwater
Coolwater
Cold -Coolwater
Coldwater
30
28
26
24
22
20
18
16
14
12
10
Water Temperature at 16:00-18:00 hours (°C)
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
2011
2012
2013
2014
2015
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Note: SR-1(01) was dry during periods of 2011, 2012 and 2014

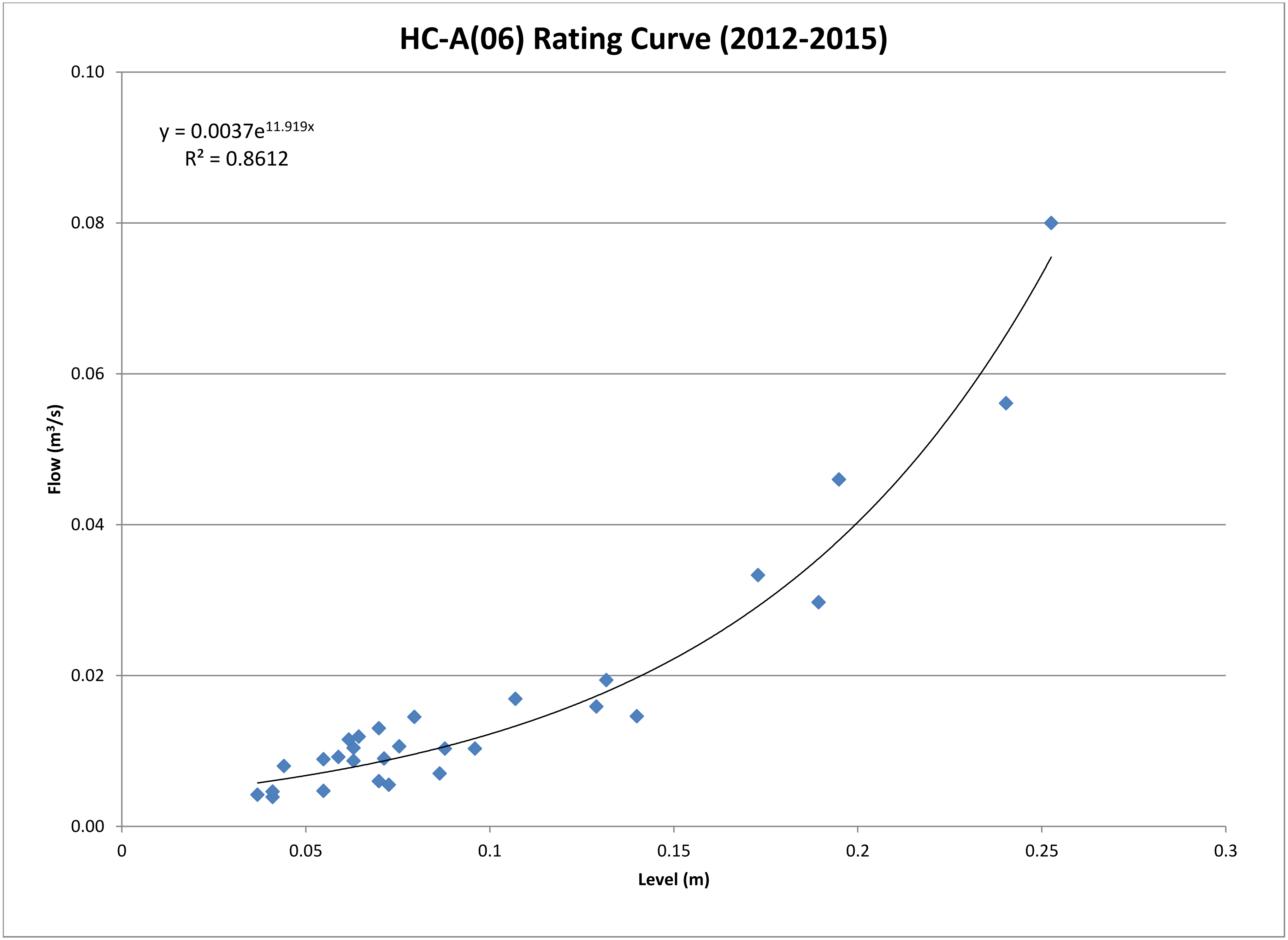
AECOM

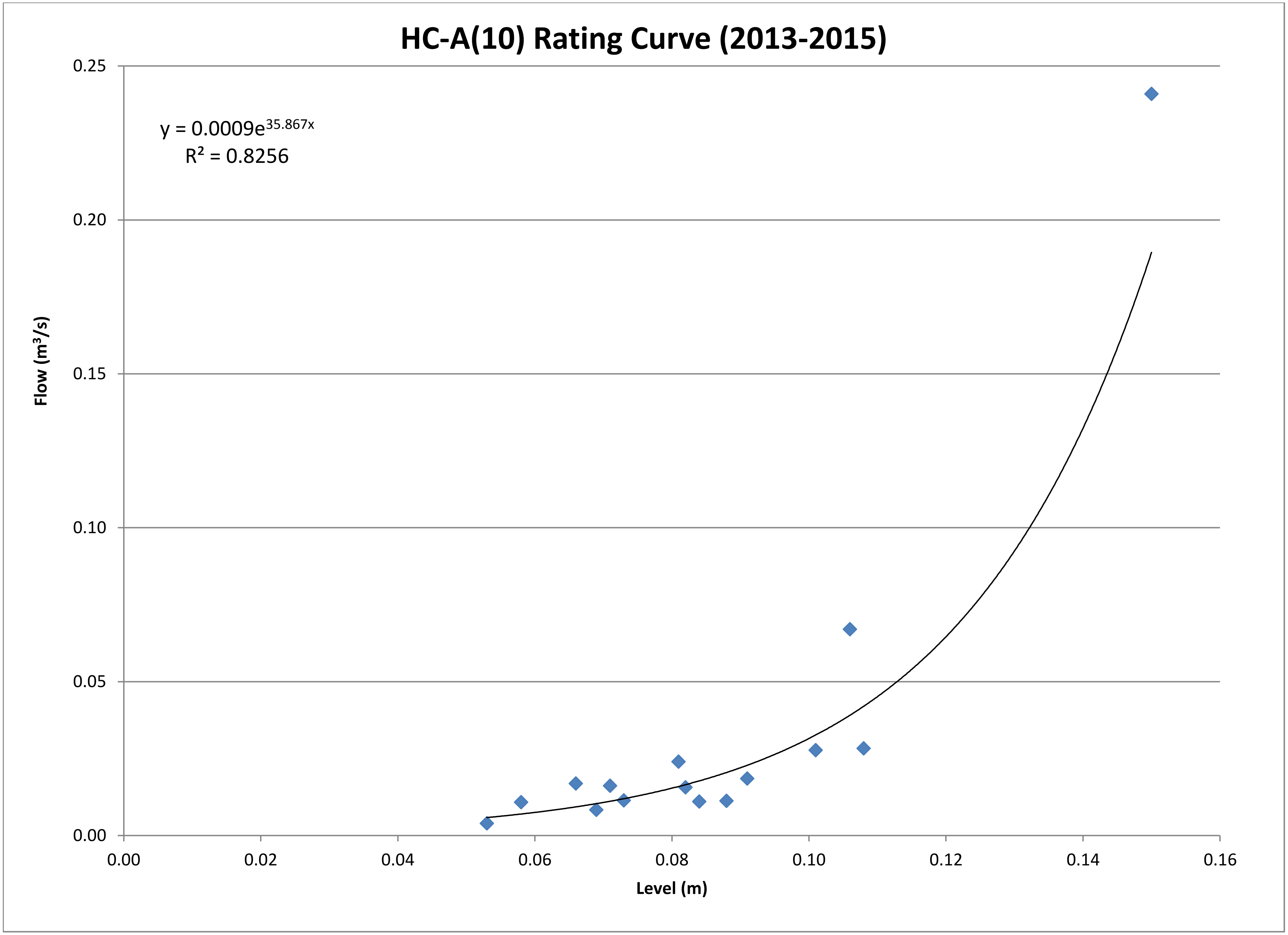
Appendix E

Stage (level) – Discharge Relationship Plots

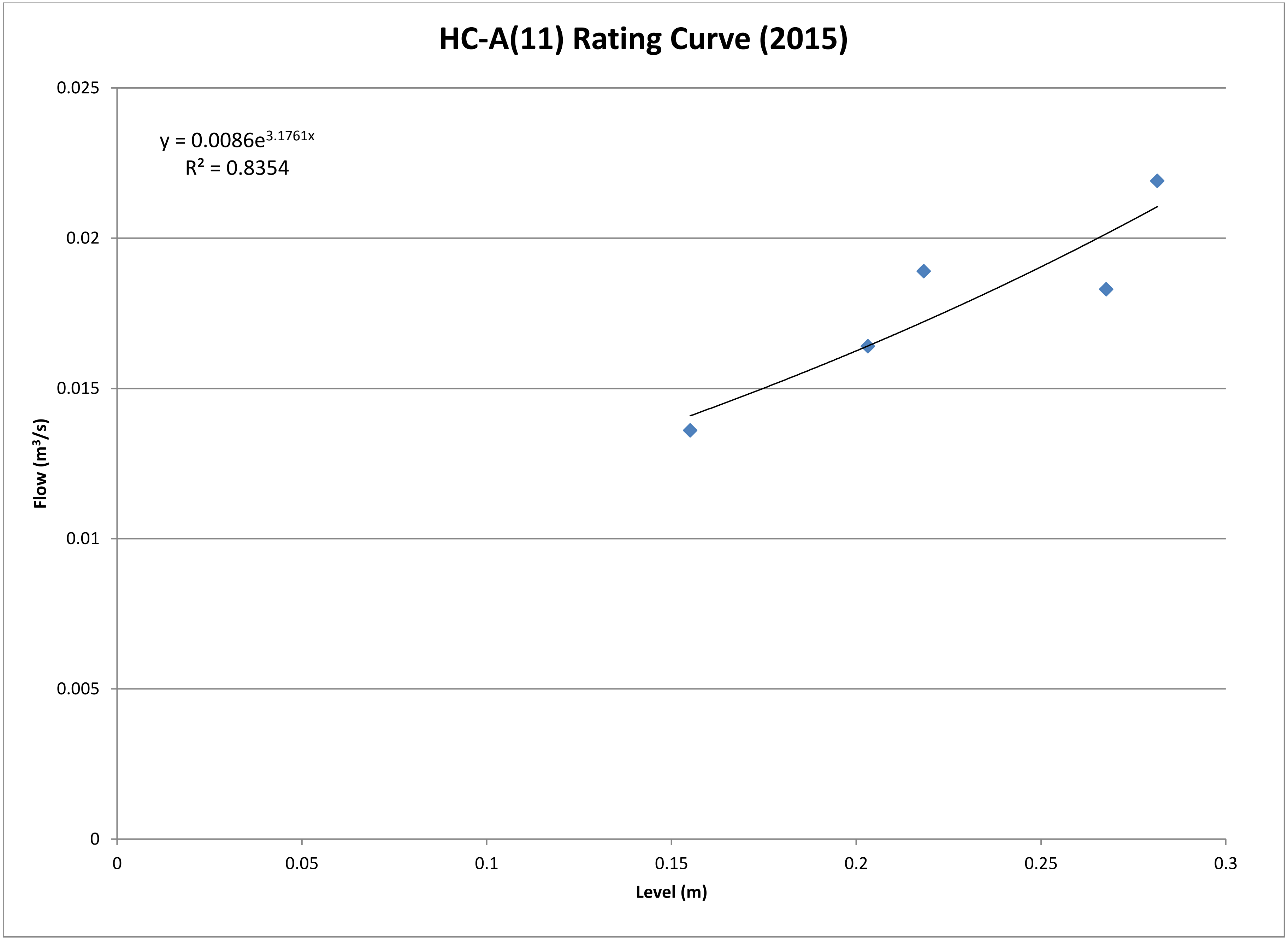

HC-A(03) Rating Curve (2012-2015)
y = 0.0005e^16.367x
R² = 0.8248
Flow (m³/s)
Level (m)
0.025
0.020
0.015
0.010
0.005
0.000
0.00
0.05
0.10
0.15
0.20
0.25

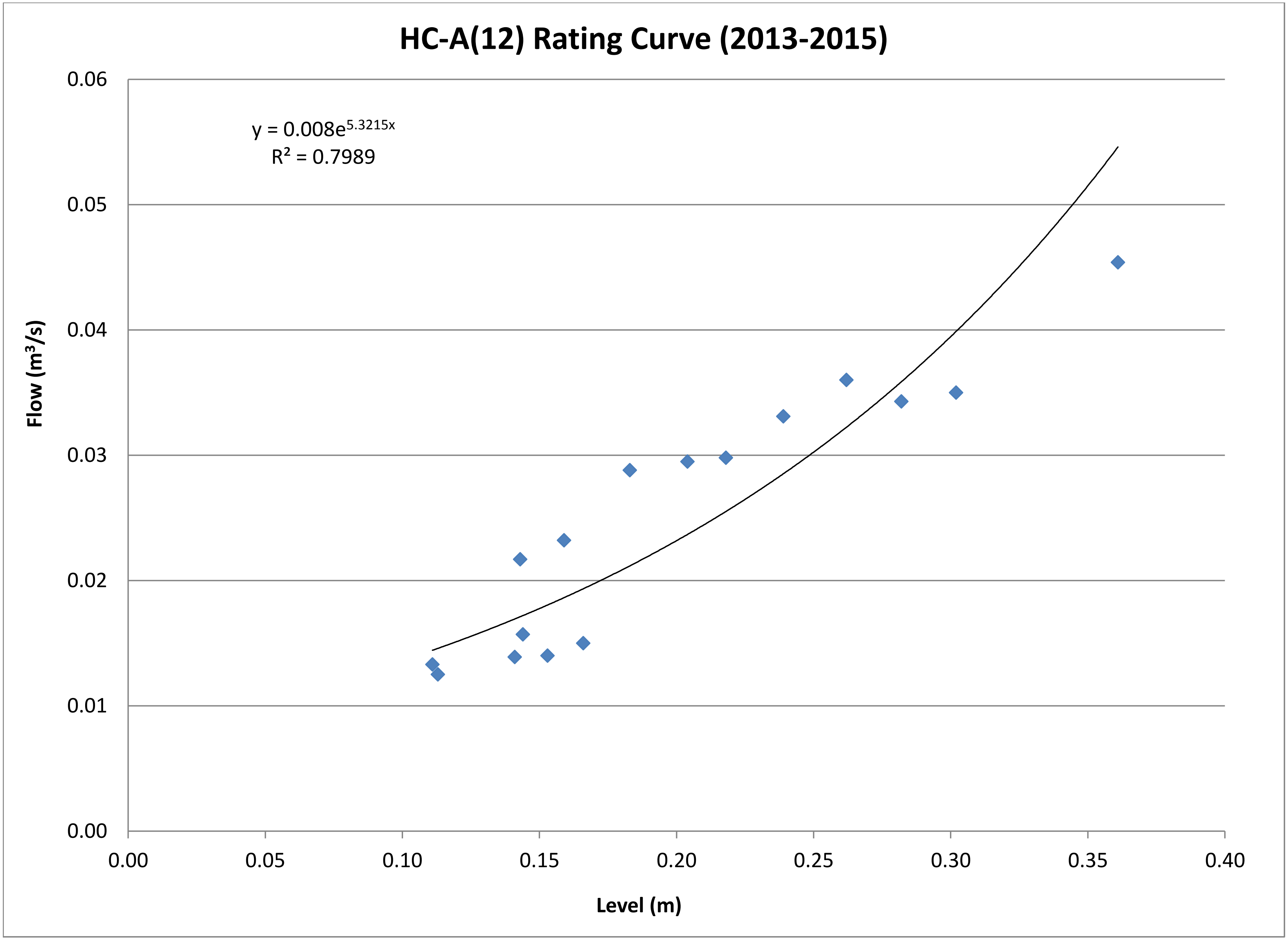

HC-A(04) Rating Curve (2012-2015)
y = 0.0049e^7.663x
R² = 0.8176
Flow (m³/s)
0.18
0.15
0.12
0.09
0.06
0.03
0.00
0.0
0.1
0.1
0.2
0.2
0.3
0.3
0.4
0.4
0.5
Level (m)

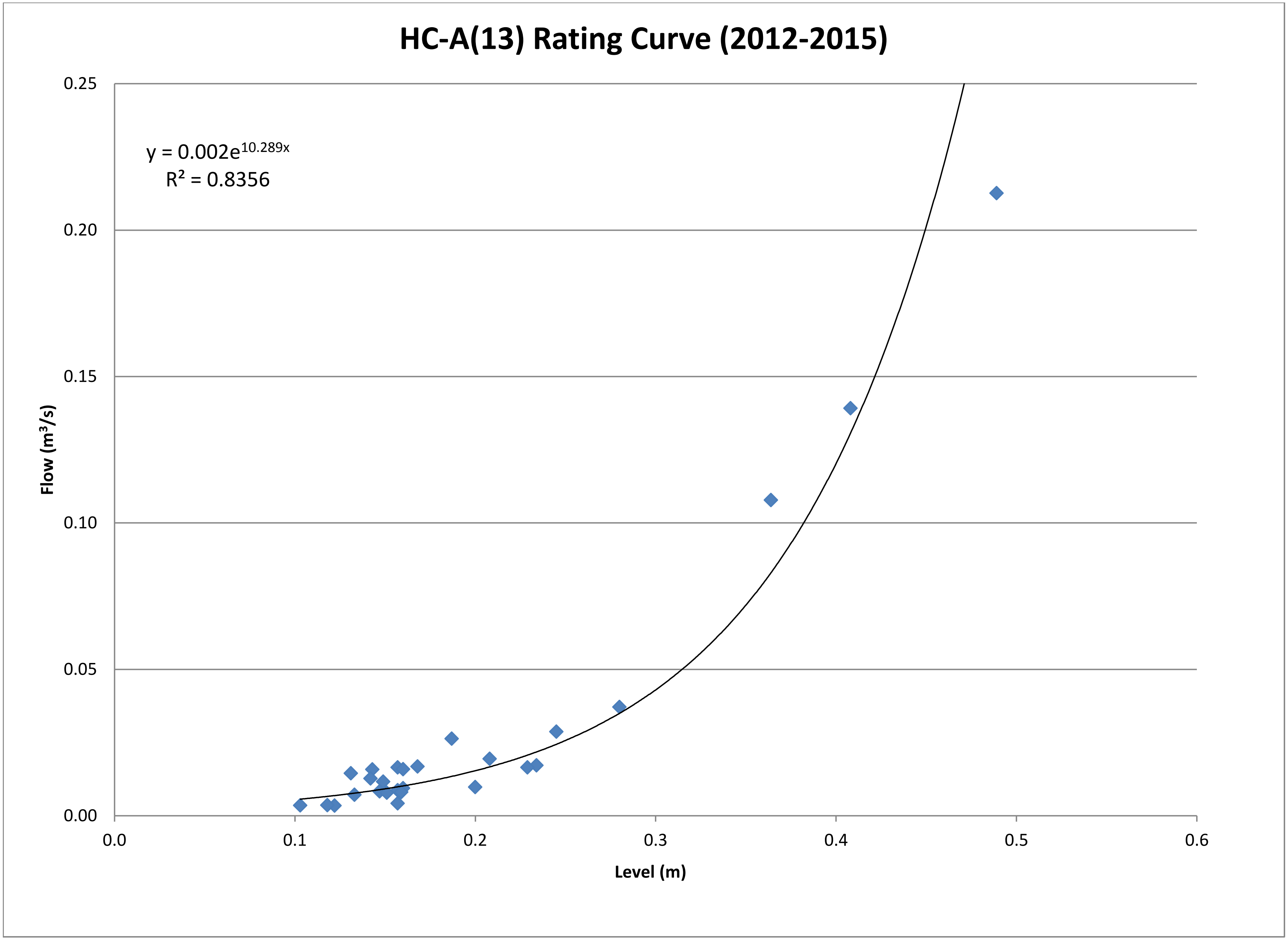

HC-A(06) Rating Curve (2012-2015)
y = 0.0037e^11.919x
R² = 0.8612
0.10
0.08
0.06
0.04
0.02
0.00
Flow (m³/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
Level (m)



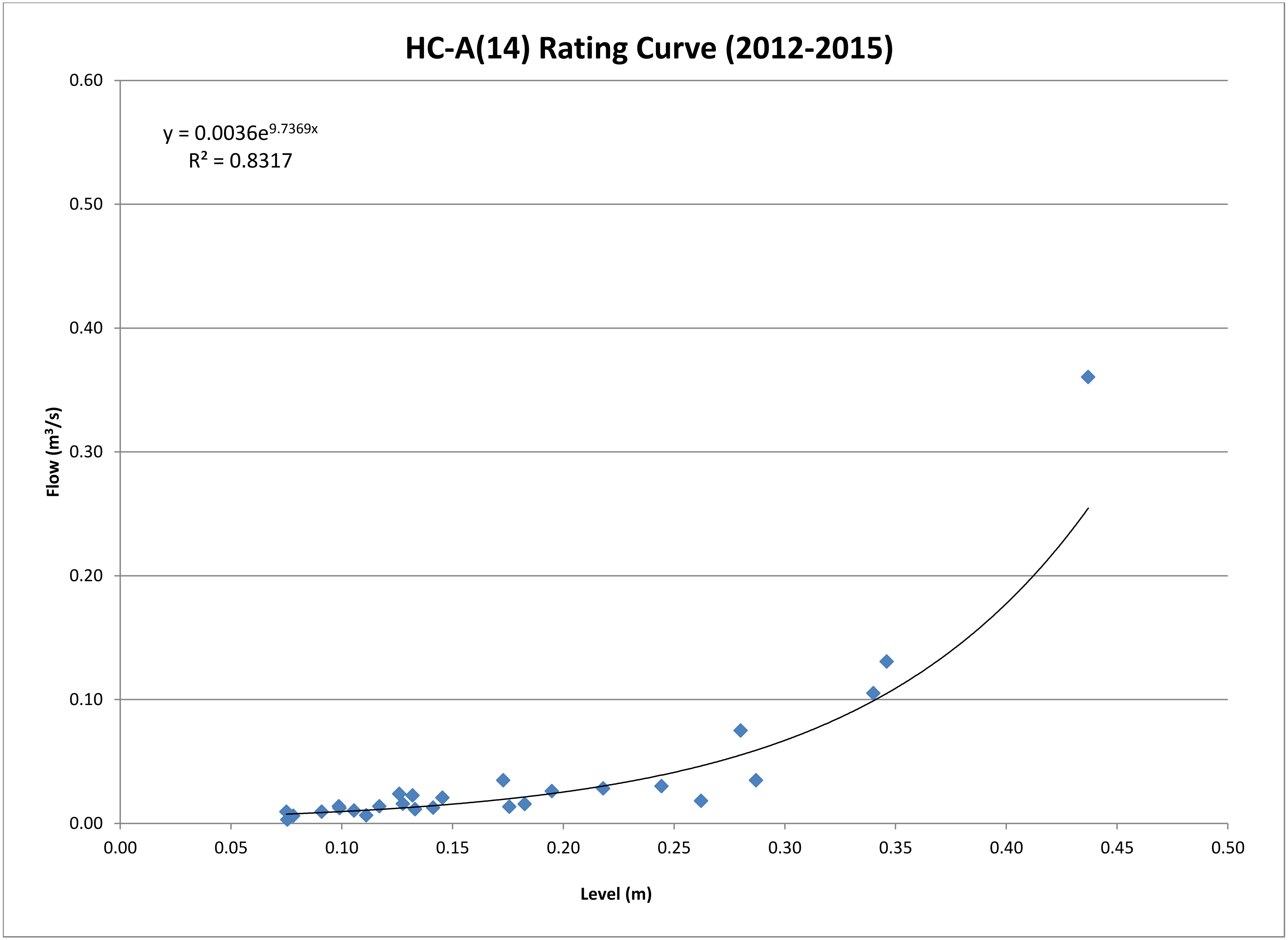
HC-A(10) Rating Curve (2013-2015)
y = 0.0009e^35.867x
R² = 0.8256
Flow (m³/s)
Level (m)
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16


HC-A(11) Rating Curve (2015)
y = 0.0086e^3.1761x
R² = 0.8354
Flow (m³/s)
Level (m)
0
0.005
0.01
0.015
0.02
0.025
0
0.05
0.1
0.15
0.2
0.25
0.3


HC-A(12) Rating Curve (2013-2015)
y = 0.008e^5.3215x
R² = 0.7989
Flow (m³/s)
Level (m)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40



HC-A(13) Rating Curve (2012-2015)
y = 0.002e^10.289x
R² = 0.8356
Flow (m³/s)
Level (m)
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.1
0.2
0.3
0.4
0.5
0.6


HC-A(14) Rating Curve (2012-2015)
y = 0.0036e^9.7369x
R² = 0.8317
Flow (m³/s)
Level (m)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50

Appendix F

Tabular Water Quality Sampling Results

			PWQO		Guelph Storm		SITES SAMPLED ON 3/25/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.029	<0.010	<0.010	<0.010	0.026	<0.010
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.116	0.056	0.090	0.120	0.139	0.106	2.08	0.191	0.189	0.036	1.97	0.069
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	<0.050	0.096	0.077	0.120	0.106	1.20	0.693	0.247	0.533	0.767	0.307	0.120
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00062	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00126	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0018	<0.0010	<0.0010	<0.0010	0.0013	<0.0010
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.0494	0.0612	0.0647	0.0755	0.0776	0.0342	0.0185	0.0625	0.0184	0.0026	0.0241	0.0570
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.0500	0.0601	0.0613	0.0710	0.0725	0.0357	0.0573	0.0616	0.0209	0.0022	0.0660	0.0541
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
BOD Carbonaceous	mg/L	2	-	-	-	15	2.0	<2.0	<2.0	3.7	2.0	4.5	10.1	<2.0	7.7	5.7	5.7	2.5
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	<0.010	<0.010	0.023	0.012	<0.010	0.015	0.020	0.012	<0.010	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	<0.010	<0.010	0.023	0.010	<0.010	0.086	0.019	0.012	<0.010	0.093	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	0.000161	0.000096	<0.000090	<0.000090	0.000100	<0.000090
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	67.2	79.3	81.1	104	99.9	44.0	28.5	130	26.2	2.42	35.9	68.0
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	64.1	76.1	78.8	97.5	89.1	41.7	34.4	127	25.9	1.58	38.7	66.3
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	2	-	-	-	-	146	169	168	299	307	204	361	440	141	33.5	428	245
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00209	<0.00050	<0.00050	<0.00050	0.00072	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	<0.00050	<0.00050	<0.00050	<0.00050	0.00078	<0.00050	0.00672	0.00089	<0.00050	<0.00050	0.00401	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00137	<0.00050	<0.00050	<0.00050	0.00138	<0.00050
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.0010	<0.0010	<0.0010	0.0021	0.0011	0.0014	0.0120	0.0018	0.0020	<0.0010	0.0037	<0.0010
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.0013	<0.0010	<0.0010	0.0024	0.0013	0.0017	0.0224	0.0031	0.0026	<0.0010	0.0100	0.0012
E. Coli	CFU/100mL	10	-	100	-	-	20	20	20	<10	<10	<10	1100	10	<10	<10	10	10
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.205	0.134	0.170	0.116	0.137	0.148	2.89	0.238	0.205	<0.050	2.79	0.093
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0110	0.00083	0.00053	<0.00050	0.00781	<0.00050
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	20.5	25.0	25.6	28.1	33.5	14.3	4.19	32.0	6.76	0.53	6.96	20.3
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	19.5	24.2	24.3	27.4	28.6	13.3	8.14	30.6	6.71	<0.50	8.40	19.6
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.0249	0.0213	0.0187	0.0162	0.0119	0.0162	0.0198	0.0105	0.0153	0.0070	0.0948	0.0032
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.0384	0.0334	0.0400	0.0199	0.0151	0.0251	0.117	0.0244	0.0253	0.0067	0.175	0.0388
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	0.00054	<0.00050	<0.00050	0.00118	<0.00050	<0.00050	0.00085	<0.00050	0.00086	<0.00050	0.00105	0.00064
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	0.00059	<0.00050	<0.00050	0.00136	<0.00050	0.00053	0.00115	<0.00050	0.00098	<0.00050	0.00127	0.00067
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0036	<0.0010	<0.0010	<0.0010	0.0032	<0.0010
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.833	0.657	0.638	1.34	0.575	0.122	1.05	0.656	0.381	0.384	0.719	0.786
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.180	<0.050	<0.050	0.168	<0.050	0.422	0.178	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.218	<0.050	0.090	0.435	0.058	0.572	0.120	0.171	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.0076	0.0100	0.0105	0.174	0.0262	0.0169	0.163	0.0310	0.392	0.154	0.0174	0.0099
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	2.5	2.2	2.3	9.6	2.7	3.8	3.8	3.0	7.5	<1.0	3.6	3.0

Potassium (K)-Total	mg/L	1	-	-	-	-	2.4	2.1	2.2	9.0	2.3	3.4	4.0	3.1	7.4	<1.0	3.8	2.9
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	2.1	3.0	3.1	3.6	3.2	<1.0	1.2	3.5	<1.0	<1.0	1.2	1.5
Silicon (Si)-Total	mg/L	1	-	-	-	-	2.2	3.0	3.0	3.8	3.1	<1.0	4.5	3.6	1.5	<1.0	4.2	1.5
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	85.8	107	106	182	184	134	258	297	94.9	9.35	292	149
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	81.8	95.4	96.5	176	171	128	240	292	93.9	4.44	285	146
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.0944	0.110	0.108	1.04	0.155	0.104	0.179	0.832	0.0966	0.0091	0.215	0.105
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.0901	0.108	0.105	1.04	0.139	0.101	0.183	0.726	0.0996	0.0054	0.216	0.0991
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.0029	<0.0020	0.0020	0.0034	0.0047	0.0038	0.0564	0.0063	0.0055	<0.0020	0.0547	0.0024
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.0271	0.0265	0.0260	0.194	0.0370	0.0812	0.490	0.0482	0.528	0.232	0.121	0.0255
Total Suspended Solids	mg/L	3	-	-	-	15	7.5	3.8	5.6	<2.0	<2.0	3.0	95	8.6	6.7	<2.0	26.9	<2.0
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00064	<0.00050	<0.00050	0.00114	<0.00050	0.00062	<0.00050	0.00081	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00082	<0.00050	<0.00050	0.00555	0.00073	0.00093	<0.00050	0.00515	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.0554	0.0115	0.0109	0.0056	<0.0030	<0.0030	0.0114	0.0115	<0.0030	0.0054	0.0227	0.0045
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0626	0.0170	0.0190	0.0090	0.0051	0.0050	0.120	0.0201	0.0077	0.0084	0.142	0.0080
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key:	Within Guideline	Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 4/20/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.010	<0.010	<0.010	0.01	0.01	<0.010	0.03	<0.010	0.01	0.03	0.03	<0.010
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.14	0.03	0.05	0.43	0.38	0.05	0.37	0.37	0.10	0.09	1.16	0.06
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.18	<0.050	<0.050	<0.050	<0.050	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.05	0.05	0.05	0.02	0.03	0.03	0.01	0.02	0.04	0.02	0.01	0.04
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.05	0.05	0.05	0.03	0.03	0.03	0.01	0.02	0.04	0.02	0.02	0.04
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	<2.0	<2.0	3.90	2.60	2.50	4.70	2.20	2.70	<2.0
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	<0.010	<0.010	<0.010	0.01	0.01	<0.010	0.01	0.01	0.01	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	66.60	68.60	68.90	32.00	38.40	56.90	17.70	53.50	68.90	35.40	30.20	55.70
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	60.50	65.60	66.70	30.50	35.50	54.00	20.30	45.80	68.70	35.00	29.30	55.60
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	2	-	-	-	-	136.00	153.00	154.00	115.00	99.10	299.00	50.70	194.00	350.00	241.00	39.90	208.00
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	0.00	<0.00050	<0.00050	<0.00050	0.00	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	0.00	0.00	<0.00050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	<0.0010	<0.0010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.0010
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.00	<0.0010	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
E. Coli	CFU/100mL	10	-	100	-	-	40 *	70 *	60.00	20 *	20 *	40 *	350 *	140 *	10 *	10 *	450 *	20 *
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.22	0.10	0.13	0.34	0.37	0.10	0.33	0.30	0.08	0.06	0.97	0.09
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	0.00	<0.00050	<0.00050	0.00	0.00	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	<0.00050
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	22.50	23.50	24.20	6.95	11.40	23.30	3.13	16.10	22.10	8.13	7.61	19.70
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	20.30	22.00	22.50	6.73	10.50	21.60	3.80	13.90	21.40	7.76	7.43	19.20
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.02	<0.0010
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.05	0.02	0.02	0.01	0.02	0.06	0.02	0.03	0.01	0.02	0.06	0.05
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	0.00	0.00	0.00	0.00
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	0.00	<0.00050	<0.00050	0.00	0.00	0.00	<0.00050	0.00	0.00	0.00	0.00	0.00
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00	<0.0010
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.51	0.22	0.21	0.36	0.29	<0.020	0.43	0.41	0.02	0.03	0.26	0.33
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	0.09	<0.050	<0.050	0.05	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.06	0.12	<0.050	0.09	0.11	0.05	<0.050	0.09	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.01	0.01	0.01	0.03	0.10	0.01	0.05	0.06	0.01	0.03	0.02	0.01
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.90	2.10	2.10	3.40	3.70	3.30	1.70	3.40	3.80	4.50	2.40	2.10

Potassium (K)-Total	mg/L	1	-	-	-	-	1.70	1.90	2.00	3.10	3.50	3.10	1.80	3.40	3.80	4.30	2.60	2.10
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.40	2.10	2.20	<1.0	1.10	<1.0	<1.0	2.30	<1.0	<1.0	<1.0	<1.0
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.80	2.40	2.50	1.50	1.80	<1.0	1.30	3.00	<1.0	<1.0	2.60	<1.0
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	82.30	92.60	95.50	78.30	64.50	190 *	35.20	72.80	226 *	163 *	25.80	128 *
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	76.40	87.50	90.10	72.90	60.50	174 *	36.60	59.60	222 *	158 *	24.30	123 *
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.09	0.11	0.11	0.13	0.09	0.14	0.09	0.286 *	0.51	0.18	0.07	0.10
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.09	0.11	0.11	0.13	0.09	0.15	0.11	0.24	0.52	0.18	0.08	0.10
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.00	<0.0020	<0.0020	0.01	0.01	<0.0020	0.01	0.01	0.00	<0.0020	0.03	<0.0020
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.02	0.02	0.02	0.05	0.12	0.03	0.08	0.08	0.06	0.04	0.07	0.02
Total Suspended Solids	mg/L	3	-	-	-	15	11.90	5.50	6.90	4.00	2.90	5.70	8.50	9.80	17.40	2.40	13.90	3.50
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00	<0.00050	<0.00050	0.00	<0.00050	0.00	0.00	0.00	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	0.00	<0.00050	<0.00050	0.00	0.00	<0.00050	0.00	0.00	0.00	0.00	0.00	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.02	0.01	0.01	<0.0030	0.00	<0.0030	0.01	0.00	<0.0030	<0.0030	0.00	<0.0030
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.03	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.00	0.00	0.03	0.00
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	0.02	<0.0040	<0.0040	<0.0040	<0.0040

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key:	Within Guideline	Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 6/30/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	<0.010	0.022	0.011	<0.010
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.077	0.025	0.062	0.018	0.039	0.025	0.166	0.018	0.208	0.142	0.179	0.013
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	0.119	<0.050	<0.050	<0.050	<0.050	<0.050	0.236	<0.050	0.132	<0.050	0.141	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00052	<0.00050	<0.00050
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0014	<0.0010	<0.0010	<0.0010
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0015	<0.0010	<0.0010	<0.0010
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.0344	0.0513	0.0511	0.0962	0.0698	0.0460	0.0158	0.0537	0.0297	0.0196	0.0544	0.0264
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.0343	0.0512	0.0518	0.0919	0.0722	0.0474	0.0185	0.0478	0.0317	0.0200	0.0524	0.0258
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.2	<2.0	4.6	<2.0	<2.0	2.3
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	0.010	0.010	0.017	0.013	0.011	0.033	0.018	0.017	0.014	0.011	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	0.011	0.011	0.018	0.014	0.013	0.035	0.020	0.018	0.016	0.011	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	0.000098	<0.000090	<0.000090	<0.000090	<0.000090
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	0.000096	<0.000090	<0.000090	<0.000090	<0.000090
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	50.7	69.6	69.2	127	96.9	45.0	25.5	113	50.5	27.2	76.6	37.2
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	50.5	69.8	70.5	125	97.5	45.8	27.1	113	49.3	27.3	73.5	37.4
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	2	-	-	-	-	126	154	155	535	241	197	68.3	308	175	72.9	123	154
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00134	<0.00050	<0.00050	<0.00050	0.00054	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	0.0028	0.0014	<0.0010	<0.0010	<0.0010	<0.0010
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.0010	<0.0010	<0.0010	0.0014	<0.0010	<0.0010	0.0046	0.0015	0.0011	0.0013	0.0013	<0.0010
E. Coli	CFU/100mL	10	-	100	-	-	40	210	220	20	20	10	280	20	30	140	80	20
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	<0.050	0.053	0.054	<0.050	<0.050	<0.050	0.178	<0.050	0.070	<0.050	<0.050	<0.050
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.202	0.143	0.192	<0.050	0.057	0.099	0.658	<0.050	0.524	0.172	0.249	0.068
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00139	<0.00050	0.00089	0.00067	0.00054	<0.00050
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	22.6	24.7	24.5	33.1	27.6	20.4	3.97	32.1	21.5	6.13	21.9	22.1
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	21.5	24.2	23.9	31.0	27.6	19.8	4.60	29.0	19.3	5.77	20.2	20.5
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.0032	0.0058	0.0064	<0.0010	0.0045	<0.0010	0.0027	0.0173	0.0049	<0.0010	0.0171	0.0015
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.0309	0.0322	0.0392	0.0018	0.0140	0.0332	0.149	0.0192	0.144	0.0201	0.0609	0.0262
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	<0.00050	<0.00050	<0.00050	0.00051	<0.00050	<0.00050	<0.00050	0.00058	0.00052	0.00059	<0.00050	<0.00050
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	<0.00050	<0.00050	<0.00050	0.00054	<0.00050	<0.00050	<0.00050	0.00058	0.00055	0.00066	<0.00050	<0.00050
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.288	0.206	0.203	0.945	0.258	<0.020	0.241	1.05	<0.020	<0.020	1.17	<0.020
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.137	<0.050	0.106	<0.050	<0.050	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.0049	0.0141	0.0174	0.0073	0.0126	0.0097	0.0307	0.0091	0.0393	0.0156	0.0066	0.0056
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.3	1.2	1.2	2.5	1.1	2.1	1.6	2.3	1.5	1.4	2.1	1.4

Potassium (K)-Total	mg/L	1	-	-	-	-	1.3	1.2	1.2	2.4	1.1	2.1	1.6	2.1	1.5	1.4	2.0	1.4
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.6	2.8	2.8	2.4	3.6	<1.0	<1.0	4.1	<1.0	<1.0	3.0	<1.0
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.6	2.8	2.9	2.4	3.7	<1.0	<1.0	4.1	<1.0	<1.0	3.2	<1.0
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00013	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	70.4	88.8	88.6	303	139	119	38.1	175	112	50.0	66.7	89.0
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	66.7	88.1	86.8	290	142	113	41.1	142	103	46.8	60.8	82.9
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.0805	0.106	0.105	0.281	0.147	0.110	0.116	0.967	0.650	0.172	0.112	0.0718
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.0841	0.109	0.108	0.282	0.150	0.115	0.120	1.21	0.663	0.179	0.108	0.0775
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	<5.0	<5.0	<5.0	9.6	6.6	<5.0	<5.0	14.4	11.9	<5.0	<5.0	<5.0
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	<5.0	<5.0	<5.0	10.6	6.8	<5.0	<5.0	16.0	11.3	<5.0	<5.0	<5.0
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0050	<0.0020	0.0058	0.0034	0.0051	<0.0020
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.0177	0.0164	0.0215	0.0175	0.0134	0.0219	0.107	0.0094	0.137	0.0451	0.0170	0.0099
Total Suspended Solids	mg/L	3	-	-	-	15	9.6	2.7	5.0	<2.0	<2.0	3.8	29.0	<2.0	43.7	7.4	2.3	<2.0
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00082	<0.00050	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00099	<0.00050	0.00080	0.00117	0.00076	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.0256	0.0038	0.0036	<0.0030	<0.0030	<0.0030	<0.0030	0.0083	<0.0030	<0.0030	0.0051	<0.0030
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0364	0.0082	0.0095	0.0031	0.0032	<0.0030	0.0130	0.0085	0.0068	0.0035	0.0106	<0.0030
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key: Within Guideline | Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key: Within Guideline | **Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 7/14/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	0.01	<0.0050	<0.0050	<0.0050	0.01	0.01	0.02	0.01	0.01	0.05	0.01	0.01
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.12	0.05	0.10	0.17	2.64	0.04	0.27	0.06	0.06	0.20	1.31	0.02
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	0.08	<0.050	<0.050	0.05	<0.050	<0.050	0.11	0.06	<0.050	<0.050	0.07	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	0.00	0.00	<0.00010	0.00	0.00	0.00	0.00	0.00	<0.00010
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	<0.0010	0.00	0.00	<0.0010
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.04	0.06	0.05	0.04	0.02	0.03	0.01	0.04	0.02	0.01	0.02	0.02
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.04	0.06	0.06	0.04	0.04	0.03	0.01	0.04	0.03	0.01	0.03	0.02
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
BOD Carbonaceous	mg/L	2	-	-	-	15	2.10	<2.0	<2.0	7.00	2.50	<2.0	5.90	<2.0	4.50	<2.0	6.50	3.90
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	0.02	<0.010	0.01	<0.010	0.01	0.02	0.01	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	0.02	0.01	0.01	<0.010	0.02	0.02	0.01	0.01	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	0.00	<0.000010	<0.000010	0.00	0.00	<0.000010	<0.000010	0.00	<0.000010	<0.000010	0.00	<0.000010
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	0.00	<0.000090	<0.000090	<0.000090	<0.000090
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	41.80	61.40	60.10	46.20	27.00	30.20	11.30	84.00	44.10	19.00	37.10	27.20
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	43.40	62.40	62.10	43.80	30.90	29.90	13.80	93.60	45.50	19.30	38.00	27.40
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-												
Chloride (Cl)	mg/L	2	-	-	-	-	128.00	146.00	146.00	165.00	38.60	210.00	12.40	213.00	174.00	66.00	48.20	147.00
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	<0.00050	<0.00050	<0.00050	0.00	0.01	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	<0.00010
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.00	0.00	0.00	0.00	0.01	<0.0010	0.01	0.00	0.00	0.00	0.00	<0.0010
E. Coli	CFU/100mL	10	-	100	-	-	1100 *	13000 *	3400 *	1100 *	700 *	110 *	19000 *	700 *	400 *	300 *	1000 *	300 *
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	0.04	0.06	0.05	0.04	0.02	<0.010	0.08	<0.010	0.07	0.02	0.05	0.01
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.29	0.19	0.26	0.20	2.42	<0.050	0.44	0.09	0.18	0.18	1.42	<0.050
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	<0.000050	<0.000050	0.00	0.00	<0.000050	0.00	<0.000050	0.00	0.00	0.00	<0.000050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	0.00	<0.00050	0.00	<0.00050	0.01	<0.00050	0.00	<0.00050	<0.00050	0.00	0.00	<0.00050
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	<0.0010
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	20.60	21.00	20.80	10.10	5.42	19.40	1.34	21.80	20.00	5.26	8.44	19.70
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	22.80	23.80	23.00	10.60	7.28	21.60	2.91	25.70	22.20	6.07	9.61	21.70
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.02	0.02	0.01	0.00	0.01	0.00	0.00	0.03	0.01	0.00	0.07	0.00
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.04	0.05	0.06	0.02	0.08	0.01	0.09	0.04	0.07	0.01	0.15	0.02
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	0.00	0.00	0.00	<0.00050
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	<0.00050	0.00	<0.00050
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	<0.0010	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00	<0.0010
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.25	0.31	0.30	0.28	0.14	<0.020	0.18	0.79	<0.020	<0.020	0.32	<0.020
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.06	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.14	0.10	<0.050	0.11	<0.050	0.12	<0.050	0.11	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.01	0.02	0.01	0.07	0.02	0.01	0.02	0.01	0.04	0.02	0.03	0.01
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.53	1.59	1.52	5.98	1.41	1.89	1.14	1.76	2.49	1.21	3.04	1.30

Potassium (K)-Total	mg/L	1	-	-	-	-	1.50	1.60	1.60	6.40	2.30	2.00	1.20	1.90	2.80	1.30	3.40	1.40
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-												
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.25	2.45	2.44	1.54	1.01	<0.050	0.31	2.91	0.26	0.13	1.19	0.39
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.50	2.70	2.70	1.80	5.80	<1.0	<1.0	3.30	<1.0	<1.0	3.60	<1.0
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	69.70	78.20	77.00	85.40	23.00	113 *	8.85	108 *	96.20	39.80	24.10	74.40
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	70.60	85.60	83.30	86.90	24.40	120 *	8.20	117 *	107 *	43.60	26.30	80.00
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.07	0.09	0.09	0.12	0.05	0.10	0.07	0.69	0.57	0.13	0.08	0.06
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.07	0.09	0.09	0.11	0.06	0.10	0.06	0.82	0.60	0.14	0.09	0.06
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	3.96	4.07	4.17	3.38	1.74	3.89	0.81	11.30	10.20	3.35	2.85	3.91
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	13.20	11.20	<5.0	<5.0	<5.0
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-												
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	0.00	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-												
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	0.00	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.00	<0.0020	0.00	0.01	0.09	<0.0020	0.01	<0.0020	<0.0020	0.00	0.04	<0.0020
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.02	0.03	0.03	0.12	0.09	0.02	0.12	0.02	0.08	0.04	0.10	0.01
Total Suspended Solids	mg/L	3	-	-	-	15	29.70	7.90	7.60	3.50	14.90	2.90	31.80	7.70	11.90	3.20	22.80	<2.0
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	0.00	0.00	<0.00050	0.00	0.00	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	0.00	<0.00050	<0.00050	0.00	0.01	<0.00050	0.00	0.00	0.00	0.00	0.00	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.02	0.00	0.00	0.00	0.00	<0.0010	0.01	0.01	<0.0010	<0.0010	0.01	<0.0010
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.05	0.01	0.01	0.01	0.04	<0.0030	0.03	0.02	0.01	0.00	0.04	0.00
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key:	Within Guideline	Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 8/20/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	0.0051	0.0051	0.0051	0.0074	0.0125	<0.0050	0.0165	0.0222	0.0177	0.0796	0.0066	0.0065
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.776	0.088	0.155	0.158	2.05	0.018	0.130	0.112	0.034	0.221	0.461	0.013
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	0.092	<0.050	0.087	<0.050	0.097	<0.050	0.057	0.201	0.085	0.188	0.070	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	0.00014	0.00010	<0.00010	0.00026	0.00017	0.00025	0.00047	<0.00010	<0.00010
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00010	0.00013	<0.00010	0.00018	0.00014	0.00010	0.00032	0.00022	0.00024	0.00047	0.00013	0.00013
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	0.00081	0.00069	0.00069	0.00033	0.00033	0.00057	0.00065	0.00020	0.00094	0.00183	0.00060	0.00056
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	0.00147	0.00070	0.00078	0.00040	0.00095	0.00058	0.00066	0.00023	0.00096	0.00180	0.00086	0.00053
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.0528	0.0723	0.0734	0.0175	0.0174	0.0305	0.00774	0.0103	0.0153	0.00669	0.0501	0.0589
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.0610	0.0669	0.0706	0.0180	0.0291	0.0306	0.00908	0.0132	0.0151	0.00710	0.0517	0.0553
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	2.6	<2.0	2.7	3.7	3.7	<2.0	<2.0	<2.0	<2.0
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	0.014	0.016	0.016	0.012	<0.010	0.018	0.013	<0.010	0.024	0.027	0.015	0.011
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	0.012	0.014	0.014	0.011	<0.010	0.015	0.011	<0.010	0.020	0.022	0.013	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000010	<0.000010	<0.000010	<0.000010	0.000018	<0.000010	<0.000010	0.000012	<0.000010	<0.000010	0.000012	<0.000010
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	0.000253	0.000038	0.000058	0.000021	0.000066	<0.000010	0.000016	0.000033	<0.000010	0.000013	0.000042	<0.000010
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	48.4	70.4	69.3	19.8	27.8	40.2	11.2	26.4	27.1	15.9	75.7	35.5
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	47.4	64.3	67.2	19.4	26.8	38.1	10.6	30.4	25.0	14.4	73.9	33.9
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	0.000085	0.000014	0.000021	0.000017	0.000169	<0.000010	0.000016	0.000013	<0.000010	0.000017	0.000046	<0.000010
Chloride (Cl)	mg/L	2	-	-	-	-	125	165	165	70.8	36.6	167	10.7	34.9	111	27.1	77.5	162
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.00161	<0.00050	0.00095	0.00127	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	0.00128	<0.00050	<0.00050	0.00089	0.00406	<0.00050	0.00143	0.00150	<0.00050	<0.00050	0.00082	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00010	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	0.00057	0.00010	0.00014	0.00018	0.00070	<0.00010	0.00017	0.00013	<0.00010	0.00017	0.00033	<0.00010
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00053	0.00059	0.00055	0.00200	0.00102	0.00035	0.00440	0.00101	0.00054	0.00126	0.00107	0.00033
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.0039	0.0011	0.0013	0.0026	0.0042	<0.0010	0.0065	0.0018	<0.0010	0.0016	0.0021	<0.0010
E. Coli	CFU/100mL	10	-	100	-	-	6700	1000	1300	21000	1400	10	7500	22000	90	30	420	10
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	0.036	0.051	0.049	0.022	<0.010	0.016	0.105	<0.010	0.014	0.043	0.047	0.011
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	1.54	0.218	0.313	0.177	1.97	<0.050	0.386	0.156	<0.050	0.245	0.812	<0.050
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	0.000079	0.000051	0.000059	<0.000050	<0.000050	<0.000050	0.000113	<0.000050	0.000055	0.000626	<0.000050	<0.000050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	0.00318	0.00049	0.00084	0.00037	0.00480	0.00011	0.00076	0.00059	0.00015	0.00122	0.00141	<0.00010
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	0.0026	0.0026	0.0025	<0.0010	0.0012	0.0019	0.0012	0.0014	0.0021	0.0013	0.0022	0.0022
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	0.0022	0.0017	0.0017	<0.0010	0.0023	<0.0010	<0.0010	0.0010	0.0012	<0.0010	0.0017	0.0014
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	21.8	25.5	26.1	4.41	5.91	18.6	1.33	6.34	15.7	3.31	20.1	23.6
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	21.1	23.4	23.8	4.24	6.14	17.6	1.38	7.56	14.5	2.93	19.7	21.9
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.0123	0.00747	0.0171	0.00109	0.00540	0.00263	0.00142	0.00674	0.00341	0.00416	0.00837	0.00117
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.114	0.0376	0.0632	0.0145	0.0713	0.0343	0.0827	0.0366	0.0230	0.0163	0.105	0.0104
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	0.000390	0.000345	0.000337	0.000423	0.000385	0.000337	0.000359	0.000271	0.000469	0.000428	0.000629	0.000283
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	0.000409	0.000354	0.000388	0.000491	0.000461	0.000342	0.000389	0.000304	0.000496	0.000446	0.000695	0.000291
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00058	<0.00050
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	0.00139	<0.00050	0.00055	0.00063	0.00194	<0.00050	0.00059	0.00051	<0.00050	0.00054	0.00110	<0.00050
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.261	0.176	0.171	0.110	0.201	<0.020	0.161	0.118	<0.020	<0.020	0.563	<0.020
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	0.117	<0.050	0.055	0.068	0.093	<0.050	0.093	<0.050	<0.050	<0.050	0.067	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.0063	0.0215	0.0208	0.0391	0.0255	0.0093	0.0152	0.0127	0.0096	0.0190	0.0198	0.0050
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.76	1.80	1.80	2.34	1.27	2.64	1.27	0.808	1.53	1.08	2.58	1.78

Potassium (K)-Total	mg/L	1	-	-	-	-	1.80	1.72	1.73	2.32	1.71	2.47	1.19	0.867	1.45	0.978	2.52	1.66
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	0.00145	0.00128	0.00133	0.00129	0.00051	0.00069	0.00075	0.00075	0.00064	0.00036	0.00185	0.00117
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	0.00290	0.00135	0.00156	0.00151	0.00368	0.00070	0.00084	0.00090	0.00069	0.00063	0.00243	0.00123
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	0.000115	0.000137	0.000130	0.000086	0.000087	0.000060	0.000067	0.000071	0.000060	0.000087	0.000100	0.000077
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	0.000313	0.000149	0.000188	0.000098	0.000084	0.000055	0.000103	0.000075	0.000076	0.000104	0.000149	0.000082
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.52	3.67	3.64	1.12	1.27	0.354	0.527	1.10	0.059	0.128	3.87	0.112
Silicon (Si)-Total	mg/L	1	-	-	-	-	2.49	3.25	3.49	1.30	4.85	0.362	0.575	1.33	0.087	0.355	4.15	0.118
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	65.0	91.0	90.4	41.6	22.3	94.4	7.57	21.7	67.0	18.7	39.6	86.4
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	63.2	86.0	87.7	40.5	19.9	90.8	7.38	22.4	63.3	17.1	38.5	81.8
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.0754	0.0999	0.100	0.0542	0.0507	0.0969	0.0548	0.226	0.388	0.0879	0.114	0.0705
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.0786	0.0986	0.0989	0.0525	0.0532	0.0981	0.0554	0.334	0.390	0.0869	0.115	0.0715
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	5.61	5.58	5.57	1.84	1.80	3.73	1.19	4.15	9.97	2.00	3.55	5.26
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	4.84	4.81	5.05	1.73	1.50	3.46	0.94	5.35	8.71	1.58	3.20	4.62
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	0.000026	<0.000010	<0.000010	<0.000010	0.000032	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000013	<0.000010
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	0.00010	<0.00010	<0.00010	<0.00010	0.00037	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00013	0.00012	0.00012	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.0169	0.00204	0.00376	0.00599	0.0730	0.00071	0.00404	0.00343	0.00076	0.00471	0.0140	0.00044
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.100	0.0427	0.0401	0.0675	0.0934	0.0329	0.0823	0.0290	0.0577	0.0465	0.0769	0.0118
Total Suspended Solids	mg/L	3	-	-	-	15	67.1	8.3	14.6	<2.0	11.3	4.9	11.8	8.0	3.6	4.6	22.3	<2.0
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	0.000334	0.000355	0.000349	0.000024	0.000103	0.000162	0.000013	0.000147	0.000247	0.000117	0.000248	0.000249
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	0.000427	0.000353	0.000375	0.000035	0.000144	0.000167	0.000021	0.000199	0.000283	0.000129	0.000266	0.000251
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00083	0.00051	<0.00050	0.00086	0.00104	0.00059	0.00280	0.00056	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	0.00209	<0.00050	0.00065	0.00105	0.00410	<0.00050	0.00123	0.00115	0.00060	0.00302	0.00154	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.0204	0.0029	0.0027	0.0015	<0.0010	<0.0010	0.0050	0.0038	<0.0010	<0.0010	0.0036	<0.0010
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0904	0.0107	0.0157	0.0054	0.0348	<0.0030	0.0136	0.0113	<0.0030	0.0041	0.0181	<0.0030
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	0.00128	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key:	Within Guideline	Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 10/09/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.0050	<0.0050	<0.0050	0.01	0.01	<0.0050	0.01	0.01	0.03	0.02	0.01	<0.0050
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.05	0.12	0.17	0.12	1.31	0.11	0.16	0.13	0.17	0.73	0.30	0.02
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	1.03	0.45	<0.050	<0.050	0.15	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	0.00	0.00	<0.00010	0.00	0.00	0.00	0.00	0.00	<0.00010
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00010
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.05	0.08	0.07	0.02	0.03	0.07	0.01	0.01	0.01	0.02	0.01	0.04
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.04	0.08	0.08	0.02	0.04	0.06	0.02	0.01	0.01	0.02	0.02	0.04
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.50	<2.0	<2.0	4.70	<2.0	<2.0
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	<0.010	0.01	0.01	0.30	<0.010	0.02	0.03	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	<0.010	0.01	0.01	0.25	<0.010	0.02	0.03	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000010	<0.000010	<0.000010	0.00	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	0.00	0.00	0.00	0.00	0.00	<0.000010	0.00	0.00	0.00	0.00	0.00	<0.000010
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	52.60	73.30	72.30	25.60	38.40	69.80	16.40	23.70	18.20	28.70	25.80	36.30
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	51.20	73.90	71.00	25.20	40.80	71.50	15.70	25.10	16.60	28.00	25.20	35.50
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	<0.000010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.000010
Chloride (Cl)	mg/L	2	-	-	-	-	146.00	196.00	195.00	32.10	58.70	260.00	56.80	19.70	98.30	89.00	9.62	176.00
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	<0.00010	<0.00010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00010
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	<0.0010	0.00	0.00	0.00	0.01	<0.0010	0.01	0.00	0.00	0.00	0.00	<0.0010
E. Coli	CFU/100mL	10	-	100	-	-	350 *	330 *	300 *	290 *	310 *	80 *	4200 *	1000 *	340 *	450 *	4100 *	30 *
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	0.03	0.04	0.03	0.01	0.01	0.01	0.03	<0.010	<0.010	0.02	0.03	<0.010
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.17	0.25	0.30	0.12	1.51	0.25	0.30	0.23	0.22	0.87	0.42	<0.050
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.00	<0.000050	<0.000050	0.00	<0.000050	<0.000050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	0.00	0.00	0.00	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	<0.0010	0.00	0.00	<0.0010	0.00	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	25.10	26.70	25.90	4.22	9.50	28.20	2.94	5.84	10.30	2.96	3.82	25.40
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	22.40	26.20	26.40	4.09	10.50	26.50	2.74	6.07	10.20	3.10	3.82	23.90
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.01	<0.00050	<0.00050	0.00	0.00	<0.00050	0.00	<0.00050	0.00	0.00	<0.00050	<0.00050
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.03	0.03	0.04	0.01	0.10	0.02	0.08	0.03	0.01	0.04	0.03	0.00
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	0.00	<0.00050	<0.00050	<0.00050	0.00	0.00	0.00	0.00	<0.00050	0.00	0.00	<0.00050
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.21	0.31	0.31	0.42	0.39	<0.020	0.49	0.46	<0.020	0.02	0.59	<0.020
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	0.05	0.08	0.09	<0.050	0.11	0.06	<0.050	0.16	0.10	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.00	0.01	0.01	0.06	0.02	0.01	0.05	0.01	0.01	0.04	0.05	0.00
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.59	2.21	2.22	3.69	2.86	2.71	2.67	0.96	2.20	2.47	4.54	1.43

Potassium (K)-Total	mg/L	1	-	-	-	-	1.47	2.15	2.10	3.54	3.20	2.63	2.39	0.98	2.24	2.49	4.42	1.40
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.69	3.23	3.23	1.75	1.86	1.30	0.47	0.91	<0.050	0.08	0.81	0.32
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.70	3.31	3.41	1.94	4.01	1.50	0.66	1.19	0.24	1.18	1.27	0.34
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	76.00	105 *	107 *	23.20	35.30	143 *	31.00	12.30	58.80	53.10	5.61	93.40
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	69.40	107 *	105 *	22.80	34.90	136 *	26.60	12.30	59.30	52.40	5.23	88.70
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.09	0.11	0.11	0.06	0.08	0.19	0.23	0.30	0.26	0.16	0.06	0.08
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.09	0.11	0.11	0.06	0.08	0.18	0.21	0.33	0.25	0.16	0.06	0.07
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	6.04	6.27	6.31	6.88	3.51	7.76	3.65	5.80	8.19	6.78	2.27	5.34
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	6.13	6.28	6.22	6.78	3.47	8.24	3.38	6.54	7.81	6.74	2.16	5.54
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	<0.000010	0.00	<0.000010	<0.000010	<0.000010	<0.000010	0.00	<0.000010	<0.000010
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	0.00	0.00	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.00030	<0.00030	<0.00030	0.00	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.01	0.00
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.01	0.03	0.04	0.08	0.08	0.03	0.10	0.05	0.02	0.17	0.08	0.01
Total Suspended Solids	mg/L	3	-	-	-	15	3.40	8.60	16.90	<2.0	17.30	6.10	11.90	6.50	9.70	28.60	8.00	<2.0
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00	<0.00050	<0.00050	0.00	0.00	0.00	0.00	0.00	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.08	0.00	0.00	<0.0010	<0.0010	<0.0010	0.01	0.00	<0.0010	<0.0010	0.00	<0.0010
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.09	0.01	0.02	0.01	0.03	0.00	0.01	0.01	0.00	0.01	0.02	0.00
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	0.00	<0.00030	<0.00030	<0.00030	<0.00030	0.00	<0.00030	<0.00030

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key: Within Guideline | Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key: Within Guideline | **Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 10/28/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.0050	<0.0050	<0.0050	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.02	<0.0050
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.08	0.03	0.06	0.19	3.31	0.57	0.16	0.51	0.41	0.47	0.83	0.02
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.05	0.07	<0.050	<0.050	<0.050	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	0.00	0.00	<0.00010	<0.00010
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00010
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.04	0.05	0.05	0.01	0.01	0.06	0.01	0.01	0.02	0.01	0.01	0.04
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.05	0.05	0.05	0.01	0.03	0.06	0.01	0.04	0.02	0.02	0.01	0.04
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	<2.0	<2.0	2.20	6.70	2.70	<2.0	6.10	3.30	<2.0
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	<0.010	<0.010	0.01	<0.010	<0.010	0.06	0.04	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	<0.010	<0.010	0.01	<0.010	<0.010	0.06	0.04	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000010	<0.000010	<0.000010	<0.000010	0.00	<0.000010	0.00	0.00	<0.000010	<0.000010	0.00	<0.000010
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.000010
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	50.60	63.90	62.80	18.20	23.80	73.80	10.00	13.80	24.00	19.40	15.40	43.10
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	51.70	63.00	65.90	17.60	25.80	75.80	10.90	17.30	24.50	18.50	16.50	42.40
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.000010
Chloride (Cl)	mg/L	2	-	-	-	-	141.00	148.00	147.00	14.60	23.20	201.00	3.32	21.30	91.60	53.20	3.47	164.00
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	0.00	0.00	<0.00050	0.00	0.00	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	<0.00050	<0.00050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	0.00	<0.00010	<0.00010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00010
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	<0.0010
E. Coli	CFU/100mL	10	-	100	-	-	110 *	600 *	280 *	30 *	170 *	800 *	8200 *	100 *	4400 *	3800 *	1900 *	40 *
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	0.03	0.04	0.04	0.02	0.02	0.01	<0.010	0.03	0.02	0.04	0.02	<0.010
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.21	0.09	0.14	0.20	2.94	0.74	0.19	0.59	0.53	0.65	0.80	<0.050
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.000050	<0.000050	<0.000050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.000050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	0.00	0.00	0.00	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	0.00	0.00	0.00	<0.0010	0.00	<0.0010	<0.0010	<0.0010	0.00	0.00	0.00	0.00
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	24.10	21.60	21.90	3.30	4.78	24.20	1.37	1.58	7.99	2.60	2.55	25.30
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	23.80	21.90	22.60	3.04	5.90	23.10	1.58	3.09	8.05	2.66	2.79	24.40
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	<0.00050
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.03	0.01	0.01	0.01	0.09	0.08	0.02	0.04	0.03	0.04	0.03	0.00
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	0.00	<0.00050	<0.00050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00050
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.17	0.17	0.17	<0.020	0.17	<0.020	0.11	0.11	<0.020	0.04	0.12	0.04
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.05	0.05	<0.050	0.15	<0.050	<0.050	<0.050	0.11	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	0.05	0.08	0.15	0.08	0.17	0.15	0.07	0.17	0.15	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.01	0.02	0.02	0.05	0.06	0.01	0.13	0.05	0.01	0.03	0.10	0.00
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.63	3.53	3.93	3.15	2.21	3.14	1.91	1.14	3.33	3.18	2.94	1.52

Potassium (K)-Total	mg/L	1	-	-	-	-	1.69	3.57	3.98	2.89	3.06	3.00	2.05	1.36	3.18	2.96	2.93	1.58
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.00	0.00	0.00	0.00
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	<0.000050	0.00	0.00	<0.000050	0.00	0.00	0.00	0.00	0.00
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	0.92	3.46	3.47	1.15	1.06	2.05	0.47	0.63	0.10	0.23	0.62	0.14
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.06	3.40	3.58	1.46	7.02	3.03	0.72	1.46	0.69	0.98	2.11	0.18
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	72.10	77.30	74.60	10.50	13.40	117 *	2.93	15.40	56.00	33.00	2.34	89.00
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	71.00	74.50	77.50	9.84	12.90	116 *	3.08	15.20	55.90	30.20	2.19	85.70
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.08	0.09	0.09	0.08	0.07	0.16	0.04	0.07	0.26	0.12	0.03	0.08
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.08	0.09	0.09	0.08	0.07	0.17	0.04	0.08	0.27	0.11	0.03	0.08
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	7.24	6.06	5.86	2.41	1.75	11.00	0.60	1.20	6.95	3.36	0.69	5.76
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	7.80	6.13	6.45	2.66	1.89	11.70	0.72	1.40	7.13	3.32	0.70	5.95
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	<0.000010	0.00	0.00	<0.000010	0.00	<0.000010	<0.000010	0.00	<0.000010
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	0.00	0.00	<0.00010	0.00	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.00030	<0.00030	<0.00030	0.00	0.00	<0.00030	<0.00030	0.00	<0.00030	<0.00030	0.00	<0.00030
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.00	0.00	0.00	0.01	0.11	0.02	0.01	0.01	0.01	0.02	0.03	0.00
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.01	0.03	0.04	0.07	0.16	0.06	0.15	0.15	0.05	0.16	0.14	0.01
Total Suspended Solids	mg/L	3	-	-	-	15	7.30	3.00	4.60	<2.0	11.90	34.2 *	8.20	6.50	21.40	25.0 *	8.00	<2.0
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	<0.00010	<0.00010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	0.00	0.00	0.00	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.03	0.01	0.01	0.00	<0.0010	<0.0010	0.01	0.00	<0.0010	0.00	0.00	<0.0010
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.04	0.01	0.01	0.01	0.04	0.01	0.02	0.03	0.01	0.01	0.02	<0.0030
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	0.00	0.00	<0.00030	0.00	<0.00030	<0.00030	0.00	<0.00030

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key:	Within Guideline	Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 11/27/2015 WET DAY											
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-P1 (04)	HC-P1 (05)	HC-P1 (06)	HC-P2 (04)	HC-P2 (05)	HC-P2 (06)	HC-P2 (07)	HC-P4(04)	HC-P4(05)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.0050	<0.0050	<0.0050	<0.0050	0.01	<0.0050	0.04	0.02	0.03	0.04	0.06	<0.0050
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.07	0.02	0.02	0.01	4.31	0.08	1.18	1.44	0.13	0.41	4.56	0.03
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	0.07	0.09	<0.050	<0.050	0.07	<0.050	0.19	0.08	<0.050	<0.050	0.11	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	0.00	0.00	0.00	<0.00010
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	0.00	0.00	0.00	0.00	0.00	<0.00010
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.05	0.06	0.06	0.11	0.05	0.05	0.01	0.04	0.01	0.02	0.02	0.05
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.05	0.06	0.06	0.11	0.07	0.06	0.02	0.05	0.01	0.02	0.06	0.05
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.00	<0.000050
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	4.80	5.10	<2.0	3.70	4.90	<2.0
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	<0.010	<0.010	0.02	<0.010	0.01	0.01	0.02	0.04	0.03	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	<0.010	<0.010	0.02	0.01	0.01	0.01	0.02	0.04	0.03	0.01	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000010	<0.000010	<0.000010	0.00	0.00	<0.000010	0.00	0.00	<0.000010	<0.000010	0.00	<0.000010
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.000010
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	64.70	80.20	79.80	140.00	60.20	73.70	12.50	79.00	24.10	31.70	21.40	53.30
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	65.10	80.00	78.60	142.00	64.50	79.40	16.00	82.50	24.30	31.70	32.30	53.60
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	0.00	<0.000010	0.00	0.00	0.00	0.00	0.00	<0.000010
Chloride (Cl)	mg/L	2	-	-	-	-	119.00	171.00	170.00	398.00	226.00	179.00	103.00	478.00	64.10	47.20	485.00	145.00
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	<0.00050	0.00	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	<0.00010	<0.00010	0.00	<0.00010
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	0.00	<0.00010	<0.00010	<0.00010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.00010
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	<0.0010	<0.0010	<0.0010	0.00	0.01	<0.0010	0.01	0.01	0.00	0.00	0.01	<0.0010
E. Coli	CFU/100mL	10	-	100	-	-	10 *	40 *	10 *	10 *	<100 *	10 *	3100 *	<100 *	20 *	20 *	2800 *	20 *
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	0.04	0.02	0.02	<0.010	<0.010	0.02	0.29	0.03	0.02	0.06	0.03	<0.010
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.22	0.07	0.05	<0.050	3.60	0.16	1.66	1.51	0.15	0.57	5.67	<0.050
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	0.00	<0.000050	<0.000050	0.00	<0.000050	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	0.00	0.00	<0.00010	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	0.00	0.00	0.00	0.00	0.00	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.0010	0.00
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	0.00	0.00	0.00	0.00	0.00	<0.0010	0.00	0.00	<0.0010	<0.0010	0.01	0.00
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	24.00	26.00	25.60	39.80	17.70	21.40	1.70	22.10	6.36	4.31	2.44	23.50
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	23.60	25.80	24.90	39.60	18.80	21.90	3.33	22.90	6.20	4.28	6.63	23.10
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.04	0.00	0.00	0.00	0.02	0.03	0.09	0.04	0.00	0.00	0.04	0.00
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.05	0.01	0.00	0.00	0.16	0.07	0.15	0.08	0.01	0.08	0.25	0.00
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	0.00	<0.00050	<0.00050	0.00	<0.00050
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	0.00	<0.00050	<0.00050	<0.00050	0.00	0.00	0.00	0.00	<0.00050	0.00	0.01	<0.00050
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.40	0.29	0.26	2.36	0.45	<0.020	0.13	0.16	<0.020	<0.020	0.20	0.23
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.12	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	0.17	<0.050	0.27	0.17	<0.050	0.11	0.24	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.00	0.01	0.01	0.00	0.03	0.01	0.11	0.01	0.01	0.01	0.03	0.00
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.56	1.79	1.75	2.89	2.21	2.16	2.14	2.11	2.91	2.78	2.05	1.73

Potassium (K)-Total	mg/L	1	-	-	-	-	1.54	1.77	1.71	2.91	3.06	2.25	2.29	2.47	2.83	2.75	2.77	1.71
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	0.00	0.00	<0.000050	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.71	3.35	3.42	4.42	2.91	1.51	0.60	2.92	<0.050	<0.050	0.74	0.24
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.69	3.33	3.17	4.42	11.00	1.64	2.60	5.69	0.19	0.64	7.77	0.28
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	62.20	94.50	93.40	221 *	141 *	102 *	72.60	360 *	40.50	30.60	313 *	78.40
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	61.40	93.70	91.40	225 *	137 *	104 *	70.10	348 *	39.10	28.90	309 *	76.50
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.09	0.11	0.11	0.19	0.10	0.15	0.07	1.32	0.24	0.15	0.10	0.09
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.09	0.12	0.11	0.19	0.11	0.16	0.07	1.32	0.24	0.15	0.12	0.09
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	6.80	5.92	6.11	14.10	5.33	8.71	1.97	22.60	5.20	4.21	4.63	5.82
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	6.74	6.48	6.13	14.80	5.49	9.50	2.17	23.50	5.09	4.28	4.45	5.81
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	0.00	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.000010	<0.000010	<0.000010	0.00	0.00	<0.000010	0.00	0.00	<0.000010	<0.000010	0.00	<0.000010
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	0.00	0.00	<0.00010	<0.00010	0.00	<0.00010
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	0.00	0.00	<0.00010	<0.00010	0.00	<0.00010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	0.00	<0.00030	<0.00030	0.00	0.00	<0.00030
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.00	0.00	<0.0005 *	<0.0005 *	0.16	0.00	0.05	0.06	0.00	0.01	0.13	0.00
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.01	0.02	0.02	0.01	0.17	0.02	0.20	0.16	0.03	0.12	0.265 *	0.01
Total Suspended Solids	mg/L	3	-	-	-	15	7.20	<2.0	2.40	2.00	44.80	10.40	33.30	39.60	4.40	28.30	80.80	3.20
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	<0.00010	<0.00010	0.00	<0.00010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00	<0.00010	<0.00010	0.00	<0.00010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.00	<0.00050	0.00	0.00	0.00	0.00	0.00	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.01	<0.00050	0.00	0.00	0.00	0.00	0.01	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.05	0.01	0.01	0.01	0.00	<0.0010	0.01	0.01	<0.0010	<0.0010	0.01	<0.0010
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.06	0.01	0.01	0.01	0.06	0.00	0.05	0.06	0.00	0.01	0.18	<0.0030
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.00030	<0.00030	<0.00030	<0.00030	0.00	<0.00030	0.00	0.00	<0.00030	<0.00030	0.00	<0.00030

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key:	Within Guideline	Exceeds Guideline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

			PWQO		Guelph Storm		SITES SAMPLED ON 05/07/2015 WET DAY			SITES SAMPLED ON 07/30/2015 WET DAY			SITES SAMPLED ON 11/04/2015 WET DAY		
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	HC-A (04)	HC-A (13)	HC-A (14)	HC-A (04)	HC-A (13)	HC-A (14)	HC-A (04)	HC-A (13)	HC-A (14)
Aluminum (Al)-Dissolved	mg/L	0.01	-	0.015	-	-	<0.010	<0.010	<0.010	<0.0050	0.01	0.01	<0.0050	<0.0050	<0.0050
Aluminum (Al)-Total	mg/L	0.01	-	0.015	-	-	0.08	0.06	0.14	0.43	0.21	0.06	0.04	0.02	0.08
Ammonia, Total (as N)	mg/L	0.05	-	-	-	-	0.33	0.07	0.05	0.88	0.10	<0.050	<0.050	<0.050	<0.050
Antimony (Sb)-Dissolved	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Antimony (Sb)-Total	mg/L	0.005	-	0.02	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010
Arsenic (As)-Dissolved	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)-Total	mg/L	0.001	-	0.005	-	-	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	0.00	0.00	0.00
Barium (Ba)-Dissolved	mg/L	0.01	-	-	-	-	0.06	0.08	0.08	0.05	0.08	0.08	0.05	0.07	0.07
Barium (Ba)-Total	mg/L	0.01	-	-	-	-	0.05	0.07	0.07	0.05	0.07	0.07	0.05	0.07	0.07
Beryllium (Be)-Dissolved	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.001	-	0.011	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Bismuth (Bi)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.000050	<0.000050	<0.000050
BOD Carbonaceous	mg/L	2	-	-	-	15	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Boron (B)-Dissolved	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	<0.010	0.01	0.01	<0.010	<0.010	<0.010
Boron (B)-Total	mg/L	0.05	-	0.2	-	-	<0.010	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium (Cd)-Dissolved	mg/L	0.00009	-	0.0001	-	-	<0.000090	<0.000090	<0.000090	0.00	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cadmium (Cd)-Total	mg/L	0.00009	-	0.0001	-	0.001	<0.000090	<0.000090	<0.000090	0.00	<0.000090	<0.000090	0.00	<0.000010	0.00
Calcium (Ca)-Dissolved	mg/L	0.5	-	-	-	-	65.60	74.60	73.80	49.60	71.00	71.70	59.50	81.00	79.30
Calcium (Ca)-Total	mg/L	0.5	-	-	-	-	69.80	75.80	80.10	54.50	69.50	71.70	61.50	81.80	80.70
Cesium (Cs)-Dissolved	mg/L	0.00001	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	-	-	-				<0.000010	<0.000010	0.00
Chloride (Cl)	mg/L	2	-	-	-	-	149.00	181.00	182.00	133.00	195.00	195.00	122.00	181.00	179.00
Chromium (Cr)-Dissolved	mg/L	0.0005	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	<0.00050	<0.00050	<0.00050	0.00	<0.00050	<0.00050	<0.00050	<0.00050	0.00
Cobalt (Co)-Dissolved	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	0.0005	-	0.0009	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.0010	<0.0010	<0.0010	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.00	<0.0010	0.00	0.00	0.00	<0.0010	<0.0010	0.00	0.00
E. Coli	CFU/100mL	10	-	100	-	-	10 *	30 *	70 *	1200 *	1000 *	900 *	10 *	20 *	50 *
Iron (Fe)-Dissolved	mg/L	0.05	-	0.3	-	-	<0.050	<0.050	<0.050	0.02	0.01	0.01	0.04	0.02	0.02
Iron (Fe)-Total	mg/L	0.05	-	0.3	-	-	0.17	0.14	0.23	1.00	0.34	0.10	0.13	<0.050	0.12
Lead (Pb)-Dissolved	mg/L	0.001	-	0.001	-	-	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	0.00	<0.000050	<0.000050
Lead (Pb)-Total	mg/L	0.001	-	0.001	-	0.05	<0.00050	<0.00050	0.00	0.00	0.00	<0.00050	0.00	0.00	0.00
Lithium (Li) - Dissolved	mg/l	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.0010	0.00	0.00	<0.0010	0.00	0.00
Lithium (Li) - Total	mg/L	0.1	-	-	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.0010	0.00	0.00
Magnesium (Mg)-Dissolved	mg/L	0.5	-	-	-	-	24.20	26.50	26.00	23.60	27.20	26.80	24.80	27.90	28.30
Magnesium (Mg)-Total	mg/L	0.5	-	-	-	-	26.00	27.20	27.90	23.80	25.10	25.40	23.40	26.50	26.60
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-	-	0.02	0.02	0.02	0.07	0.00	0.00	0.03	0.01	0.01
Manganese (Mn)-Total	mg/L	0.001	-	-	-	-	0.04	0.04	0.06	0.20	0.07	0.02	0.03	0.01	0.02
Molybdenum (Mo)-Dissolved	mg/L	0.001	-	0.04	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum (Mo)-Total	mg/L	0.001	-	0.04	-	-	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	0.00	0.00	0.00
Nickel (Ni)-Dissolved	mg/L	0.002	-	0.025	-	-	<0.0010	<0.0010	<0.0010	0.00	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Nickel (Ni)-Total	mg/L	0.002	-	0.025	-	0.05	<0.0010	<0.0010	<0.0010	0.00	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050
Nitrate-N (NO3-N)	mg/L	0.1	-	-	-	-	0.71	0.54	0.53	0.33	0.51	0.51	0.30	0.29	0.29
Phosphorus (P)-Dissolved	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	<0.050	<0.050	<0.050	0.07	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus, Total, Dissolved	mg/L	0.003	-	-	-	-	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Potassium (K)-Dissolved	mg/L	1	-	-	-	-	1.50	1.60	1.50	1.68	1.63	1.61	1.63	1.64	1.62

Potassium (K)-Total	mg/L	1	-	-	-	-	1.60	1.60	1.70	1.70	1.60	1.60	1.60	1.59	1.61
Rubidium (Rb)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	-	-	-				0.00	0.00	0.00
Selenium (Se)-Dissolved	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (Se)-Total	mg/L	0.0004	-	0.1	-	-	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	0.00	0.00	0.00
Silicon (Si)-Dissolved	mg/L	1	-	-	-	-	1.60	2.20	2.20	1.77	2.72	2.72	1.64	3.24	3.29
Silicon (Si)-Total	mg/L	1	-	-	-	-	1.80	2.30	2.40	2.30	2.90	2.60	1.65	3.29	3.35
Silver (Ag)-Dissolved	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silver (Ag)-Total	mg/L	0.0001	-	0.0001	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.000050	<0.000050
Sodium (Na)-Dissolved	mg/L	0.5	-	-	-	-	81.80	95.3 *	109 *	74.70	117 *	118 *	68.80	105 *	111 *
Sodium (Na)-Total	mg/L	0.5	-	-	-	-	86.40	113 *	113 *	72.30	112 *	113 *	63.80	99.60	99.40
Strontium (Sr)-Dissolved	mg/L	0.001	-	-	-	-	0.10	0.11	0.11	0.08	0.11	0.11	0.09	0.11	0.12
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.10	0.11	0.11	0.09	0.10	0.11	0.09	0.11	0.11
Sulfur (S)-Dissolved	mg/L	0.5	-	-	-	-	-	-	-	4.77	7.09	6.89	6.67	7.29	7.37
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	-	-	-	<5.0	6.70	6.60	6.35	7.38	7.60
Tellurium (Te)-Dissolved	mg/L	0.0002	-	-	-	-	-	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	-	-	-				<0.00020	<0.00020	<0.00020
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	0.00	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.0003	-	0.0003	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.000010	<0.000010	<0.000010
Thorium (Th)-Dissolved	mg/L	0.0001	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	-	-	-				<0.00010	<0.00010	<0.00010
Tin (Sn)-Dissolved	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	0.001	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	0.002	-	-	-	-	<0.0020	<0.0020	<0.0020	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Titanium (Ti)-Total	mg/L	0.002	-	-	-	-	0.00	<0.0020	0.00	0.01	0.01	<0.0020	0.00	0.00	0.00
Total Phosphorus	mg/L	0.003	-	0.02	-	-	0.02	0.03	0.03	0.04	0.05	0.04	0.01	0.01	0.01
Total Suspended Solids	mg/L	3	-	-	-	15	5.50	7.50	12.50	17.50	10.00	4.80	3.00	5.50	12.90
Tungsten (W)-Dissolved	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tungsten (W)-Total	mg/L	0.01	-	0.03	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.00010	<0.00010	<0.00010
Uranium (U)-Dissolved	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	0.00	0.00	0.00	0.00	0.00	0.00
Uranium (U)-Total	mg/L	0.005	-	0.005	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.00	0.00	0.00
Vanadium (V)-Dissolved	mg/L	0.001	-	0.006	-	-	<0.00050	<0.00050	<0.00050	<0.00050	0.00	0.00	<0.00050	<0.00050	<0.00050
Vanadium (V)-Total	mg/L	0.001	-	0.006	-	-	<0.00050	0.00	0.00	0.00	0.00	0.00	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.003	-	0.02	-	-	0.05	0.00	0.00	0.12	0.00	0.00	0.06	0.00	0.00
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.06	0.01	0.02	0.21	0.02	0.01	0.06	0.01	0.01
Zirconium (Zr)-Dissolved	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Zirconium (Zr)-Total	mg/L	0.004	-	0.004	-	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.00030	<0.00030	<0.00030

* = Result Qualified <

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

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Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key:	Within Guideline	**Exceeds Guideline**

HANLON CREEK BUSINESS PARK

CONSTRUCTION-PHASE AQUATIC MONITORING 2015

Prepared for:

City of Guelph
Economic Development Services
65 Delhi Street
Guelph, ON

Project No. 1034F October 2016

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Hanlon Creek Business Park
Construction-Phase Aquatic Monitoring 2015

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Report submitted on October 4, 2016

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Project Manager, Aquatic Biologist

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1.0 Introduction

The need for aquatic monitoring for the Hanlon Creek Business Park development was identified in the *Hanlon Creek Business Park Consolidated Environmental Impact Study* (NRSI 2004), which recommended benthic invertebrate sampling and more frequent fish sampling at the state-of-the-watershed fish sampling site. Monitoring of aquatic habitat was also recommended in the conditions for the Draft Plan approval of the Hanlon Creek Business Park as set by the Ontario Municipal Board (2006). Specifically, Draft Plan Condition #12 requires that thermal impact of stormwater management ponds be monitored.

A multi-disciplinary monitoring program was developed for the Hanlon Creek Business Park (HCBP) development to achieve a variety of objectives, including the aquatic habitat. The overall monitoring program also includes terrestrial features, hydrogeology, surface water flows, surface water temperatures, benthic invertebrates and fish.

This monitoring report addresses the benthic invertebrate and fish communities. The aquatic monitoring components were implemented prior to construction to establish an adequate baseline data set against which development conditions can be compared. The pre-construction data includes the years 2006 - 2009. Data has been collected at 5 stations (3 stations prior to 2009). One of the stations coincides with the aforementioned state-of-the-watershed fish sampling station. Monitoring will continue until 75% of the development is built by area in Phases I, II and III of the HCBP, plus an additional 2 years.

In 2015, construction activities continued within the Hanlon Creek Business Park. Construction activities began in 2010 with grading, servicing, and building construction initiated. As a result, aquatic monitoring conducted since 2010 is considered construction-phase monitoring.

In addition to the monitoring for the HCBP, state-of-the-watershed monitoring in the Hanlon Creek watershed is to occur on a 5-year schedule based on the recommendation for long-term monitoring in the Hanlon Creek Watershed Plan (1993). The aquatic component of the state-of-the-watershed monitoring includes one fish sampling site within the HCBP development lands. The Hanlon Creek State-of-the-Watershed Report (PEIL 2004) is a report on the state-of-the-watershed monitoring.

2.0 Study Area

Hanlon Creek Business Park is located in the south end of the City of Guelph. As shown on Map 1, the project area is bounded to the east by Hanlon Expressway, to the north by the Kortright IV subdivision, to the west by Downey Road and to the south by Forestell Road. Laird Road runs parallel to Forestell Road, dividing the project area into north and south sections. The project area comprises forested areas and swamp/marsh pockets, as well as lands to be developed. The project area also includes a system of tributary streams that is part of the Hanlon Creek watershed. These streams are the subject of the aquatic monitoring. The watercourses are shown on Map 1.

The aquatic monitoring program is being conducted primarily in the northern portion (Phase I) of the business park development, north of Laird Road. The interest in this location is based on the historic presence of brook trout (*Salvelinusfontinalis*) in the coldwater habitat provided by Tributary A1, and Tributary A north of Laird Road. One of the stations, added in 2009, is south of Laird Road, situated downstream of the outlet of Stormwater Management Pond 4.

2.1 Construction Activity

Construction commenced in late 2009 and has continued each year through to 2015. Construction activity in 2015within Phases 1 and 2 is outlined below and highlighted on Map 2.

Phase 1, Stage 2

- Operation of commercial building – 500 Hanlon Creek Boulevard (Fusion Homes)
- Construction of commercial building – 501 Hanlon Creek Boulevard(Compass)

Phase 1, Stage 3

- Operation of commercial buildings – 197-345 Hanlon Creek Boulevard (Wurth Canada, Graniteworx, etc.)
- Construction of commercial building – 28 Bett Court (MF Property Management Inc.)

Phase 2

- Construction of commercial building – 104 Cooper Drive (Ontario One Call)
- Preliminary grading of Blocks 8, 9 and 26 completed in 2014
- Laird Road overpass has been in-use since 2014

No construction activity occurred within Phase 3 in 2015.

3.0 Methods

A total of 3 sampling sites in the northern portion of the subject property were selected during the 2006 field season. The same sites were sampled again every year from 2007 to 2015. Two sites were added in 2009 to expand the monitoring program and have been sampled continuously, including 2015. At each site, there is a benthic invertebrate sampling station (BTH) and a quantitative fish sampling station (EMS).

- Site 1 (BTH-001 and EMS-001) is located on Tributary A approximately 150m downstream (north) of Laird Road.
- Site 2 (BTH-002 and EMS-002) is located on Tributary A immediately downstream of the confluence with Tributary A1 and upstream (south) of Hanlon Creek Boulevard.
- Site 3 (BTH-003 and EMS-003) is located on Tributary A1.
- Site 4 (BTH-004 and EMS-004) is located on Tributary A downstream (north) of the Hanlon Creek Boulevard crossing.
- Site 5 (BTH-005 and EMS-005) is located on Tributary A upstream (south) of Laird Road

Fish sampling and benthic invertebrate collections were conducted at each site, but they occurred in separate areas of the stream to facilitate collection of both parameters on the same day (Map 1).

The original selection of stations was based in part on historic knowledge of brook trout inhabitance. The stations were also positioned to help locate sources of future impacts, should any occur. To the extent possible, station selection followed the recommendation in the Ontario Stream Assessment Protocol (Stanfield 2005) to establish the upstream and downstream extents of a site at a crossover point of the thalweg (concentration of flow). The specific sections of stream were selected to represent the habitat types in the vicinity of each station.

3.1 Benthic Invertebrate Community

There are a number of advantages in sampling benthic invertebrates for water quality monitoring:

- They reflect local aquatic conditions as a result of their limited mobility;
- They integrate all the surrounding parameters of their environment into one easily assessable sampling unit;
- They integrate the physical and chemical aspects of water quality over annual time periods due to their short life spans (approximately 1 year); and
- They may indicate the probable cause of impairment because many benthic invertebrate species have known environmental sensitivities and/or tolerances.

3.1.1 Benthic Invertebrate Sampling

Sampling for the benthic invertebrate monitoring took place on September 8, 2015. It employed the sampling methodology from the Ontario Benthos Biomonitoring Network (OBBN) protocols (Jones et al 2005). Most of the following procedures have been taken from these protocols. Some of the specimen processing procedures are not covered by the OBBN protocols.

According to the OBBN methods for streams, a total of 3 subsamples are collected at each station in stream habitats: 2 from riffles, and 1 from a pool. Where riffle and pool habitats are not clearly defined (as is the case at some of the subject stations) pools and riffles can be functionally defined as slow/deep and fast/shallow sections, respectively. For wadable streams, the OBBN protocol employs a Travelling Transect Kick and Sweep method. For each subsample, a total of at least 10 linear metres of transect must be sampled in approximately 3 minutes. For small streams such as those in this study, this requires that several transects be positioned in the same riffle or pool in order to sample 10 metres of transect. Beginning at one bank and moving across each transect, the substrate is disturbed to a depth of approximately 5cm by vigorously kicking the substrate. A 500-µm-mesh D-net is held downstream of and close to the disturbed area by the person sampling. The net is held on or close to the bottom, and is swept back and forth so that dislodged invertebrates will be carried into the net. In areas of slow current, the sweeping motion is important for collecting the invertebrates into the net. A stopwatch is used to time the sampling.

When sampling is complete, the net is rinsed and the sample is placed in plastic jars. The sample is then preserved with a 75% concentration of ethyl alcohol and sent to a professional taxonomist for identification. Benthic samples collected in 2015 were processed and identified in the NRSI laboratory. Samples are identified to the lowest practical taxonomic level. Subsampling is conducted by randomly dipping a small portion of the sample from a container until at least 200 organisms are obtained. After reaching the 200th organism, the portion being sampled is completed in order to facilitate measurement of the proportion of the total sample that is subsampled and identified. The subsample proportion is determined by measuring the total sample weight/volume before identification and the remaining sample weight/volume after identification. The difference between those 2 measurements represents the portion sampled, which is recorded as a percentage of the total sample. While the OBBN protocol requires that a minimum of 100 organisms be collected, 200 organisms per subsample are collected to provide a robust sample for this program's use of the Percent Model Affinity analysis.

The OBBN data form was used to record habitat information at the benthic invertebrate sampling stations. The form includes both measured and visually estimated parameters, and facilitates comparison with other years provided the estimated parameters are treated as approximations.

3.1.2 Benthic Invertebrate Data Analysis

Analysis was performed using the Percent Model Affinity (PMA) method developed in New York State by Novak and Bode (1992). This method was adapted for southern Ontario by Dr. David Barton (1996) of the University of Waterloo.

In his 1996 paper, Dr. Barton sampled over 200 streams in southern Ontario, 69 of which were used as the reference streams for the model community. Instead of using the 7 groupings originally used by Novak and Bode (1992), Dr. Barton compared the use of model communities at the order, family, genus, and 'lowest practical' taxonomic levels. He found that there was an improvement with increasing taxonomic resolution, particularly between the family and genus levels. He also analyzed seasonal differences (Barton 1996).

The model communities used for analysis in this study are based on values from Dr. Barton for streams with mud and cobble/gravel substrates sampled in August (Barton 2007). The model community for mud substrates was used for BTH-001, BTH-003, BTH-004 and BTH-005, and the model community for cobble/gravel substrates was used for BTH-002. The family level of taxonomic resolution was used because many of the invertebrates are very small in August and September, making it difficult or impossible to identify some of the specimens beyond their family.

The equation used to determine the percent similarity of community (PSC) is as follows:

$$PSC = 100 - 0.5\,\Sigma\left|a - b\right|$$

Where: a is the model community value for a taxonomic group expressed as a percentage of the organisms in the model community; and

b is the percentage of the same taxonomic group in a sample from the stream being studied.

The sample PSC value is calculated by summing the absolute differences between the family model values and the families in the sample, multiplying the sum by 0.5 and subtracting this number from 100 (Novak and Bode 1992). The sample PSC value is then compared to the critical PSC value for the chosen model community.

Each critical PSC value is effectively a lower confidence limit of the mean for the expected community. It is essentially a statistical one-tailed t-test comparing a single observation with the mean of the sample, where the P-Value = 0.05 (Zar 1999). The critical PSC values were provided by Dr. Barton along with the model community data (Barton 2007).

This index does not assign a degree of impairment or non-impairment. Rather, significant impact at a sample site is determined when the calculated sample PSC value is less than the critical PSC value. Significant impact implies that the sample community is statistically significantly different from the model community. A determination of no significant impact occurs when the calculated sample PSC value is greater than the critical PSC value (Barton 1996).

The PMA analysis was conducted for each station with the 3 subsamples (riffles and pool) combined into one sample, which is the intention of the OBBN protocol.

In addition to PMA analysis, three other indices were calculated to provide additional insight into the water quality conditions at the sampling sites. They were:

- The number of taxa present in each sample (taxonomic richness);
- The percentage of individuals in each sample belonging to the taxonomic groups Ephemeroptera, Plecoptera, and Tricoptera (EPT richness); and
- The percentage of individuals in each sample that were the dominant taxon (% dominant taxon).

Taxonomic richness is a measure used to determine the number of different species that are present in a sampled area and provide an indication of the diversity of a given site. Generally, a higher number of taxa present in a sample reflect a more diverse habitat and/or better water quality.

The percentage of Ephemeroptera, Plecoptera, and Trichoptera (EPT richness) is based on the premise that EPT taxa are less tolerant of pollution. Therefore, a higher EPT richness value suggests better water quality and/or habitat conditions.

The dominant taxon and its percentage of the sample are very helpful in characterizing the benthic community at a site. It describes an aspect of the diversity of the community, and can provide some indication of habitat and/or water quality at the site.

3.2 Fish Community

NRSI biologists conducted quantitative fish sampling at the 5 stations to provide population estimates that can be compared over the years of monitoring.

3.2.1 Fish Community Sampling

Fish sampling was conducted on September 9, 10, and 11, 2015 using a depletion sampling method that is outlined in the Ontario Stream Assessment Protocol (Stanfield 2010). At each quantitative station, the chosen stream length was isolated from the rest of the stream using block nets. The block nets were small seine nets with a mesh size similar to the size of mesh on the dip net used with the electrofisher. The rope across the bottom of the net was weighted to keep it against the bottom of the channel, and the top of the net was a floating line. The nets were secured to trees or woody material on each shore.

A 2-person electrofishing crew conducted multiple passes of the enclosed area using a Smith-Root LR-20B backpack electrofisher set to a pulsating frequency of 70Hz, and an electric potential of 150 or 250 volts with current (amperes) ranging from approximately 2.0 to 3.0A. Once collected, the fish were identified, measured on site, and released outside of the sampling area downstream of the block nets. This process was repeated until the number of individuals caught exhibited a downward trend, or a minimum of three times. The number of individual fish, and minimum and maximum lengths were recorded for each species. The water quality conditions, electrofisher settings, and number of shocking seconds for each pass were recorded. An effort was made to keep the sampling effort the same for each pass with respect to shocking seconds and netting technique.

Habitat information for the stations included classifications of adjacent lands, and basic visual estimates of macrohabitats (riffles, pools, etc.), instream vegetation, instream cover and overhead canopy shading. General flow conditions were also determined by measuring the wetted width, bankfull width, and five equally spaced depths, at five transects along the station. These habitat parameters provide a basic description of the conditions and help to understand the fish data. This information is intended to help interpret the fish community data for the quantitative stations. Because the focus of the monitoring is on the fish community, they are approximate and not intended for detailed comparison among years of monitoring.

Brook trout spawning surveys were carried out during the spawning season in the fall of 2015. Three site visits were conducted, occurring on October 23, November 9, and

November 26, 2015 to document redds and observe any brook trout exhibiting spawning behaviour. The survey was conducted at several locations along Tributary A and Tributary A1 within the HCBP and covered approximately 650 m of creek.

3.2.2 Fish Community Data Analysis

The analysis of the data for the sampling stations provides estimates of the population of the fish at each station. A simple method for these calculations uses a regression of the data, which is plotted on a 2-dimensional graph with the catch from an individual fishing (1 pass) on the y-axis and the previous total catch (sum of previous passes) on the x-axis. This method is described by Zippen (1958) in the context of trapping small mammals. This calculation assumes a constant probability (P) of capture with each fishing pass. However, this method is generally considered inferior because it does not give valid estimates of the standard error of the estimated population size.

A better method employs maximum likelihood estimates, as described by Schnute (1983). This method calculates the probability of capture, and this probability can be either constant or variable. For 2015, the data collected at 4 of the 5 sampling sites were limited to 3 passes since they exhibited a consistent downward trend. Station EMS-003 required a fourth pass to achieve a consistent downward trend. These data are well suited to the maximum likelihood constant P method. All five stations met the necessary criteria required for estimating population size under the constant P method, and the population estimates are considered reliable.

A computer software package called *Removal Sampling 2* by Pisces Conservation Ltd. was used to perform the calculations using the maximum likelihood – constant probability method.The estimated population calculations were carried out separately for each station, and estimates were made for all species combined. Capture of brook trout warrants a separate estimate, but none were captured in 2015.

4.0 Results and Discussion

4.1 Benthic Invertebrate Sampling

4.1.1 Habitat and Sampling Conditions

Station BTH-001 is situated within a white cedar – hardwood mixed swamp as defined in the Ecological Land Classification for Southern Ontario Guide (ELC, Lee et al. 1998). This swamp extends up to 100 m to the west, but a fallow agricultural field occupies land within 50 m to the southeast of the station. The riparian vegetative community is predominantly coniferous forest which was estimated to provide 75 - 100% shade. The channel is composed of runs, riffles, and pools. At the time of sampling no aquatic macrophytes or algae were observed within the channel. Woody debris and detritus was present throughout the entire site with woody debris abundant in some locations. The sampling conditions are summarized in Table 1.

Table 1. Benthic Invertebrate Sampling Conditions for Station BTH-001

Date	September 8, 2015		
Time	12:10		
Air Temperature (°C)	n/a		
Water Temperature (°C)	21.5		
Dissolved Oxygen (mg/L, %)	7.0, 82.1		
Conductivity (µS/cm)	790		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	2.3	1.3	2.0
Maximum Depth (m)	0.16	0.13	0.08
Maximum Hydraulic Head (mm)	10	1	5
Dominant Substrate	Gravel	Silt	Silt
Second Dominant Substrate	Sand	Sand	Sand
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	1	3	2

n/a = not available

Station BTH-002 is situated within a white cedar – hardwood mixed swamp (Lee et al. 1998). The vegetative community adjacent to the stream is mainly deciduous forest from 1.5 to 30 m on the west side and 1.5 to 10 m on the east side. Beyond 30 m to the west a 100 m meadow buffer separates forest from a newly developed block of land with a recently built Fusion Homes corporate office building. Beyond 10 m of forest to the east exists a strip of meadow approximately 10 m wide and a recently constructed gravel walking trail, which runs parallel to Tributary A and A1 and is fenced along both sides. The overhead canopy at this station provides an estimated 75 to 100% shade. The channel includes shallow riffle, pool, and run features. Within the channel aquatic macrophytes and algae are generally absent with some crusted algae covering the substrate. Detritus was noted to be abundant and woody debris is present throughout the sample location. Sampling conditions are summarized in Table 2.

Table 2. Benthic Invertebrate Sampling Conditions for Station BTH-002

Date	September 8, 2015		
Time	14:30		
Air Temperature (°C)	n/a		
Water Temperature (°C)	20.8		
Dissolved Oxygen (ppm, %)	6.5, 76.0		
Conductivity (µS/cm)	1120		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	3.0	4.0	4.0
Maximum Depth (m)	0.09	0.08	0.10
Maximum Hydraulic Head (mm)	11	10	15
Dominant Substrate	Cobble	Cobble	Cobble
Second Dominant Substrate	Gravel	Gravel	Gravel
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	2:50
Number of Jars to Retain Sample	1	1	1

n/a = not available

Station BTH-003 is situated within a white cedar – hardwood mixed swamp (Lee et al. 1998). The riparian community is dominated by deciduous forest along both banks of the creek, providing up to 100% canopy cover. To the west this vegetative community extends beyond 100m while to the east it extends to approximately 30 m. Beyond the trees a 30 m strip of meadow habitat separates the forest from the gravel walking path described under station BTH-002, which occurs within the Phase 1 construction area. The channel includes flats, runs and shallow pools. There is limited to no aquatic vegetation or algae in the channel, however woody debris and detritus are both found to be abundant throughout the site. This abundance of woody debris, provided by fallen logs and branches, adds complexity to the instream habitat. Sampling conditions for this site are provided in Table 3.

Table 3.Benthic Invertebrate Sampling Conditions for Station BTH-003

Date	September 8, 2015		
Time	15:10		
Air Temperature (°C)	n/a		
Water Temperature (°C)	12.8		
Dissolved Oxygen (ppm / %)	7.52, 73.2		
Conductivity (µS/cm)	830		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.1	2.0	1.0
Maximum Depth (m)	0.08	0.13	0.09
Maximum Hydraulic Head (mm)	1	1	1
Dominant Substrate	Silt	Silt	Silt
Second Dominant Substrate	Clay	Clay	Clay
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	3	2	2

n/a = not available

Station BTH-004 is situated in a white cedar – hardwood mixed swamp (Lee et al. 1998). The vegetative community adjacent to the stream is a white cedar – hardwood mixed swamp along both banks and extending approximately 30 m. Beyond this to the west exists a section of mineral meadow marsh and fallow agricultural land. To the east this transitions to a predominantly deciduous forest and then to meadow. Beyond this lies the Phase 1 construction area which includes a gravel walking trail. Construction activities were taking place within the Phase 1 and Phase 2 lands throughout 2015 and have been described in Section 2.1. The forest adjacent to the creek is estimated to provide approximately 75 to 100% shade over the station. The channel at this station includes a variety of shallow flats, runs and pool features. No aquatic vegetation was present in the channel at the time of sampling, however detritus and woody material were found to be present throughout the station. Sampling conditions for BTH-004 are summarized in Table 4.

Table 4. Benthic Invertebrate Sampling Conditions for Station BTH-004

Date	September 8, 2015		
Time	13:30		
Air Temperature (°C)	n/a		
Water Temperature (°C)	20.4		
Dissolved Oxygen (ppm / %)	7.36, 84.5		
Conductivity (µS/cm)	540		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.7	1.5	1.5
Maximum Depth (m)	0.18	0.14	0.18
Maximum Hydraulic Head (mm)	2	1	2
Dominant Substrate	Silt	Silt	Silt
Second Dominant Substrate	Clay	Clay	Clay
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	2	3	3

Station BTH-005 is situated in a fresh – moist poplar deciduous forest which provides from 25 to 100% canopy cover, depending on the sample location. Smaller areas of reed canary grass mineral meadow marsh and willow mineral thicket swamp communities occur from 1.5 to 10 m on both sides of the channel (Lee et al. 1998). Fallow agricultural land occurs beyond 30 m to the southwest, and Laird Road is approximately 30 m to the north. Instream habitat is characterized by flat and run features with a limited amount of emergent and rooted floating vegetation within the channel. An abundance of detritus and variable amounts of woody debris were also observed. Sampling conditions are summarized in Table 5.

Table 5. Benthic Invertebrate Sampling Conditions for Station BTH-005

Date	September 8, 2015		
Time	10:45		
Air Temperature (°C)	n/a		
Water Temperature (°C)	21.3		
Dissolved Oxygen (ppm / %)	46.5, 3.97		
Conductivity (µS/cm)	400		
	Riffle 1	**Pool 2**	**Riffle 3**
Wetted Width (m)	1.2	1.25	1.25
Maximum Depth (m)	0.15	0.19	0.11
Maximum Hydraulic Head (mm)	3	1	2
Dominant Substrate	Silt	Silt	Silt
Second Dominant Substrate	Clay	Clay	Clay
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	2	3	3

4.1.2 Benthic Invertebrate Community Data

The identification and enumeration of benthic invertebrates are summarized in tabular format in Appendix I.

The Percent Model Affinity (PMA) index calculation generates Percent Similar Community (PSC) values, which are summarized in Table 6. Values that are higher than the critical PSC value indicate no impact, while values that are lower than the critical PSC value indicate impact. The impact determinations for the years 2006 through 2014are provided along with the 2015 results for comparison.

Table 6. Percent Similar Community Values and Impact Determination

Station	2006 Result	2007 Result	2008 Result	2009 Result	2010 Result	2011 Result	2012 Result	2013 Result	2014 Result	2015 Critical PSC	2015 Sample PSC	2015 Result
BTH – 001	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	42.12	41.35	Impact
BTH – 002	Impact	No Impact	Impact	Impact	No Impact	Impact	Impact	Impact	Impact	50.7	38.36	Impact
BTH – 003	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	Impact	Impact	No Impact	42.12	49.26	No Impact
BTH – 004	-	-	-	No Impact	No Impact	No Impact	Impact	Impact	Impact	42.12	49.78	No Impact
BTH – 005	-	-	-	No Impact	No Impact	No Impact	No Impact	No Impact	Impact	42.12	16.55	Impact

The additional indices that were calculated include taxonomic richness, EPT richness, and % dominant taxon. These results are summarized in Tables 7 through 11 and are shown on Figures 3, 4, and 5. The results are discussed by station in the text that follows.

Table 7. Benthic Invertebrate Metrics for Station BTH-001 for the Years 2006 to 2015

	BTH-001									
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Taxonomic Richness	40	42	38	38	47	46	48	25	25	26
% EPTs	21.3	25	41.8	37.2	23.6	27.0	11.9	9.1	3.9	6.7
% Dominant Taxon	27.8	19.4	25.5	20.5	23.8	17.2	16.6	16.4	27.5	11.8

Table 8. Benthic Invertebrate Metrics for Station BTH-002 for the Years 2006 to 2015

	BTH-002									
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Taxonomic Richness	47	42	39	32	49	42	43	23	19	27
% EPTs	42.9	16.4	44.4	48.8	29.6	47.6	25.1	31.6	21.3	31.4
% Dominant Taxon	18.5	32.0	20.2	19.1	14.4	16.3	31.2	16.8	30.0	14.3

Table 9. Benthic Invertebrate Metrics for Station BTH-003 for the Years 2006 to 2015

	BTH-003									
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Taxonomic Richness	21	28	30	35	42	19	22	16	13	15
% EPTs	6.9	16.3	25.4	22.2	15.3	2.8	2.0	6.7	0.8	3.5
% Dominant Taxon	66.3	37.2	42.4	30.7	34.9	68.4	54.9	57.9	41.2	37.8

Table 10. Benthic Invertebrate Metrics for Station BTH-004 for the Years 2009 to 2015

	BTH-004									
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Taxonomic Richness	-	-	-	39	43	41	27	18	15	19
% EPTs	-	-	-	12.5	10.0	8.2	0.8	3.9	1.3	7.5
% Dominant Taxon	-	-	-	29.0	19.0	29.3	49.7	56.8	34.3	20.6

Table 11. Benthic Invertebrate Metrics for Station BTH-005 for the Years 2009 to 2015

	BTH-005									
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Taxonomic Richness	-	-	-	42	26	34	31	14	18	14
% EPTs	-	-	-	14.8	2.8	5.1	16.9	9.3	1.4	35.3
% Dominant Taxon	-	-	-	22.5	31.6	24.9	26.9	22.2	31.6	29.1

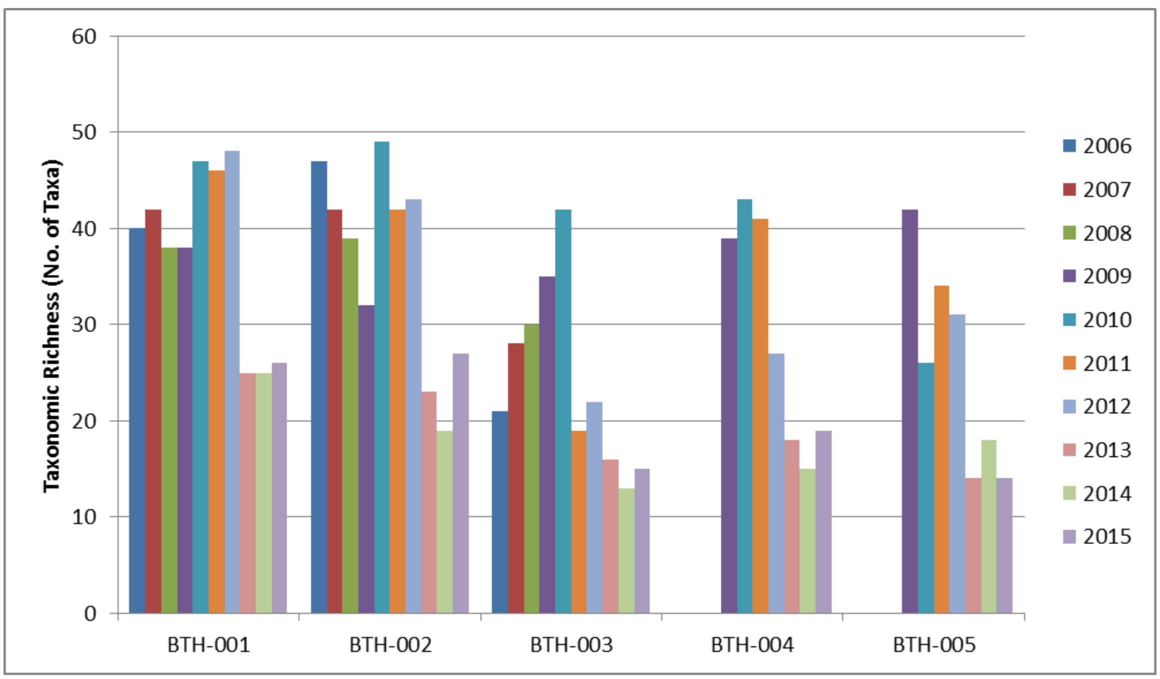

Figure 1. Benthic Invertebrate Taxonomic Richness for the Years 2006 to 2015

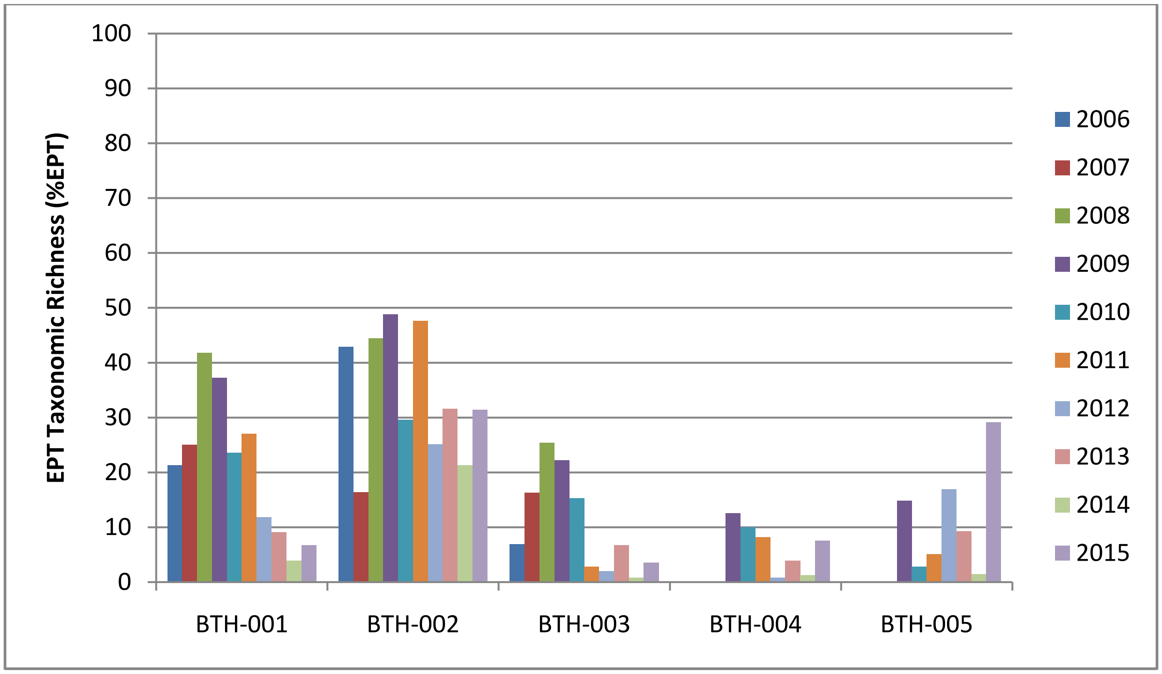

Figure 2. Benthic Invertebrate EPT Taxa Richness for the Years 2006 to 2015

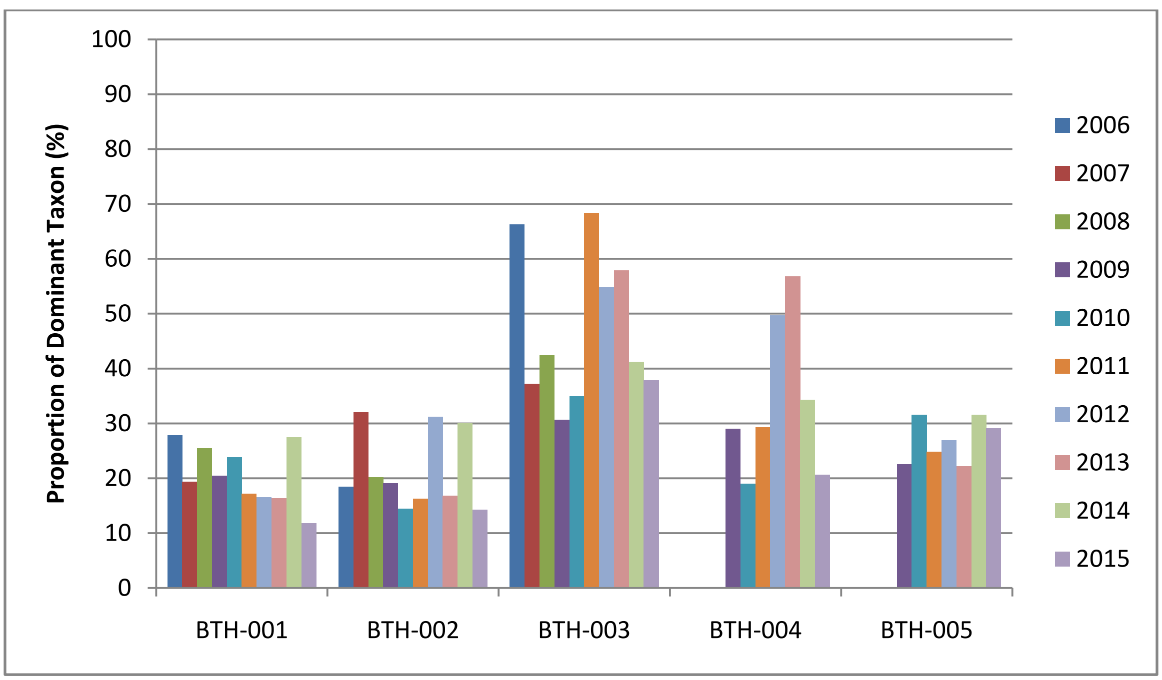

Figure 3. Benthic Invertebrate Proportion of Dominant Taxa for the Years 2006 to 2015

Station BTH-001

Taxonomic richness at station BTH-001 has varied from 25 to 48 over the 10 years of monitoring. Between 2006 and 2012 the taxa richness at this station remained fairly consistent with an increase observed in 2010. The highest taxa richness occurred in 2012 with a high of 48 (Figure 1). In 2013 a decline was noted with numbers dropping from 48 to 25, the lowest that had been observed to date. Taxonomic richness in 2014 remained low with a richness of 25,which was found for a second straight year. In 2013 it was determined that this low taxa richness was largely a function of the level of identification ofchironomids, which changed between 2012 and 2013 from genus to sub-family level. This appears to have continued into 2014 and 2015, resulting in a similarly low richness. The changes experienced between 2012 and 2013 as well as the low taxonomic richness in 2014 and 2015 have been discussed in detail in Section 4.1.3. No consistent trends have been established at BTH-001 as it relates to taxonomic richness.

The EPT richness at BTH-001 has varied greatly between 2006 and 2015. Pre-construction values ranged from a low of 21.3% in 2006 to a high of 48.1% in 2008, which appeared to be uncharacteristically high for this station (Figure 2). Following 2008 the EPT richness has declined to below 10% with the lowest EPT richness (3.9%) occurring in 2014. The EPT richness increased slightly to 6.7% in 2015 but overall remains lower than what had been observed during pre-construction monitoring. Threshold exceedances occurred at this station for three consecutive years (2012, 2013, and 2014).

The dominant taxon in 2015belonged to the family Sialidaeof the order Megaloptera (Alderfly). Species belonging to this family may be associated with a variety of substrates and current types and are exclusively predatory (Merritt *et al*. 2008). The conditions at station BTH-001 are consistent with this generalized habitat description providing silt, sand and gravel substrates, as well as moderately abundant detritus and woody debris. Sialidaeare considered to be indicative of very good water quality with only slight organic pollution (Mandaville 2002).This species represented 11.8% of the total number of individuals within the sample (Figure 3) and dominated the sample for the first time in 2015. Several subdominant species were observed, comprising between 8.0 and 9.0% of the sample. These species represented three distinct families includingAmphipods (*Gammaruspseudolimnaeus* - 8.7%), Isopods (*Caecidotea* *intermedius* - 8.3%), and Coleopterans (*Optioservusfastiditus* - 8.3%). These species have all historically comprised a large proportion of the samples at this station and have dominated the samples during different years from 2010 to 2012. Species of Dipterans (true flies) have also previously comprised large proportions of the samples at BTH-001, and did again in 2015. Species of *Chironominae*(*Chironomus sp.*), a subspecies of Chironomidae, and Tabanidae (*Chrysops sp.*) both comprised 7.5% of the sample. In total, Dipteran species accounted for 37.8% of the overall sample, the highest of any of the benthic families in 2015. Dipteran species previously dominated the samples in 2006, 2007, 2013, and 2014. Previously observed dominant taxa have also included a species of caddisfly (Trichopteran) of the family Hydropsychidae in 2008 and 2009.

The PMA index showed 'impact' in 2015 as the calculated PSC value of 41.4 was slightly lower than the critical PSC value of 42.12. This is the first year since monitoring began in 2006 that results have shown an 'impact' determination for the PMA index (Table 6). A decrease in EPT species at this site between2012and 2014 indicated a potential change in conditions, and continued low EPT richness combined with the PMA impact determination in 2015 suggests that impact is occurring.

Station BTH-002

Taxonomic richness at station BTH-002 was 27 in 2015. Results show an increase following two consecutive years of decreasing taxa richness in 2013 and 2014, during which the lowest-to-date taxa richness of 19 was observed (Figure 1). This metric experienced a steep decline in the taxonomic richness between 2012 and 2013 from 43 to 23. The result in 2013 was likely a function of the level of identification of the benthic invertebrates, which changed from 2012 to 2013 and continued in 2014 and 2015. This change is discussed in detail in Section 4.1.3. When considering the change in the level of identification used, it appears that taxonomic richness has continued to be fairly consistent at BTH-002.

The EPT richness was 31.4% in 2015, an increase from 21.3% in 2014 and similar to what was observed in 2010 and 2013 (Figure 2). This metric has shown no obvious increasing or declining trends. EPT richness has frequently been high (above 40%) with large declines noted in 2007 (16.4%), 2010 (29.6%), and most recently in 2012. Further to this, it has never experienced declining richness values over consecutive years. The lowest levels in EPT richness at BTH-002 were seen during a pre-construction year in 2007 indicating that the observed declines in EPT taxa are within the natural variations of the station.

The dominant taxa at station BTH-002 in 2015 was *Optioservusfastiditus*, a species belonging to the family Elmidae(riffle beetle) from the order Coleoptera. Species belonging to this family occur primarily in well-aerated streams and are indicative of very good water quality. They are considered to be collector-gatherers or scrapers feeding mainly on algae and detritus (Elliott 2008, Mandaville 2002). These characteristics are consistent with the habitat found at this site, which is mainly cobble and gravel riffles. Some finer sediment was observed in addition to the presence of small amounts of woody debris and detritus. This is the first year that this species has dominated the sample at BTH-002 comprising 14.3% of the sample. In 2014 *Gammaruspseudolimnaeus*, a species of Amphipod, was the dominant taxa and represented 30.0% of the total number of individuals in the sample (Figure 3).*G. pseudolimnaeus*had been the dominant taxa at this station since 2012. The result for % dominant taxon has generally been lower at this station over the years of monitoring with 2007, 2012 and 2014 being relatively high (32.0%, 31.2% and 30.0%, respectively). The dominant taxonomic group has changed several times at BTH-002 including *Sialis sp.* (Megaloptera) in 2006, *Micropsectra sp.* (Diptera) in 2007 and 2008, *Cheumatopsyche spp.*(Trichoptera) in 2009, and *Leuctra spp.* (Plecoptera) in 2010 and 2011. In 2013 two species dominated the sample including*G. pseudolimnaeus* and *Diplectronamodesta*, a species of Trichoptera. EPT species were well represented within the sample again in 2015 including*Cheumatopsyche spp.* (Trichoptera) which was the subdominant species. The proportion of *Sialis sp.* was also relatively high within the sample.

The PMA index in 2015 showed ‘impact’for the fifthconsecutive year. Results since pre-construction monitoring began in 2006 have been inconsistent up until 2011 with results showing no reliable trend of ‘impact’ or ‘no impact’. Since 2011results have consistently indicated ‘impact’, which has been the most common result, with ‘no impact’ observed only two out of ten years of monitoring (2007 and 2010) (Table 6). Continuation of the ‘impact’ determinations suggests that some change has occurred. Monitoring using the PMA analysis should continue with the intention of determining whether or not a ‘no impact’ determination is observed again, at least on occasion.

The predominance of the ‘impact’ result should not be construed to mean that station BTH-002 is in poorer condition than the other stations. This station is the only station that uses the cobble/gravel model community for PMA index, and it was chosen based on the habitat characteristics of the station. Because of this difference, comparisons among the other four stations using the PMA index are not valid. The monitoring program is intended to provide temporal comparison within stations.

Station BTH-003

Taxonomic richness at station BTH-003 was 15 in 2015. This was a slight increase from 13 in 2014 (Figure 1). Taxa richness has experienced a general decrease that began in 2011, which followed an exceptionally high year in 2010 where the richness was 42. The results in 2014 were the lowest that had been recorded at this site since sampling began. This result is likely a function of the level of identification of certain groups of the benthic invertebrates, which changed between 2012 and 2013 and continued through to 2015. This change is discussed in detail in Section 4.1.3. Over the 5 years of monitoring prior to 2011 species richness had increased steadily by 50%, beginning in 2006 with a measure of 21 and increasing to 42 in 2010. The results observed in 2011 and 2012 appeared to be a return to the degree of taxonomic richness that was observed during pre-construction monitoring. While the results in 2015remain below pre-construction numbers, it can be explained by the change in the level of identification of some groups between 2013 and 2015.The high richness in 2010 included many taxa in the family Chironomidae. There were numerous individuals in that family in 2015, but they were only identified to the subfamily. This accounts for much of the reduction in taxa richness.

The EPT richness was 3.5% in 2015, anincrease from a historic low of 0.8% in 2014 (Figure 2). This value is higher than what was observed in 2011, 2012, and 2014. Results have varied throughoutthe years with an increasing trend observed during the first three years of monitoring and a decreasing trend between 2008 and 2014. The EPT richness values seen between 2011 and 2014 show levels that are lower than results from pre-construction monitoring, with the exception of 2013 which saw an increase to pre-construction levels. The decrease experienced between 2013 and 2014 resulted in the exceedance of threshold number three in 2014.

The dominant taxon in 2015 was *Gammaruspseudolimnaeus*, which comprised 20.1% of the total sample (Figure 3). This marks the fourth consecutive year that *G. pseudolimnaeus* has been the dominant species at BTH-003 comprising between 37.8% and 68.4% of the samples. *G. pseudolimnaeus* prefers soft substrates and the shallow areas of both lotic and lentic environments. The preference of this species for depositional areas explains its abundance at station BTH-003 as this station occurs in a slow-flowing, groundwater-fed headwater tributary with abundant detritus and underlying substrates dominated by silt and clay. *G. pseudolimnaeus* are indicative of very good water quality (Mandaville 2002). Prior to 2012, the dominant taxon was *Micropsectra*spp., a Dipteran species that had previously been the dominant taxon throughout all six years of pre-construction monitoring. In 2015 a variety of Chironomid species comprised the majority of the subdominant group including several species belonging to the *Chironominae* and *Prodiamesinae* subfamilies. The proportion of *Sialis sp.* was also relatively high within the sample.

The PMA analysis showed ‘no impact’ in 2015, which is consistent with the result from 2014. This is a change from 2012 and 2013, both of which showed ‘impact’ (Table 6). Prior to 2011 the results suggested that habitat and/or water quality conditions at station BTH-003 were generally improving as evidenced by a consistent increase in species diversity (taxonomic richness) and a similarly consistent result of ‘no impact’. Results in 2011 and 2012, however, suggested a change in the habitat conditions at this site leading to results that are similar to those observed in 2006. This was demonstrated through a decrease in taxonomic richness and EPT taxa richness, and a large increase in the proportion of the dominant taxon, *Micropsectra*spp in 2011, and *G. pseudolimnaeus* in 2012 and 2013. However, since this change was consistent with pre-construction monitoring results in 2006, it was attributed to natural variation. Results in 2015show similar levels to 2014 in terms of taxa richness, EPT richness, and dominant taxa, however EPT richness was noted to increase suggesting improvement in water quality.

<u>Station BTH-004</u>

This was the seventh consecutive year of sampling conducted at this station, which began in 2009. Taxonomic richness at Station BTH-004 was 19 in 2015, a slight increase from 15, which was observed in 2014 and was the lowest taxa richness observed to date (Figure 1). The highest taxa richness to date was 43 in 2010 although results in 2009 and 2011 were similarly high. A decrease in taxa richness at BTH-004 began in 2010 and continued to 2014. The most noteworth decrease was in 2012, which was a substantial decrease compared to results from 2009 to 2011. Beginning in 2013 this decline was likely a function of the level of identification of the benthic invertebrates, which changed between 2012 and 2013 and has continued into 2015. After accounting for this factor, it can be concluded that taxonomic richness has been stable with the exception fo the year 2012.

The EPT richness was 7.5% in 2015, anincrease from 1.3% in 2014 (Figure 2). This result is similar to the high EPT richness values observed between 2009 and 2011 and is a substantial increase from the previous three years of monitoring. The EPT richness values at BTH-004 have been relatively low in relation to the other four monitoring stations with the highest proportion of EPT taxa (12.5%) occurring in 2009.

The dominant taxon at BTH-004 in 2015 was *Gammaruspseudolimnaeus*, consistent with Stations BTH-003 and BTH-005. The preference of this species for shallow, depositional areas that offer soft substrates and detritus is generally consistent with the habitat characteristics of BTH-004, which is comprised exclusively of fine substrates including silt and sand. Woody debris and detritus are also present throughout the site. This species represented 20.6% of the total sample in 2015 (Figure 3) and was the dominant taxa at this site for the fourth consecutive year, although its proportion within the sample has decreased by over 35.0% since 2013. Prior to 2012, the dominant taxa was identified as *Caecidotea intermedius*, a species of aquatic sowbug, which dominated the sample in 2010 and 2011. Both *C. intermedius* and *G. pseudolimnaeus* inhabit shallow waters where detritus is present and are likely to coexist in such habitat. In 2015 *C. intermedius* once again comprised a large proportion of the sample along with *Sialis sp.*, however the subdominant species was*Paratendipes sp.*, a genus of Dipteran belonging to the *Chironominae*sub-family.

The PMA analysis showed ‘no impact’ at station BTH-004 in 2015 (Table 6). This signifies a change following three consecutive years of ‘impact’ determinationswhich resulted in two years of threshold exceedances at this station. Prior to this the PMA analysis had shown 'no impact'. The 'no impact' result is most likely a function of the higher proportion of EPT taxa richness, which was similar to the EPT richness during previous years that showed 'no impact' determinations (2009, 2010, and 2011).

Station BTH-005

This was the seventh consecutive year of sampling conducted at this station, which began in 2009. Taxonomic richness at Station BTH-005 was 14, which was the lowest observed at the HCBP in 2015 (Figure 1). This is a slightly lower taxa richness than what was observed in 2014 (taxa richness = 18)but the same as 2013. These results continue to be considerably lower than what was generally observed at this station prior to 2013. A threshold exceedance was observed in 2013 following a decrease from 42, the highest value that has been noted at this site, to 14, the lowest that has been observed. This exceedance was determined most likely to be a function of the level of identification of certain groups of the benthic invertebrates, which was adjusted between 2012 and 2013.

In 2015 the EPT taxonomic richness experienced a substantial increase at BTH-005. The richness increased from 1.4%, the lowest that has been observed at this station, to 29.1%, the highest observed at this station. This was the second highest EPT richness value across all stations at the HCBP in 2015, second only to BTH-002 at 34.1%. The EPT richness values at BTH-005 have fluctuated since 2006 with no obvious trends observed. The highest results have been observed in 2009, 2012 and 2015 while low results were observed in 2010, 2011, and 2014.

The dominant taxon at BTH-005 was *Gammaruspseudolimnaeus*in 2015, consistent with what was observed at BTH-003 and BTH-004.*G. pseudolimnaeus* represented 29.1% of the total sample in 2015 (Figure 3). The habitat preferences of this species are consistent with the habitat characteristics of BTH-005, which is largely comprised of silt and sand along with detritus and some woody debris. This was the dominant species in 2014 at this station as well. Prior to 2014 the dominant taxa had been*Caecidotea* sp., which includes a variety of sowbug species (Asellidae spp.). In 2014 and 2015 this species continued to comprise a large proportion of the sample. In 2015 the subdominant species was a species of Trichoptera (caddisfly) belonging to the family

Hydropsychidae. Both the dominant and subdominant species observed at BTH-005 in 2015 are indicative of very good water quality (Mandaville 2002).

The PMA analysis indicated 'impact' in 2015for the second year in a row and for the second time since sampling began that this result has been seen (Table 6). Between 2009 and 2013 results had consistently shown 'no impact'. Overall the results suggest an improvement in the conditions at BTH-005, primarily due the large increase in EPT species at the station. Nevertheless, the two consecutive years of PMA 'impact' result has caused a threshold exceedance.

4.1.3 Benthic Invertebrate Threshold Analysis

The HCBP Consolidated Monitoring Program includes thresholds for various monitoring parameters. For benthic invertebrate monitoring, thresholds were developed for three benthic invertebrate metrics based on the degree of variation observed in the pre-construction monitoring data. The thresholds are as follows:

1. For the Percent Model Affinity (PMA) analysis, the threshold is an 'impact' determination at a station for 2 consecutive years following 2 consecutive years where the determination was 'no impact' at that station.
2. For Total Taxonomic Richness, the threshold is a 50% decline in the total number of taxa at a station, as compared to the results from the previous year.
3. For EPT Taxonomic Richness, the threshold is a 50% decline in the number of EPT taxa at a station, as compared to the average results from the previous 2 years.

<u>Benthic Invertebrate Threshold 1</u>

Based on the criteria for the exceedance of threshold number one, twostations experienced an exceedance in 2015 (BTH-002 and BTH-005). Station BTH-002first experienced a threshold exceedance in 2013 resulting from two consecutive years of 'impact' following two years of 'no impact'. In 2015, an 'impact' determination was made at BTH-002 for the fifth consecutive year. These results suggest an overall change in the quality of the benthic community at this station over the last several years. However, in 2015 there was an increase in EPT taxa and the subdominant family found within the sample was a species of caddisfly, which suggests that the water quality may have improved over the previous year. Further to this, the dominant species found at BTH-

002 in 2015 was *Optioservusfastiditus*, a species thatoccurs primarily in well-aerated streams and one that is generally indicative of very good water quality (Mandaville 2002). The model community used is for streams with rock/cobble substrate, and it sets a higher standard for BTH-002. This threshold is therefore of little concern in 2015.

Station BTH-005 experienced an 'impact' determination for the second year since monitoring began at this station in 2009. This was also the determination in 2014 resulting in the first exceedance of threshold number one at this station in 2015.Station BTH-005 is the uppermost station along Tributary A and exists just downstream of the outlet of SWM Pond 4. The 'impact' determination in 2015 is somewhat surprising, as the EPT richness index showed a substantial increase from 2014, which suggests an improvement. Monitoring using the PMA analysis should continue with the intention of determining whether or not a 'no impact' determination is observed again at these stations.

Benthic Invertebrate Threshold 2

Benthic invertebrate threshold numbertwo was not reached at any of the benthic monitoring stations in 2015. The taxonomic richness was generally observed to increase across the HCBP with only a small decrease of 22.2% observed at one station (BTH-005).

In 2013, threshold two was exceeded at BTH-005.This station experienced a decrease in taxonomic richness from 31 to 14, or 55%, between 2012 and 2013. That threshold was attributed to a change in the level of identification of some groups of invertebrates from 2012 to 2013. In 2013,Chironomids were identified to sub-family level, while in 2012 they were identified to species. This resulted in a difference of approximately 20 taxa and significantly affected the taxonomic richness results for each sampling station. Thus, the threshold exceedance was not a cause for concern.In 2014, the taxonomic richness at BTH-005 experienced some recovery, increasing from 14 to 18.

Benthic Invertebrate Threshold 3

Benthic invertebrate threshold number three was not reached at any of the benthic monitoring stations in 2015. The overall EPT richness values experienced increases at all stations ranging from 3.5% at BTH-003 to 31.4% at BTH-002.The EPT richness values appear to have rebounded following substantial declines in 2014 that resulted in threshold exceedances at three stations (BTH-001, BTH-003, and BTH-005) and saw declines at the remaining two stations that weren't large enough to exceed the threshold. The most substantial increase in EPT taxa was experienced at BTH-005, which saw the richness increase to the highest that has been observed to date. At BTH-002, BTH-003, and BTH-004 the EPT richness values were still below pre-construction conditions but generally saw an increase to levels higher than what has been observed between 2012 and 2014.

Prior to 2015 there appeared to be a trend of decreasing EPT richness across the five benthic monitoring stations starting in2008 and 2009 when the EPT richness values were generally at their highest. This decrease followed a trend of increasing EPT richness that was observed during pre-construction monitoring from 2006 to 2008.Possible reasons for the decreasing trend in EPT richness include the drought conditions in 2012, and the continuous discharge from SWM Pond 4 beginning in late 2011. However, EPT values were noted to increase at all stations in 2015 even though there was continued discharge from SWM Pond 4 into Tributary A.It is important to note that the change in level of identification that affected the overall taxonomic richness in 2013 did not apply to the EPT richness, because Ephemeroptera, Plecoptera and Trichoptera groups were identified to the same taxonomic resolution as the data prior to 2013.

4.2 Fish Sampling

4.2.1 Habitat Conditions

Station EMS-001 starts and ends within a riffle feature, and pools and runs are present throughout the station. Channel substrates are dominated by gravel, along with some silt, clay, sand, and cobble. Instream habitat and cover is provided by woody debris, shallow pools and riffles, undercut banks, with some cover offered by cobble, overhanging terrestrial vegetation and backwater areas. At this monitoring station the creek exhibited a low gradient, meandering channel with a wetted width ranging from 1.0 to 2.0 m. Riffles were measured no deeper than 10cm while a maximum depth of 20 cm was measured within one of the pools at this station.

Fish sampling was conducted on September 10, 2015. Water quality measurements were made at 1230hrs and are provided in Table 12.

Station EMS-002 was noted to have variable channel substrates consisting of mainly of cobble, gravel, sand, and pebble with some detritus, muck, and silt. Riffles marked the upstream and downstream extents of the station throughout which pools, cobble, backwater areas and aquatic vegetation provided instream habitat and cover. The creek at this location exhibited a meandering channel with a moderate gradient. Wetted widths ranged from 1.5 to 3.0 m. A maximum depth of 22 cm was measured within a pool at this station while average depths were approximately 10 cm. Dense mats of watercress were observed growing throughout nearly the entire length of the station, which made electrofishing and netting difficult in some areas.

Fish sampling was conducted at this location on September 9, 2015. Water quality measurements were made at 1530hrs and are provided in Table 12.

Station EMS-003 was noted to have channel substrates comprised of silt, clay, muck, and detritus with a small amount of sand. Riffles marked the upstream and downstream extents of the station throughout which instream habitat and cover were provided by woody debris, undercut banks, backwater areas, and pools. At this monitoring station the creek exhibited a low gradient through a meandering channel with a wetted width ranging from 0.5 to 1.5 m and bank-full widths from 2.0 to 3.0 m. A maximum depth of 15 cm was measured at this station.

Fish sampling was conducted at this location on September 11, 2015. Water quality measurements were made at 1045hrs and are provided in Table 12.

Station EMS-004 was noted to have a variety of channel substrates, dominated by sand, gravel, and cobble with small amounts of silt, and pebble. Detritus and muck were also present throughout the site. Riffles marked the upstream and downstream extents of the station. Woody debris provided the majority of instream habitat and cover but additional cover was present in the form of shallow riffles, small backwater areas, undercut banks, and cobble. At this monitoring station the creek exhibited a moderate gradient, meandering channel witha wetted width ranging from 3.0 to 5.0 m.

Fish sampling was conducted at this location on September 9, 2015. Water quality measurements were made at 1210hrs and are provided in Table 12.

Station EMS-005 exhibited channel substrates comprised mainly of cobble and gravel with some cobble and silt. Riffles marked the upstream and downstream extents of the station throughout which the riffles provided the majority of instream habitat and cover in the channel. Instream habitat and cover at EMS-005 was provided by a combination of small pools, riffles, undercut banks, woody debris, aquatic vegetation, and cobble. At this monitoring station the creek exhibited a moderate gradient, meandering channel with a wetted width ranging from 0.8 to 1.3 m. This station was relatively shallow measuring an average of approximately 10 cm with the deepest pool measuring a maximum depth of 25 cm.

Fish sampling was conducted at this location on September 10, 2015. Water quality measurements are provided in Table 12.

4.2.2 Fish Community Data

The water conditions during electrofishing, the settings on the electrofisher, and sampling duration are all important to document for comparing fish sampling results from year to year. This information is summarized in Table 12.

Table 12.Water Quality Measurements, Electrofishing Settings, and Shocking Times.

	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Date	September 10, 2015	September 9, 2015	September 11, 2015	September 9, 2015	September 10, 2015
Sampling Start Time	1130	1330	0930	1030	1430
Sampling End Time	1230	1530	1045	1210	1630
Air Temperature (°C)	20.0	24.0	18.0	22.5	DNC
Water Temperature (°C)	20.0	19.0	12.8	18.5	24.0
Time Water Temp. Taken	1230	1530	1045	1210	1630
Conductivity (μs/cm)	790	1120	1640	1070	800
Dissolved Oxygen (ppm, %)	7.0, 82.1	6.5, 76.0	7.5, 73.2	7.36, 84.5	3.97, 46.5
Electrofisher Type	Smith-Root LR-20B	Smith-Root LR-20B	Smith-Root LR-20B	Smith-Root LR-20B	Smith-Root LR-20B
Number of Netters	1	1	1	1	1
Voltage (V)	150	150	250	250	150
Pulsating Frequency (Hz)	70	70	70	70	70
Shocking Time (sec.) – Pass 1	581	632	435	442	768
Shocking Time (sec.) – Pass 2	449	601	469	479	754
Shocking Time (sec.) – Pass 3	503	625	419	462	594
Shocking Time (sec.) – Pass 4	N/A	N/A	438	N/A	N/A

DNC – Did not collect
N/A – Not applicable

During 2015 construction-phase aquatic monitoring a total of 481 individual fish were captured representing five different species: blacknose dace (*Rhinichthysobtusus*), brook stickleback (*Culaeainconstans*), central mudminnow (*Umbra limi*), creek chub (*Semotilusatromaculatus*), and white sucker (*Catostomuscommersonii*). The total catch in 2015was higher than but generally similar to the 454 fish that were captured during 2014 sampling. This is the second highest catch to be recorded since sampling began in 2006, with the highest occurring in 2013 with an uncharacteristically high catch of 735 fish. Prior to 2013 and 2014the total catches ranged from 92 in 2006 to 260 in 2012.It should be noted that between 2006 and 2008 only three stations were being sampled. Between 2009 and 2014 a total of five stations were sampled, requiring careful comparison of2015 results to results from 2006, 2007 and 2008.

A description of electrofishing results for each station in 2015 can be found below.

<u>Population Estimates</u>

The data collected during 2015 monitoring produced reliable statistical models for all electrofishing monitoring stations. The results for 2015 are provided in Table 18 along with the results from all past years of monitoring and have been described below. Some of the results in the past years could not be reported as estimates because a statistical model could not produce a reliable estimate. In these cases the actual catch data is provided in Table 18, denoted by a single asterisk. Population estimates that were calculated using the least squares regression method are denoted in Table 18 by a double asterisk.

<u>Station EMS-001</u>

Electrofishing in 2015 resulted in the capture of two species; blacknose dace and creek chub. A combined total of 116 individual fish were captured through a total of three passes. Brook stickleback and central mudminnow have typically been captured here every year but were absent in 2015. Fathead minnow (*Pimephalespromelas*), northern redbelly dace (*Chrosomuseos*), and white sucker have also been previously captured at this station. The detailed results are provided in Table 13.

Fish population estimates at this station have varied greatly between 2006 and 2015, and have generally been higher during construction-phase monitoring beginning in 2010 than they were during pre-construction monitoring prior to 2010. The population estimate increased slightlyfrom

102 in 2014 to 123 in 2015.This followed 2013 during which the fish population was estimated to be 184, the highest that has been observed to date at BTH-001. This was attributed to increased baseflows following a year of above-average precipitation. The lowest population estimate was observed in 2010, which was estimated at 5. This result was similar to the low population estimate observed in 2006. Detailed results are provided in Table 18.

<u>Station EMS-002</u>

Electrofishing in 2015 resulted in the capture of three fish species and a combined total of 114 individual fish in a total of three passes. The species captured were blacknose dace, brook stickleback, and creek chub. Blacknose dace and brook stickleback have been captured at this station every year while creek chub have been captured sporadically. Central mudminnow and white sucker have also been previously captured throughout the years at this station. Mottled sculpin (*Cottusbairdii*), a coldwater species was captured at this site in 2011 and pumpkinseed (*Lepomisgibbosus*), a warmwater species was captured in 2014. These species have not been captured a second time.The detailed results are provided in Table 14.

The estimated fish population at EMS-002 has exhibited no obvious trend since sampling began in 2006. The estimated numbers have experienced a great deal of variation with the lowest estimate occurring in 2009 (approximately 40) and the highest estimate of approximately 241 in 2013. In 2015 this estimate decreased but continued to remainabove most of the previous years. Detailed results are provided in Table 18.

<u>Station EMS-003</u>

Electrofishing in 2015 resulted in the capture of two fish species and a combined total of 5 fish over four passes. The species captured were blacknose dace and brook stickleback. Electrofishing results at this station indicate a low diversity of species relative to the other stations as only the two species captured in 2015 have been consistently captured here since 2007. Three species were captured in 2006, which also included creek chub. The detailed results are provided in Table 15.

Population estimates at EMS-003 have been consistently low relative to the other stations within the HCBP study area. The estimate calculated in 2015 shows a decrease from 2014 and is similar to some of the lower population estimates that were observed at this station between

2010 and 2012. Overall, the pre-construction population estimates have been generally higher than during-construction, with the exception of 2013. Detailed results are provided in Table 18.

Station EMS-004

Electrofishing took place at this site for the first time in 2009 and it has been sampled every year since. Electrofishing in 2015resulted in the capture of four fish species and a combined total of 92 individual fish in three passes. The species captured included backnose dace, brook stickleback, central mudminnow, and creek chub. These four species have been consistently captured over the previous years of monitoring. White sucker has also been previously captured at this station in 2013. The detailed results are provided in Table 16.

Fish population estimates remained relatively consistent at EMS-004 between 2009 and 2012 ranging from approximately 29 to 58. In 2013 the population estimate increased substantially to 266, the highest estimate recorded at any of the five stations since sampling began in 2006. In 2014 the numbersdecreased to more typical levels before increasing again to 114 in 2015.Detailed results are provided in Table 18.

Station EMS-005

Electrofishing took place at this site for the first time in 2009 and has been sampled every year since. Electrofishing in 2015 resulted in the capture of three fish species and a combined total of 154 individual fish over three passes.The species captured included blacknose dace, brook stickleback, central mudminnow, creek chub, and white sucker. Prior to 2013, this station typically contained between two and three species. In 2013, seven species were captured including fathead minnow and northern redbelly dace. Blacknose dace has been captured during every year of sampling at this station. Brook stickleback, central mudminnow and creek chub have also been captured regularly throughout previous years of monitoring. The detailed results are provided in Table 17.

The population estimate at station EMS-005 in 2015 was 168, a slight decrease from 2014 when the estimate was 204. This marks a decline following four consecutive years of increasing estimates that started in 2010 with a low of roughly 2. The population estimate at EMS-005 in 2015 was the highest observed across any of the five monitoring stations within the HCBP. Detailed results are provided in Table 18.

Table 13. Fish Sampling Results for EMS-001

Fish Name		Number Captured				Fork Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthysobtusus*	38	18	8	64	27	69
Creek Chub	*Semotilusatromaculatus*	38	11	3	52	26	102
COMBINED TOTAL (n/a = not applicable)		76	29	11	**116**		

Table 14. Fish Sampling Results for EMS-002

Fish Name		Number Captured				Fork Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthysobtusus*	59	21	8	88	33	81
Brook Stickleback	*Culaeainconstans*	3	0	1	4	41	50
Creek Chub	*Semotilusatromaculatus*	10	8	4	22	39	150
COMBINED TOTAL (n/a = not applicable)		72	29	13	**114**		

Table 15. Fish Sampling Results for EMS-003

Fish Name		Number Captured					Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthysobtusus*	3	0	1	0	4	45	80
Brook Stickleback	*Culaeainconstans*	1	0	0	0	1	0	49
COMBINED TOTAL (n/a = not applicable)		4	0	1	0	**5**		

Table 16. Fish Sampling Results for EMS-004

Fish Name		Number Captured				Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthysobtusus*	26	16	8	50	23	82
Brook Stickleback	*Culaeainconstans*	3	0	1	4	35	48
Central Mudminnow	*Umbra limi*	1	0	0	1	0	70
Creek Chub	*Semotilusatromaculatus*	17	14	6	37	31	109
COMBINED TOTAL		47	30	15	**92**		

Table 17. Fish Sampling Results for EMS-005

Fish Name		Number Captured				Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthysobtusus*	43	23	12	78	27	77
Brook Stickleback	*Culaeainconstans*	3	0	0	3	32	38
Central Mudminnow	*Umbra limi*	2	1	1	4	64	84
Creek Chub	*Semotilusatromaculatus*	42	19	4	65	32	90
White Sucker	*Catostomuscommersonii*	3	1	0	4	76	107
COMBINED TOTAL (n/a = not applicable)		93	44	17	**154**		

Species Biology

Five fish species were captured during the 2015 monitoring program: blacknose dace, brook stickleback, central mudminnow, creek chub, and white sucker. Descriptions of each species' habitat preferences have been provided below.

Blacknose dace are known to inhabit small to medium-sized, clear, swiftly flowing streams with gravelly substrate. These typically exhibit a moderate to steep gradient and provide a variety riffle habitat. This species is considered to be benthic and an invertivore, feeding primarily on aquatic insect larvae (Scott and Crossman 1998; Eakins 2015).

Brook stickleback are a native species to Ontario that inhabit the "clear, cold, densely vegetated waters of small streams and spring-fed ponds and may also be found along the swampy margins of beach ponds of larger lakes" (Scott and Crossman 1998). This species is considered to be benthopelagic and a planktivore/invertivore, feeding on a variety of aquatic insects and crustaceans. This species is tolerant of low dissolved oxygen, acidity and alkalinity but is generally intolerant of turbidity (Scott and Crossman 1998; Eakins 2015).

The central mudminnow is a native species common to Ontario that inhabits"heavily vegetated ponds, wetlands or pools of small creeks and quiet, shallow (0.5 m) areas of lakes with mud and organic substrates" (Eakins 2015). It is considered to be a benthic species and an invertivore, which feeds primarily on benthic invertebrates. This species is tolerant of low dissolved oxygen, low pH and high water temperatures (29°C) and is moderately tolerant of turbidity (Scott and Crossman 1998; Eakins 2015).

The creek chub is a species known to inhabit the pools of small, clear streams and rivers with preferred water temperatures around 21°C (Eakins 2015). It is considered to be benthopelagic and an invertivore/carnivore, feeding on a variety of aquatic and terrestrial invertebrates. This species is tolerant of pollution and low dissolved oxygen but is moderately intolerant of turbidity (Scott and Crossman 1998; Eakins 2015).

The white sucker is a species known to inhabit the pools and riffles of creeks and rivers, warm shallow lakes and embayments of larger lakes with preferred water temperature range from 17 to 23°C (Eakins 2015). White suckers are considered to be benthic fish and are invertivore/detritivores, feeding on a variety of benthic invertebrates. This species is tolerant of pollution and is moderately tolerant of turbidity (Scott and Crossman 1998; Eakins 2015).

The five fish species captured in 2015 are previously known from the monitoring program and exhibit a cool-water thermal regime (Eakins 2015). Warmwater species previously captured from the site include pumpkinseed at EMS-002 in 2014 and fathead minnow at EMS-001 in 2011 and at EMS-005 in 2013. One coldwater species, mottled sculpin, was also been previously captured at EMS-002 in 2011. None of these species were captured in 2015. The thermal preferences of the fish captured in 2015 are consistent with the cool to cold water temperatures known from these watercourses.

No trout species were captured during monitoring in 2015, which is consistent with sampling in the quantitative stations in previous years.

Population Estimates

Population estimates have fluctuated over the years with no obvious increasing or decreasing trends for Tributary A as a whole. In 2015 these estimates were seen to increase at two stations (EMS-001 and EMS-004) and decrease at three stations(EMS-002, EMS-003, and EMS-005). None of the declines observed in 2015 resulted in threshold exceedances (Table 18 and Figure 6).

Table 18. Fish Population Estimates by Station for the Years 2006 to 2015

Station	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EMS-001	9.07	> 87*	80	48.5	5.22	59.37	129.32	184.20**	101.57	122.78
EMS-002	55.56	173.07	>53*	40.2	76.95	100.31	73.78**	241.10	210.10	123.02
EMS-003	>31*	13.89	31	32.7	>5*	8.35	1	33.03	16.05	5.04
EMS-004				29.4**	58.33	54.47	53.46	266.39	62.84	114.08
EMS-005				82.3	2.18	10.16	42.95	167.53	203.77**	168.35

* These results are approximate because the population estimate was not statistically valid.
** Estimate obtained using the least squares regression method.

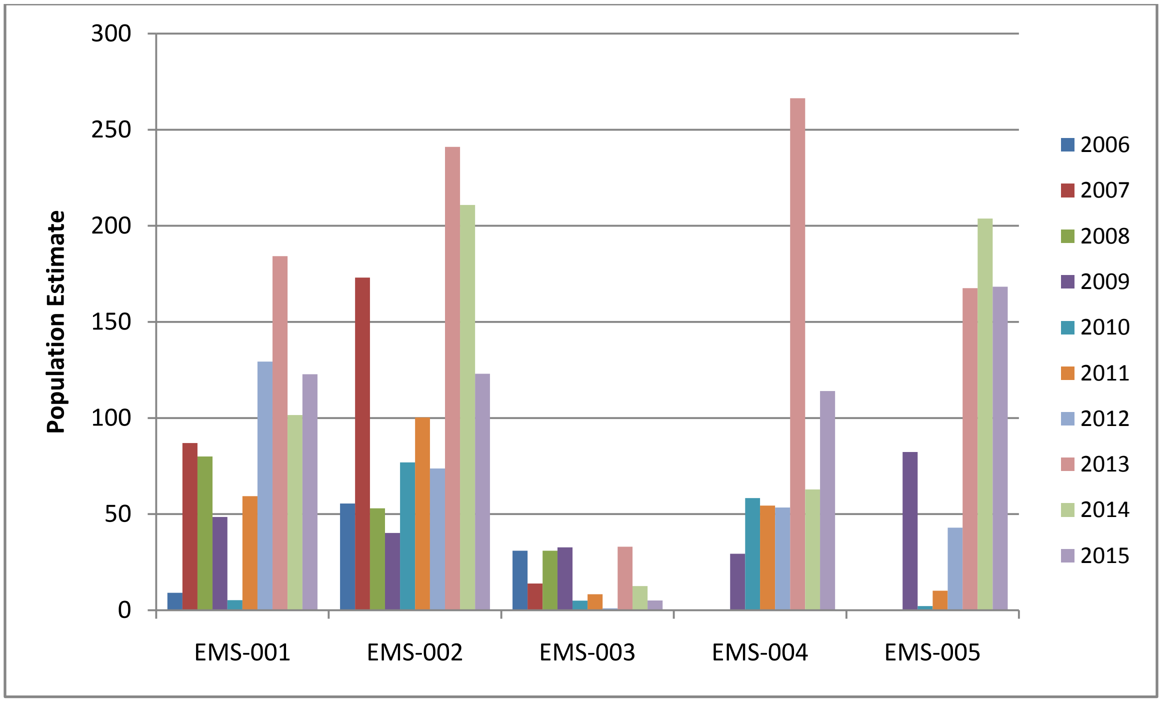

Figure 4. Population Estimates at Electrofishing Stations for the Years 2006 to 2015

Brook Trout Spawning Survey

Brook trout spawning surveys were conducted on three separate occasions during the fall of 2015. These were conducted on October 23, November 9, and November 26, 2015. No brook trout, brook trout redds, or evidence of brook trout spawning were observed during any of the surveys. The survey area shown on Figure 1 includes the sections of Tributary A and Tributary A1 from the swamp north of the newly constructed Road A – Tributary A crossing to the tile drain outlet located approximately 400m north of Laird Road.A summary of the survey conditions are provided in Table 19.

Table 19. 2015 Brook Trout Spawning Survey Summary

Date (2015)	Location	Start Time	End Time	Water Temperature (°C)	Air Temperature (°C)	Spawning /Evidence Observed
October 23	Tributary A	1000	1100	5.5 – 6.0	6.0	No
	Tributary A1	1110	1145	7.0 – 10.5	6.0	No
November 9	Tributary A	0945	1100	4.5 – 5.0	8.0	No
	Tributary A1	1110	1140	7.5 – 9.5	8.0	No
November 26	Tributary A	0930	1010	4.5 – 5.0	10.0	No
	Tributary A1	1020	1040	7.0 – 8.0	10.0	No

Spawning survey and habitat conditions were found to vary within the survey area based on differences in flow rates, water temperatures, substrate composition, and habitat availability.

In 2015 water temperatures were lowest on Tributary A ranging from 4.5 to 6.0°C. Along Tributary A1 water temperatures ranged from 7.0 to 10.5°C (refer to Table 19).At the upstream extent of the surveyed reach, along Tributary A1, the dominant substrates consisted of silt, muck, and detritus (primarily leaf litter). Woody debris was also found throughout the channel and a small amount of watercress was present along the margins of the creek in several locations. This section is believed to offer little to no suitable spawning habitat for brook trout. However, small schools (approximately 5 to 10) of cyprinids were utilizing the habitat throughout downstream section of Tributary A1, upstream from its confluence with Tributary A.

Throughout the centre of the site, near the new road crossing (Tributary A) water velocities were noted to be higher than upstream and substrates were dominated by cobble and gravel with small amounts of silt and sand. The water temperature here was generally the lowest observed throughout the entire reach and watercress was observed in very high abundance at this location. The water temperature at this location is typically similar to or slightly lower than what was seen in Tributary A1. This section of creek offered the most suitable spawning habitat for brook trout. A large pool, aquatic vegetation, and woody debris provided a relatively high amount of instream cover at the

Hanlon Creek Boulevard crossing. Schools of small cyprinids were regularly observed throughout this section of Tributary A within the woody debris and aquatic vegetation.

Near the downstream extent of the survey area (Tributary A) substrates were similar to the upstream extent, comprised of silt and detritus. Flow at this location is evident and velocity is greater than the upstream extent, but less than what was observed throughout the middle section, which also has a higher gradient. At this location there was a high density of fallen trees and woody debris throughout the channel. It appeared that there was more woody debris throughout this section than what has been observed in past years. This added woody debris created a slight backwater effect on the upstream side of some of the log jams.

Within the surveyed reaches of the creek the most suitable brook trout habitat was observed immediately upstream and downstream of the Hanlon Creek Boulevard culvert crossing of Tributary A. This area provided appropriate spawning conditions which included predominantly gravel substrates, groundwater upwelling, and oxygenation of the water as a result of the variety of shallow riffle sections (Scott and Crossman 1998). Tributary A1 offers little to no suitable spawning habitat as result of the sand and silt substrates and detritus. Although conditions throughout Tributary A appeared suitable for brook trout spawning, no brook trout or brook trout spawning activities (ie. redds, visible eggs, etc.) were observed during any of the three spawning surveys.

4.2.3 Fish Threshold Analysis

The HCBP Consolidated Monitoring Program (NRSI 2010) includes thresholds for various monitoring parameters. For fish monitoring, pre-construction and initial construction-phase fish monitoring did not result in capture of any brook trout at the quantitative monitoring stations. A specific quantitative threshold for brook trout is not appropriate unless sufficient numbers of brook trout become established such that they can be monitored in a quantitative manner.

Although a threshold is not provided for brook trout, the overall fish community is being monitored as a surrogate indicator of the suitability of the aquatic habitat for brook trout. The results will be evaluated and compared to previous year’s data from the same stations. If any anomalies are seen, these will be addressed. Two thresholds have been developed as follows:

1. A 50% change in the number of taxa represents a potential decline in the suitability of the habitat for brook trout. Because coldwater fish communities typically have a lower species diversity, an increase in species diversity may represent a negative change in relation to the brook trout management objective. Specifically, the warm-water fish community may increase in species richness as a result of warmer water temperatures, which indicates that the habitat is becoming less suitable for brook trout. A decrease in species diversity may also represent a negative change in the suitability of the habitat for brook trout, likely attributable to some cause other than water temperature.
2. A 50% reduction in the number of fish captured represents a potential decline in the fish community resulting from habitat impacts. However, it may also represent an improvement in habitat suitability for brook trout based on temperature changes, as discussed above.

<u>Fish Threshold 1</u>

For the first threshold, one station, EMS-001, exhibited a 50% reduction in the number of taxa captured in 2015. This occurred due to a decrease in the number of taxa from 4 to 2. Prior to 2015 this threshold has not been reached since 2011 when it was exceeded at station EMS-003.

The number of taxa has been variable since sampling began in 2006 and has varied between 2 and 5 species. Five species have been recorded at this station three times between 2011 and 2013, 4 species have been recorded twice (2008 and 2014) while 3 species have been recorded four times (2006, 2007, 2009, and 2010). Sampling in 2015 marked the first year that only 2 species have been captured. This result appears to be a step back toward more ‘typical’ numbers for this station. As noted, during pre-construction monitoring (prior to 2010) the number of taxa present at this station was typically 3, which would have occurred under natural conditions. As such it is not believed that this threshold exceedance is of concern at this time. The taxa at EMS-001 will be considered during future monitoring to see if the low taxa richness continues.

Fish Threshold 2

For the second threshold, one station, EMS-003, exhibited a 50% reduction in the number of fish captured. At EMS-003 this occurred due to the decrease in total catch from 10 fish in 2014 to 5 fish in 2015, a 50% decline in fish capture.

The catch totals at EMS-003 have been consistently low since monitoring began in 2006. As a result it has a greater likelihood of exhibiting threshold exceedances than the other four monitoring stations since a small fluctuation in fish presence within the delineated site could result in a 50% decline. This monitoring station is located on a small groundwater-fed tributary (Tributary A1) to Hanlon Creek Tributary A, which typically provides less habitat than Tributary A. Numbers of fish have been low in the pastparticularly between 2010 and 2012. Those years registered as threshold exceedances as well, but as noted the low numbers of fish predispose this site to an exceedance. Therefore, the results are considered typical for station EMS-003.

5.0 Conclusions and Recommendations

The 2015construction-phase monitoring program was successful in providing informative aquatic monitoring data on conditions during the sixth year of construction.

A great deal of variation has been observed between 2006 and 2015 in both benthic invertebrate and fish communities within the Hanlon Creek watershed. This has largely been attributed to natural variation caused by inconsistencies in abiotic factors (ie. temperature, precipitation etc.) and stream dynamics across years in which monitoring occurred. The 2014 monitoring results indicated that a dry winter and lower than average precipitation between March and October likely impacted benthic and fish habitat suitability at many of the stations, which resulted in both benthic and fish threshold exceedances. In 2015 precipitation levels were once again lower than average throughout the summer months and were lower than what had been observed in 2014. Average air temperatures were also higher during the summer months. Although benthic and fish threshold exceedances were observed in 2015, generally the 2015 monitoring results indicate improvements in both the benthic and fish communities.

Benthic invertebrate threshold number oneas identified in the HCBP Consolidated Monitoring Program (NRSI 2010) was reached at two stations; BTH-002 and BTH-005 in 2015. These stations both showed two consecutive years of ‘impact’ following two years of ‘no impact’. Even though an ‘impact’ determination was made at BTH-002 for the fifth consecutive year the EPT taxa increasedand the dominant taxa was a species indicative of well-aerated and good overall water quality.Station BTH-002 is the only station that uses a cobble/gravel model community for the PMA index and as such, comparisons among the other four stations using the PMA index are not valid. It should be noted that ‘impact’ determinations were made for BTH-002 during pre-construction years and results have been inconsistent between 2006 and 2014. Station BTH-005 experienced an ‘impact’ determination for only the second year since 2009. This was also the determination in 2014 resulting in the first exceedance of threshold number one at this station in 2015.Monitoring using the PMA analysis should continue with the intention of determining whether or not a ‘no impact’ determination is observed again at these stations.

Both of the fish community thresholds identified in the HCBP Consolidated Monitoring Program (NRSI 2010) were reached in 2015. Station EMS-001 exhibited a 50% reduction in the number of taxa captured in 2015 compared to 2014 with a decrease from 4 species to 2. This was noted to be a return to more ‘typical’ conditions with pre-construction monitoring (prior to 2010) typically resulting in the capture of 3 taxa, which would have occurred under natural conditions.Station EMS-003, exhibited a 50% reduction in the number of fish captured compared to the numbers observed during the previous year with a decrease in total catch from 10 fish in 2014 to 5 fish in 2015, a 50% reduction. The numbers of fish captured at this station are generally lowerat this station as it is located on a small groundwater-fed headwater tributary (Tributary A1), which typically experiences shallow water depths. The naturally low numbers of fish predispose this site to threshold exceedances. Tributary A1 does not experience the augmented flows resulting from SWM Pond 4. Baseflows within the tributary are directly influenced by the groundwater system, which experienced slightly lower levels in 2015, a result of lower than average precipitation.

We recommend the following regarding future monitoring:

1. Aquatic biological monitoring should continue during the construction and build-out of the HCBP until 75% of the development is built (by area) in Phases 1, 2 and 3 of the HCBP, plus an additional 2 years. The aquatic biological monitoring will continue to be one component of the complete monitoring program, which is outlined in the HCBP Consolidated Monitoring Program.

2. Fish and benthic invertebrate monitoring should continue to occur at the 5 sites sampled in 2015.

3. A brook trout spawning survey should be conducted each year in autumn throughout the months of October and November. Even if brook trout are not captured during fish sampling at the 5 biomass stations, the spawning survey will provide an additional opportunity to observe the presence/absence of brook trout on the subject property during a different part of the brook trout life cycle.

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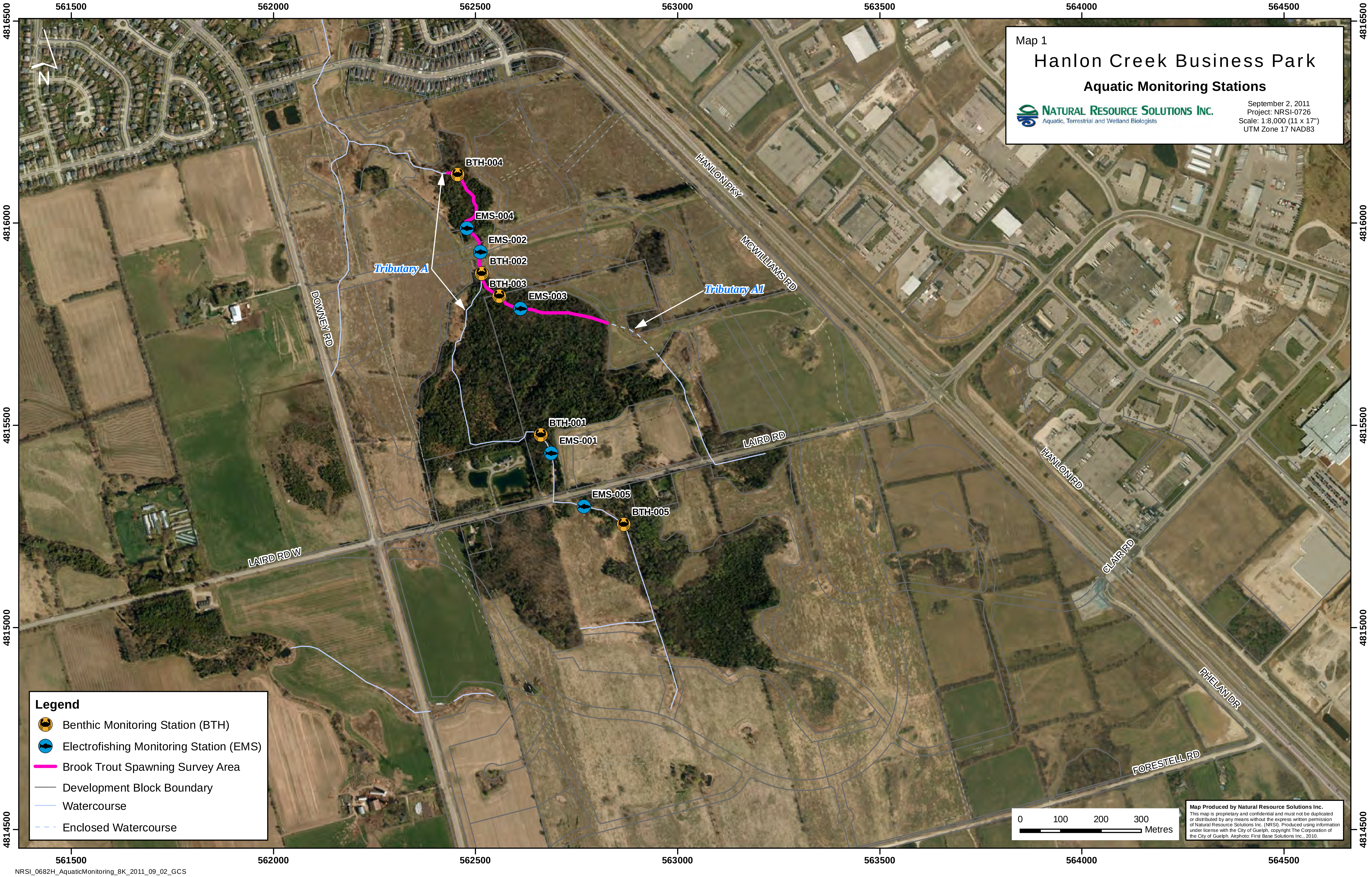
MAPS


Map 1
Hanlon Creek Business Park
Aquatic Monitoring Stations
Natural Resource Solutions Inc.
Aquatic, Terrestrial and Wetland Biologists
September 2, 2011
Project: NRSI-0726
Scale: 1:8,000 (11 x 17")
UTM Zone 17 NAD83
561500
562000
562500
563000
563500
564000
564500
4816500
4816000
4815500
4815000
4814500
N
BTH-004
EMS-004
EMS-002
BTH-002
BTH-003
EMS-003
BTH-001
EMS-001
EMS-005
BTH-005
Tributary A
Tributary A1
HANLON PKY
MCWILLIAMS RD
DOWNEY RD
LAIRD RD
LAIRD RD W
HANLON RD
CLAIR RD
PHELAN DR
FORESTELL RD
Legend
Benthic Monitoring Station (BTH)
Electrofishing Monitoring Station (EMS)
Brook Trout Spawning Survey Area
Development Block Boundary
Watercourse
Enclosed Watercourse
0 100 200 300
Metres
Map Produced by Natural Resource Solutions Inc.
This map is proprietary and confidential and must not be duplicated or distributed by any means without the express written permission of Natural Resource Solutions Inc. (NRSI). Produced using information under license with the City of Guelph, copyright The Corporation of the City of Guelph. Airphoto: First Base Solutions Inc., 2010.
NRSI_0682H_AquaticMonitoring_8K_2011_09_02_GCS

561500 562000 562500 563000 563500 564000 564500 565000

4816000 4815500 4815000 4814500

561500 562000 562500 563000 563500 564000 564500 565000

Path: X:\0682_HanlonTerrestrialandAquaticMonitoring\NRSI_1033_Map2_2015ConstructionAreas_9K_2016_07_05_JAS.mxd

APPENDIX I

Benthic Invertebrate Raw Data

Appendix I - Hanlon Creek Business Park 2015
RAW Benthic Invertebrate Data

GROUP	FAMILY	TAXON	BTH001	BTH001	BTH001	BTH001	Proportion	BTH002	BTH002	BTH002	BTH002	Proportion	BTH003	BTH003	BTH003	BTH003	Proportion	BTH004	BTH004	BTH004	BTH004	Proportion	BTH005	BTH005	BTH005	BTH005	Proportion
			riffle 1	pool	riffle 2			riffle 1	pool	riffle 2			riffle 1	pool	riffle 2			riffle 1	pool	riffle 2			riffle 1	pool	riffle 2		
			8-Sep	8-Sep	8-Sep	Pooled		26-Aug	26-Aug	26-Aug	Pooled		9-Sep	9-Sep	9-Sep	Pooled		8-Sep	8-Sep	8-Sep	Pooled		8-Sep	8-Sep	8-Sep	Pooled	
						0	0				0	0				0	0				0	0				0	0
AMPHIPODA	Gammaridae	Gammarus pseudolimnaeus	8	9	5	22	8.661417323	25	19	4	48	9.375	30	44	44	118	37.82051282	33	17	19	69	20.59701493	29	32	28	89	29.08496732
						0	0				0	0				0	0				0	0				0	0
ISOPODA	Asellidae	Caecidotea intermedius	10	6	5	21	8.267716535	9	4		13	2.5390625		5	4	9	2.884615385	4	4	14	22	6.567164179	4	22	15	41	13.39869281
						0	0				0	0				0	0				0	0				0	0
						0	0				0	0				0	0				0	0				0	0
COLEOPTERA	Elmidae	Dubiraphia quadrinotata	12		6	18	7.086614173	7	3		10	1.953125				0	0				0	0				0	0
		Optioservus fastiditus	10	11		21	8.267716535	12	15	46	73	14.2578125				0	0	1	2	6	9	2.686567164				0	0
		Stenelmis crenata	6			6	2.362204724		6	12	18	3.515625				0	0				0	0				0	0
						0	0				0	0				0	0				0	0				0	0
DIPTERA	Ceratopogonidae	Ceratopogonidae type I	1	1		2	0.787401575				0	0				0	0				0	0				0	0
	Chironomidae					0	0				0	0				0	0				0	0				0	0
	Chironominae	Chironomus	3	4	12	19	7.480314961	18	15		33	6.4453125	3	10	14	27	8.653846154	7	9	4	20	5.970149254			2	2	0.653594771
		Microtendipes		2	5	7	2.755905512	17	10		27	5.2734375	15	12	12	39	12.5	5	7		12	3.582089552			6	6	1.960784314
		Paratendipes			7	7	2.755905512	6	7		13	2.5390625	14	8	9	31	9.935897436	13	19	10	42	12.53731343			7	7	2.287581699
		Polypedilum				0	0		6		6	1.171875		9	3	12	3.846153846				0	0		5	12	17	5.555555556
	Prodiamesinae	Prodiamesa sp	4	9	4	17	6.692913386	12	4		16	3.125	15		4	19	6.08974359	6			6	1.791044776				0	0
	Orthocladiinae	Thienemanniella				0	0	15	12		27	5.2734375				0	0	7	15	7	29	8.656716418			1	1	0.326797386
	Tanypodinae	Apsectrotanypus	1	3		4	1.57480315	7	5		12	2.34375	4	7	4	15	4.807692308	9	10	12	31	9.253731343				0	0
		Macropelopia				0	0	3			3	0.5859375			4	4	1.282051282		2	4	6	1.791044776				0	0
	Empididae	Hemerodromia sp	8	1	2	11	4.330708661			1	1	0.1953125				0	0				0	0				0	0
	Simulidae	Simulium sp juv				0	0			1	1	0.1953125				0	0				0	0				0	0
	Tabanidae	Chrysops sp	8	3	8	19	7.480314961		3	3	6	1.171875		4		4	1.282051282	7	7	8	22	6.567164179				0	0
	Stratiomyidae	Odontomyia				0	0				0	0				0	0				0	0				0	0
	Tipulidae	Tipula	2	5		7	2.755905512				0	0				0	0				0	0	6		1	7	2.287581699
		Dicranota	3			3	1.181102362				0	0				0	0				0	0				0	0
						0	0				0	0				0	0				0	0				0	0
MEGALOPTERA	Sialidae	Sialis sp	1	10	19	30	11.81102362	13	28	1	42	8.203125		13	8	21	6.730769231	3	15	10	28	8.358208955	1	11	7	19	6.209150327
						0	0				0	0				0	0				0	0				0	0
ODONATA	Aeshnidae	Boyeria	2		3	5	1.968503937	2			2	0.390625				0	0	1			1	0.298507463				0	0
	Aeshnidae	Aeshna	3			3	1.181102362				0	0				0	0				0	0				0	0
	Calopterygidae	Calopteryx	3	8		11	4.330708661				0	0				0	0				0	0				0	0
						0	0				0	0				0	0				0	0				0	0
PLECOPTERA	Leuctridae	Leuctra sp				0	0	1			1	0.1953125		3		3	0.961538462				0	0				0	0
						0	0				0	0				0	0				0	0				0	0
TRICHOPTERA	Glossosomatidae	Glossosoma				0	0				0	0				0	0			6	6	1.791044776				0	0
	Hydropsychidae	Cheumatopsyche	8			8	3.149606299	53	7	11	71	13.8671875				0	0	4			4	1.194029851	20	19	8	47	15.35947712
		Hydropsyche	7			7	2.755905512	8	6	19	33	6.4453125				0	0			5	5	1.492537313	35	8	12	55	17.97385621
		Diplectrona						1	1	6	8	1.5625				0	0										
	Lepidostomatidae	Lepidostoma sp				0	0	1			1	0.1953125				0	0				0	0				0	0
	Limnephilidae	Frenesia sp		1		1	0.393700787				0	0			1	1	0.320512821		1		1	0.298507463				0	0
	Philopotamidae	Chimarra sp	1			1	0.393700787	14		23	37	7.2265625				0	0				0	0				0	0
	Phryganeidae	Phryganea				0	0			5	5	0.9765625	2	4	1	7	2.243589744				0	0		6		6	1.960784314
	Polycentropodidae	Polycentropus				0	0			1	1	0.1953125				0	0	3	6		9	2.686567164					
	Rhyacophilidae	Rhyacophila				0	0			4	4	0.78125				0	0										
						0	0				0	0				0	0										
GASTROPODA	Physidae	Physella gyrina		1		1	0.393700787				0	0				0	0				0	0	1			1	0.326797386
						0	0				0	0				0	0				0	0				0	0
BIVALVIA	Sphaeriidae	Pisidium sp	1	1		2	0.787401575				0	0		2		2	0.641025641	2	5	6	13	3.880597015	1	5	2	8	2.614379085
						0	0				0	0				0	0				0	0				0	0
PLATYHELMINTHES	Tricladida	Planariidae			1	1	0.393700787				0	0				0	0				0	0				0	0
		TOTALS	102	75	77	254	100	224	151	137	512	100	83	121	108	312	100	105	119	111	335	100	97	108	101	306	100
		Number of Taxa	21	16	12	26		19	17	14	27		7	12	12	15		15	14	13	19		8	8	12	14	
		Percentage picked	100.00%	100.00%	100.00%			18.18%	11.76%	5.00%			100.00%	100.00%	33.33%			28.57%	26.19%	33.33%			10.71%	25.71%	12.50%			

APPENDIX II
Fish Population and Biomass Estimate Data

Fish Population Estimates Using Maximum Likelihood Constant P – 2006

Results	EMS-001	EMS-002	EMS-003
Estimated Population	9.07	55.56	34.81
Chi-squared	0.52	1.44	2.57
Standard error	0.3	3.05	3.82
Degrees of freedom	1	1	1
Number observed	9	52	31
Lower 95% conf. interval	9.00	52.00	31.00
Upper 95% conf. interval	9.66	61.53	42.30
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4724 (accept)	0.2305 (accept)	0.1089 (reject)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2006

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	5.03	66.10	67.21
Chi-squared	0.23	0.03	14.37
Standard error	0.19	1.30	2.05
Degrees of freedom	1	1	1
Number observed	5	65	65
Lower 95% conf. interval	5.00	65.00	65.00
Upper 95% conf. interval	5.40	68.65	71.22
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.6319 (accept)	0.8638 (accept)	0.0002 (reject)

Fish Population Estimates Using Maximum Likelihood Constant P – 2007

Results	EMS-001	EMS-002	EMS-003
Estimated Population	88.76	173.07	13.89
Chi-squared	3.42	0.44	0.23
Standard error	1.68	3.84	1.53
Degrees of freedom	1	1	1
Number observed	87	166	13
Lower 95% conf. interval	87.00	166.00	13.00
Upper 95% conf. interval	92.05	180.59	16.88
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0646 (reject)	0.5073 (accept)	0.6315 (accept)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2007

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	52.51	158.46	18.45
Chi-squared	3.97	1.06	0.02
Standard error	1.65	5.28	0.88
Degrees of freedom	1	1	1
Number observed	51	148	18
Lower 95% conf. interval	51.00	148.11	18.00
Upper 95% conf. interval	55.75	168.81	20.17
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0463 (reject)	0.3040 (accept)	0.8853 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2008

Results	**EMS-001**	**EMS-002**	**EMS-003**
Estimated Population	80.02	91.84	30.93
Chi-squared	1.08	3.39	0.58
Standard error	4.17	35.62	5.22
Degrees of freedom	1	1	1
Number observed	74	53	26
Lower 95% conf. interval	74.00	53.00	26.00
Upper 95% conf. interval	88.20	161.65	41.15
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.2922 (accept)	0.0655 (reject)	0.4444 (accept)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2008

Results	**EMS-001**	**EMS-002**	**EMS-003**
Estimated Biomass (g)	55.82	105.00	36.08
Chi-squared	1.13	9.30	5.39
Standard error	4.63	1.17	9.68
Degrees of freedom	1	1	1
Number observed	50	104	27
Lower 95% conf. interval	50.00	104.00	27.00
Upper 95% conf. interval	64.89	107.29	55.05
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.2870 (accept)	0.0023 (reject)	0.0202 (reject)

Fish Population Estimates Using Maximum Likelihood Variable P – 2009

Results	EMS-001	EMS-002	EMS-003	EMS-005
Estimated Population	48.51	40.19	32.73	82.31
Chi-squared	0.56	0.35	0.24	0.17
Standard error	0.90	7.84	5.71	23.13
Degrees of freedom	1	1	1	2
Number observed	48	33	28	61
Lower 95% conf. interval	48.00	33.00	28.00	61.00
Upper 95% conf. interval	50.28	55.56	43.93	127.64
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4550 (accept)	0.5516 (accept)	0.6234 (accept)	0.9179 (accept)

** Constant P method used for Population Estimate due to only 3 passes.

Fish Population Estimates Using Least Squares Regression – 2009

Results	EMS-004
Estimated Population	29.42
Slope	- 0.596
Y – Intercept	17.55
r^2 (Coefficient of Determination)	0.969
Residual Sum of Squares	3.916
Regression Sum of Squares	124.084
Degrees of Freedom	1
F	31.687

Fish Population Estimates Using Maximum Likelihood Constant P – 2010

Results	EMS-001	EMS-002	EMS-003	EMS-005
Estimated Population	5.22	76.95	-	2.18
Chi-squared	1.03	0.44	-	0.68
Standard error	0.67	1.17	-	0.74
Degrees of freedom	1	1	-	1
Number observed	5	76	-	2
Lower 95% conf. interval	5.00	76.00	-	2.00
Upper 95% conf. interval	6.54	79.24	-	3.63
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.3111 (accept)	0.5073 (accept)	-	0.4096 (accept)

Fish Population Estimates Using Maximum Likelihood Variable P – 2010

Results	EMS-004
Estimated Population	58.33
Chi-squared	0.47
Standard error	6.45
Degrees of freedom	1
Number observed	52
Lower 95% conf. interval	52.00
Upper 95% conf. interval	70.97
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4929 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2011

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	59.37	100.31	8.35	54.47	10.16
Chi-squared	0.29	0.55	0.14	0.05	0.14
Standard error	7.99	7.22	9.69	5.16	2.15
Degrees of freedom	1	1	1	1	1
Number observed	49	88	5	48	9
Lower 95% conf. interval	49	88	5	48	9
Upper 95% conf. interval	75.03	114.46	27.33	64.58	14.37
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.59 (accept)	0.4565 (accept)	0.7095 (accept)	0.8316 (accept)	0.7105 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2012

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	129.32	70.08	1.00	53.46	42.95
Chi-squared	0.09	3.54	0.00	4.11	0.37
Standard error	5.57	11.05	0.00	5.78	3.55
Degrees of freedom	1	1	1	3	2
Number observed	119	55	1	46	39
Lower 95% conf. interval	119.00	55.00	1.00	46.00	39.00
Upper 95% conf. interval	140.24	91.74	1.00	64.80	49.90
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.7649 (accept)	0.0597 (**reject**)	0.9748 (accept)	0.2496 (accept)	0.8294 (accept)

Fish Population Estimates Using Least Squares Regression – 2012

Results	EMS-002
Estimated Population	73.78
Intercept (a)	27.35
Probable uncertainty of Intercept (a)	5.54
Gradient (b)	-0.37
Probable uncertainty of Gradient (b)	0.18
Chi-squared	36.24
Number observed	55.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2013

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	190.10	241.10	33.03	266.39	159.89
Chi-squared	3.48	0.34	0.29	1.07	0.46
Standard error	5.62	18.73	5.14	27.56	9.46
Degrees of freedom	1	1	1	1	2
Number observed	178	193	28	197	139
Lower 95% conf. interval	179.09	204.40	28.00	212.37	141.34
Upper 95% conf. interval	201.11	277.81	43.11	320.40	178.44
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0619 (**reject**)	0.5593 (accept)	0.5903 (accept)	0.3001 (accept)	0.7933 (accept)

Fish Population Estimates Using Least Squares Regression – 2013

Results	EMS-001
Estimated Population	184.20
Intercept (a)	117.69
Probable uncertainty of Intercept (a)	7.13
Gradient (b)	-0.64
Probable uncertainty of Gradient (b)	0.06
Chi-squared	52.59
Number observed	178.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2014

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	101.57	210.10	16.05	62.84	198.34
Chi-squared	0.01	1.73	0.72	1.35	3.64
Standard error	4.16	6.72	11.68	8.95	67.17
Degrees of freedom	1	2	2	1	1
Number observed	95	194	10	51	104
Lower 95% conf. interval	95.00	196.93	10.00	51.00	104.00
Upper 95% conf. interval	109.72	223.27	38.93	80.38	329.99
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.9142 (accept)	0.4221 (accept)	0.6993 (accept)	0.2450 (accept)	0.0564 **(reject)**

Fish Population Estimates Using Least Squares Regression – 2014

Results	EMS-005
Estimated Population	203.77
Intercept (a)	43.22
Probable uncertainty of Intercept (a)	8.91
Gradient (b)	-0.21
Probable uncertainty of Gradient (b)	0.17
Chi-squared	97.29
Number observed	104.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2015

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	122.78	123.02	5.04	114.08	168.35
Chi-squared	0.00	0.05	2.66	0.27	0.26
Standard error	4.04	5.07	0.23	12.43	6.73
Degrees of freedom	1	1	2	1	1
Number observed	116	114	5	92	154
Lower 95% conf. interval	116.00	114.00	5.00	92.00	155.17
Upper 95% conf. interval	130.70	132.95	5.50	138.45	181.53
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.9903 (accept)	0.8229 (accept)	0.2650 (accept)	0.6034 (accept)	0.6129 (accept)

Hanlon Creek Business Park
2015 During-Construction

Terrestrial and Wetland Monitoring

Prepared for:

Peter Cartwright
Economic Development & Tourism Services
City of Guelph
1 Carden Street, City Hall
Guelph, ON

Project No. 1033F | October 2016

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Hanlon Creek Business Park
2015 During-Construction

Terrestrial and Wetland Monitoring

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1.0 Introduction

Terrestrial and wetland monitoring in the Hanlon Creek Business Park (HCBP) has been ongoing annually since 2006. The objective of the terrestrial and wetland monitoring is to identify and track any changes that may occur to the terrestrial and wetland ecology resulting from the planned industrial development of the HCBP. The terrestrial and wetland monitoring program focuses on assessing features within the entire subject property; however, it is noted that development of the Business Park is occurring in phases (Phases 1 (Stage 1 & 2), 2, and 3) (Map 1). Baseline (pre-construction) monitoring was conducted from 2006 to 2009. During construction monitoring commenced in 2010, making 2015 the sixth during construction monitoring year. The monitoring program also includes components related to the Mast-Snyder Gravel Pit, located west of the HCBP. These components of the monitoring are tied to the timing of the pit's operation and restoration.

Over time, the terrestrial and wetland monitoring program has expanded to address concerns and recommendations made by reviewing groups and agencies. The following taxonomic groups were monitored in 2015 and are documented in this report:

- Vascular flora
- Breeding birds
- Calling anurans (frogs and toads)

This report provides a summary of findings from the 2015 monitoring year, as well as a comparison of the data to previous baseline and during construction years. Recommendations related to the terrestrial and wetland monitoring program are summarized.

1.1 Construction Activity

Construction commenced in late 2009 and has continued each year through to 2015. Construction activity in 2015 within Phases 1 and 2 is outlined below and highlighted on Map 2.

Phase 1, Stage 2

- Operation of commercial building – 500 Hanlon Creek Boulevard (Fusion Homes)
- Construction of commercial building – 501 Hanlon Creek Boulevard (Compass)

Phase 1, Stage 3

- Operation of commercial buildings – 197-345 Hanlon Creek Boulevard (Wurth Canada, Graniteworx, etc.)
- Construction of commercial building – 28 Bett Court (MF Property Management Inc.)

Phase 2

- Construction of commercial building – 104 Cooper Drive (Ontario One Call)
- Preliminary grading of Blocks 8, 9 and 26 completed in 2014
- Laird Road overpass has been in-use since 2014

No construction activity occurred within Phase 3 in 2015.

2.0 Methodology

Since 2006, the terrestrial and wetland monitoring program has focused on plot-based surveys to document breeding anuran, breeding birds and vascular flora (herbaceous, shrubs and trees) as well as incidental wildlife throughout the property. Baseline soils information was collected from each of the monitoring plots in 2006.

For plot set-up and annual monitoring survey methodologies, the reader is referred to Section 3.0 in the HCBP Terrestrial and Wetland Monitoring Reports submitted to the City for the 2011-2014 monitoring years (NRSI 2011 – 2014).

Table 1 provides a summary of the plots that have been monitored in each year and the monitoring focus. Map 3 identifies the vegetation communities throughout the Business Park and monitoring locations.

2.1 Incidental Observations

Incidental observations of all wildlife (i.e. birds, mammals, butterflies, dragonflies, reptiles, etc.) were documented during all field visits conducted in 2015. This included observations of individuals, as well as signs of animal presence, such as tracks, scat, trails, dens, etc.

Table 1. Summary of Plot Monitoring

Plot	2006				2007-2008				2009-2010				2011-2015			
	A	V	S	B	A	V	S	B	A	V	S	B	A	V	S	B
1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3		■	■	■		■	■	■		■	■	■		■	■	■
4	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5		■	■	■		■	■	■		■	■	■		■	■	■
6	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
8	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9					■	■	■	■	■	■	■	■	■	■	■	■
10									■		■		■		■	
11									■		■	■	■		■	■
12									■		■		■		■	
13									■		■		■		■	
14									■		■		■		■	
15									■		■		■		■	
16									■		■		■	■	■	■
17									■		■		■		■	
18													■	■	■	
19																■
20																■

Calling anuran monitoring
Vegetation monitoring
Soil monitoring
Breeding bird monitoring

3.0 Monitoring Results

3.1 Vascular Flora Surveys

The Ecological Land Classification (ELC) vegetation community codes and descriptions for each monitoring plot are shown on Map 3.

Refer to Appendix I for a comprehensive list of vascular flora species observed within the monitoring plots between 2006 and 2015. Table 2 lists the number of species that were observed each year. Overall, 258 different species have been observed in the vegetation monitoring plots over the course of the monitoring program. In 2015, vegetation surveys documented 12 species not previously recorded;

- Spikenard (*Aralia racemosa ssp. racemosa*) – VEG-002
- Long-stalked Sedge (*Carex pedunculata*) – VEG-002
- Radiate Sedge (*Carex radiata*) – VEG-004
- Hay-scented Fern (*Dennstaedtia punctilobula*) – VEG-004
- Balsam Poplar (*Populus balsamifera*) – VEG-005
- Meadow Fescue (*Festuca pratensis*) – VEG-006
- Dudley's Rush (*Juncus dudleyi*) – VEG-006
- Bristle-leaved Sedge (*Carex eburnea*) – VEG-007
- Evergreen Wood Fern (*Dryopteris intermedia*) – VEG-007
- Basswood (*Tilia americana*) – VEG-007
- Ninebark (*Physocarpus opulifolius*) – VEG-008
- Philadelphia Fleabane (*Erigeron philadelphicus*) – VEG-018

Specimens cannot always be identified to species level due to a lack of diagnostic features (i.e. sedge or grass species lacking an inflorescence due to the time of year) and as such some plants were only identified to genus.

Table 2. Number of Vegetation Species Observed by Year

Year	Number of Species
2006	96
2007	109
2008	108
2009	117
2010	123
2011	138
2012	147
2013	146
2014	135
2015	141

3.1.1 Significant Vascular Flora Species

Several regionally rare species within Wellington County (Dougan 2009) have been observed, which are listed in Table 3. In 2015, Meadow Horsetail (*Equisetum pratense*), Rough-leaved Goldenrod (*Solidago patula*), Clearweed (*Pilea pumila*), American Mountain-ash (*Sorbus americana*) and Hay-scented Fern were observed and are considered rare within Wellington County. 2015 was the first year Hay-scented Fern has been observed within any plot. Previously documented regionally rare species are also listed in Table 3. No federally or provincially significant species of vascular flora were observed during 2015 monitoring.

3.1.2 Floristic Indices

A common method for evaluating and assessing natural areas is using floristic composition. This method is based on the character of a region's flora. Plant species display varying degrees of fidelity to specific habitats, which is expressed by species conservatism. Species conservatism is the degree of faithfulness a plant displays to a set of environmental conditions. The quality of a natural area is reflected in the number of conservative species found within a certain habitat (Wilhem and Ladd 1988 *In* Oldham et al. 1995). There are several floristic indices which can be used to describe the character of the vegetation in the plot. These include the Coefficient of Wetness (CW), the Coefficient of Conservatism (CC), and the Natural Area Index (NAI). All species (herbs, shrubs, and trees) from each plot are considered in these equations.

Coefficient of Wetness

The CW is based on wetland values given to each individual plant species. Values range from -5 to +5, where -5 indicates an obligate wetland species, and +5 indicates an obligate upland species. “0” is assigned to facultative species, those that are just as likely to be found in wetland or upland habitats. The CW values used are based on Oldham et al. (1995). Figure 1 shows the average wetness per plot, based on the wetness coefficients of all species found within a plot. All of the monitoring plots, with the exception of 2 are located within wetland areas. Plot 1 has consistently been the wettest plot in previous monitoring years; however in 2015 Plot 4 was the wettest plot in with an average CW value of -3.10; Plot 1 had an average CW value of -3.00 in 2015.

Table 3. Regionally Significant Vascular Flora Species Recorded

Common Name	Scientific Name	SRANK[1]	Wellington[2]	Year of Observation										Plot
				2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Bristly Buttercup	*Ranunculus hispidus var. hispidus*	S3				x								
Clearweed	*Pilea pumila*	S5	R			x					x		x	4,16
Clinton's Wood Fern	*Dryopteris clintoniana*	S4	R		x			x	x					
Hay-scented Fern	*Dennstaedtia punctilobula*	S5	R										x	4
Marsh Horsetail	*Equisetum palustre*	S5	R	x	x				x					
Meadow Horsetail	*Equisetum pratense*	S5	R	x		x	x	x	x	x		x	x	18
Mountain Ash	*Sorbus americana*	S5	R					x					x	7
Pale Jewelweed	*Impatiens pallida*	S5	R		x	x			x					
Rough Avens	*Geum laciniatum*	S4	R		x				x	x				
Rough-leaved Goldenrod	*Solidago patula*	S5	R		x	x			x	x		x	x	4,7
Smooth Gooseberry	*Ribes hirtellum*	S5	R				x							
Witch Hazel	*Hamamelis virginiana*	S5	R			x		x						
Yellow Water-crowfoot	*Ranunculus flabellaris*	S4?	R			x			x					

[1]MNRF 2015a; [2]Dougan & Associates 2009

LEGEND	
SRANK	**Wellington Status**
S3 Vulnerable	R Rare
S4 Apparently Secure	
S5 Secure	
#? Uncertainty about rank	

Plot 1 and Plot 4 have remained relatively stable since 2008. Both plots are dominated by wet areas with the exception of hummocks, some of which include upland plant species. Plot 4 is comprised of saturated organic soils and Plot 1 typically exhibits shallow pooled water above mineral substrates at the time of vegetation monitoring. Plot 8, which is situated almost entirely within Tributary A (to the north of Hanlon Creek Boulevard) had an average CW value of -2.09 in 2015 which is the wettest value recorded in this plot to date. This value is based largely on riparian (bank) vegetation as the central portion of the plot is largely comprised of un-vegetated watercourse. Overall, 8 of 11 vegetation monitoring plots exhibited a drier CW value in 2015 over 2014 value. In many cases these plots have shown a slight drying trend over the past several monitoring years.

Plot 3 (Sugar Maple forest) continues to exhibit the driest average CW value (1.00). Plot 5, which was the second plot with a positive CW value in 2015 (0.22) is situated within a Fresh-Moist Forest community which nears wetland conditions. As discussed in previous monitoring reports, the low diversity of species in this plot (9 in 2015) makes for a high degree of fluctuation in data from one year to the next as the inclusion or omission of a single species can influence results substantially. As the average CW does not account for abundance and only provides an analysis of the overall species list, outlier species can inflate average CW values for low diversity plots.

In 2014, Plot 7 had exhibited a positive CW value (0.16) which is not indicative of White Cedar-Hardwood Swamp conditions. It is noted that the plot contains hummocks with upland plant species as well as a portion of watercourse. In 2015 this plot had a slightly wetter CW value (-0.10). This plot showed the wettest CW value in 2011 at -1.00 and has generally been between 0.00 and -1.00 in most monitoring years.

At Plot 16 and Plot 18, CW values have shown a steady drying trend between 2011 and 2015, with the most pronounced decrease in CW values occurring between 2011 and 2013. These plots are located in close proximity to recent commercial building development and the Hanlon Creek Boulevard. Plot 16 has consistently contained limited herbaceous vegetation, and is located in a wetland that is physically separate from the core PSW but considered part of the Hanlon Swamp Wetland Complex. The groundwater monitoring well MW103 is located adjacent to this wetland and a continuous data logger has recorded groundwater elevations since April 2010. Groundwater elevation data shows clear dry periods, most notably in 2012 but also in 2011. Groundwater studies (Banks Groundwater Engineering Limited 2016) concluded that overall, groundwater levels were higher in 2015 than in recent years across the site:

> "*Groundwater elevations across the HCBP were affected by the lack of precipitation in 2012. However, precipitation, combined with the spring melt in 2013, 2014 and 2015, have caused groundwater levels to rise across the HCBP. Throughout 2015, groundwater elevations at almost all monitoring stations remained within the respective ranges observed in previous years, and as a result, there were no thresholds observed during this monitoring period.*"

Plots 16 and 18 were added in 2011 to monitor any changes within the wetland community due to the potential dewatering required as part of the City of Guelph SW Quadrant Class EA. Plot 18 has contained a diversity of species with good coverage of the 10x10m plot. It too is located in a small wetland that is physically separate from the core PSW but considered part of the Hanlon Swamp Wetland Complex. Monitoring Well MW118A is located approximately 80m south of this wetland. The continuous data logger indicates 2015 to have been a year of average groundwater elevation over the course of monitoring at this location. Again, notably low levels were documented in 2011 and 2012; however since 2013 levels have rebounded and remained relatively steady.

The groundwater monitoring data (Banks Groundwater Engineering Limited 2016) observed in the vicinity of Plot 16 and Plot 18 would indicate that climatic factors (reduced snow accumulation and fluctuations in accumulated spring rainfall) are the likely cause of changes in vegetation being observed at these plots.

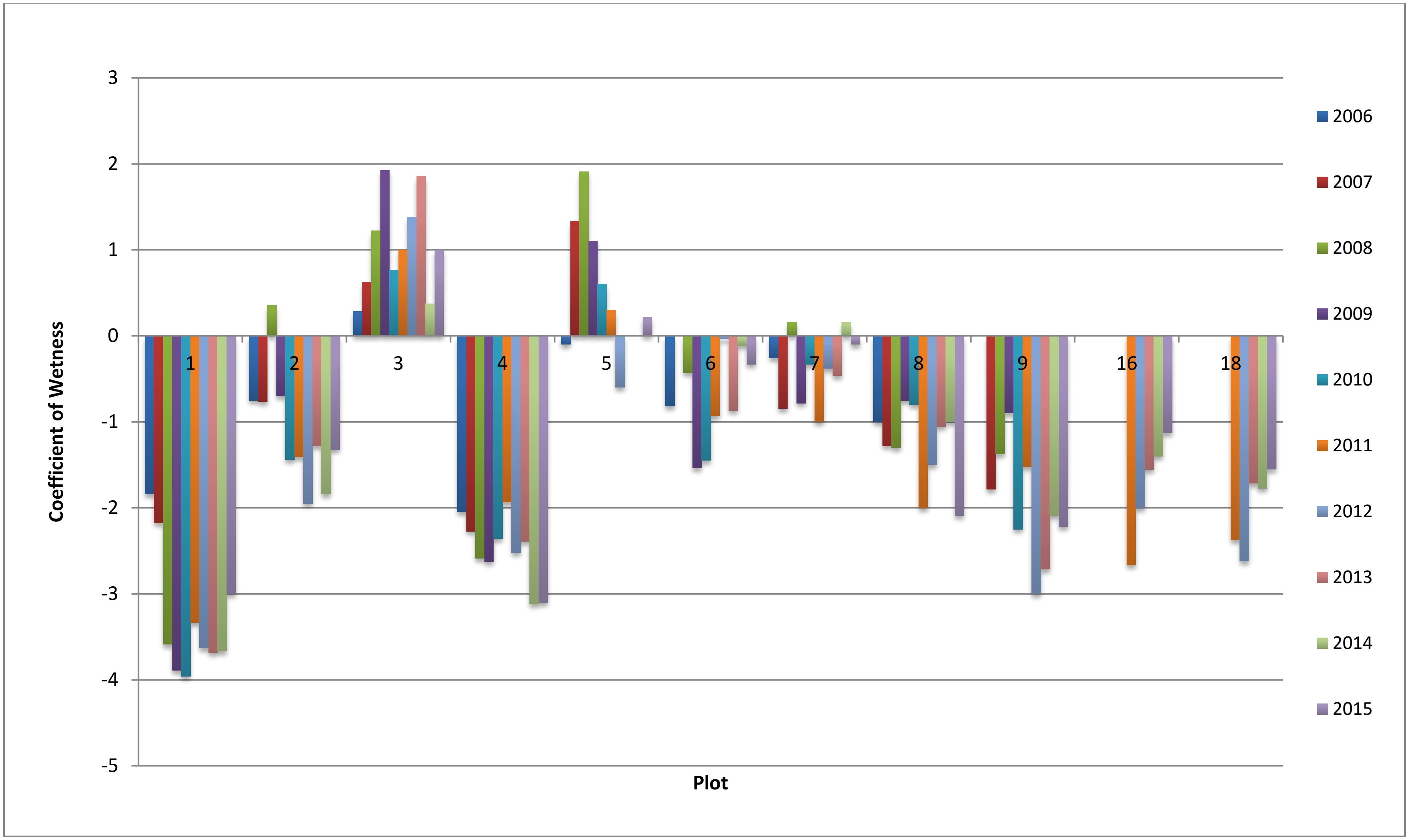

Figure 1. Coefficient of Wetness by Plot 2006 - 2015

Coefficient of Conservatism

The CC is also based on Oldham et al. (1995). Each species is given a rank between 0 and 10, based on its degree of fidelity to a range of synecological parameters (Oldham et al. 1995). Synecology is the study of the structure, development, and distribution of ecological communities. Species ranked between 0 and 3 are found in a variety of plant communities, including disturbed sites. Species ranked between 4 and 6 are those associated with a specific plant community, but which can tolerate moderate disturbance. Species ranked from 7 to 8 are found in plant communities in an advanced stage of succession with minor disturbance. Plants with a ranking of 9 or 10 have high degrees of fidelity to a narrow range of synecological factors.

The average CC per plot is shown on Figure 2. The highest average CC value in 2015 was found in Plot 7 (4.93), which is located at the transition between Fresh-Moist Sugar Maple Deciduous Forest and White Cedar-Hardwood Mineral Mixed Swamp habitats (Map 3). Plot 3, Plot 4 and Plot 7 all exhibited average CC values between 4 and 5 in 2015 and are consistently among the highest values from year to year. Plot 4 contains high CC value species including Rough-leaved Goldenrod (CC 8) and Black Ash (*Fraxinus nigra*), Cinnamon Fern (*Osmunda cinnamomea*), Crested Wood Fern (*Dryopteris cristata*) and Water Sedge (*Carex aquatilis*) (CC 7). Similarly, Plot 7 contains several of these species as well as Mountain Ash (*Sorbus americana*) (CC 8) and Bluebead Lily (*Clintonia borealis*), Dwarf Scouring-rush (*Equisetum scipoides*), Eastern Hemlock (*Tsuga canadensis*) and Oak Fern (*Gymnocarpium dryopteris*) (CC 7).

The lowest average CC values have been found within Plot 6 between 2010 and 2015. The average CC value for the Reed Canary Grass meadow marsh (MAMM1-3) in 2015 was 2.54 followed by Plot 9 (2.73), a Cattail shallow marsh (MASM2-1) which is also dominated by low CC plant species. Neither of these plots contain trees and are likely to have been cleared and farmed historically given the abundance of early successional and non-native species as well as their proximity to existing (or previously existing) farm fields. These plots are dominated by species which have a low CC value or no CC value for those species considered non-native to Ontario.

In most plots, the average CC value fluctuates from one year to the next but the overall trend between 2006 and 2015 is that values have remained steady. As applicable to other parameters such as average CW, the low species diversity in Plot 5 is prone to producing fluctuations in average CC as some species are noted within the plot some monitoring years but not others. Plot 16 has demonstrated a trend of decreasing average CC and this is largely attributed to the seasonal standing water levels within the swamp feature and the influence this has on vegetation diversity. Since Plot 16 monitoring began in 2011, species with CC values of 6 including Common Skullcap (*Scutellaria galericulata*) and Spotted Water Hemlock (*Cicuta maculata*) have not been recorded in the plot since 2011 and 2012 respectively and both in small numbers. Marsh Fern (*Thelypteris palustris*), CC 5 was last observed in 2013 and Hop Sedge (*Carex lupulina*), CC 6 was last observed in 2014 but neither were present in 2015. It is likely that a decrease in the amount of standing water and period within which the plot is inundated may contribute to these changes. The spring of 2012 was notably quite dry and may have reduced or eliminated some of the higher CC value species which may now be permanently absent from the feature or drastically reduced in numbers

There is potential that species which have disappeared from a plot may re-appear in later years through the germination of the seedbank. Additionally, plants may recolonize from areas adjacent to the plot as conditions permit.

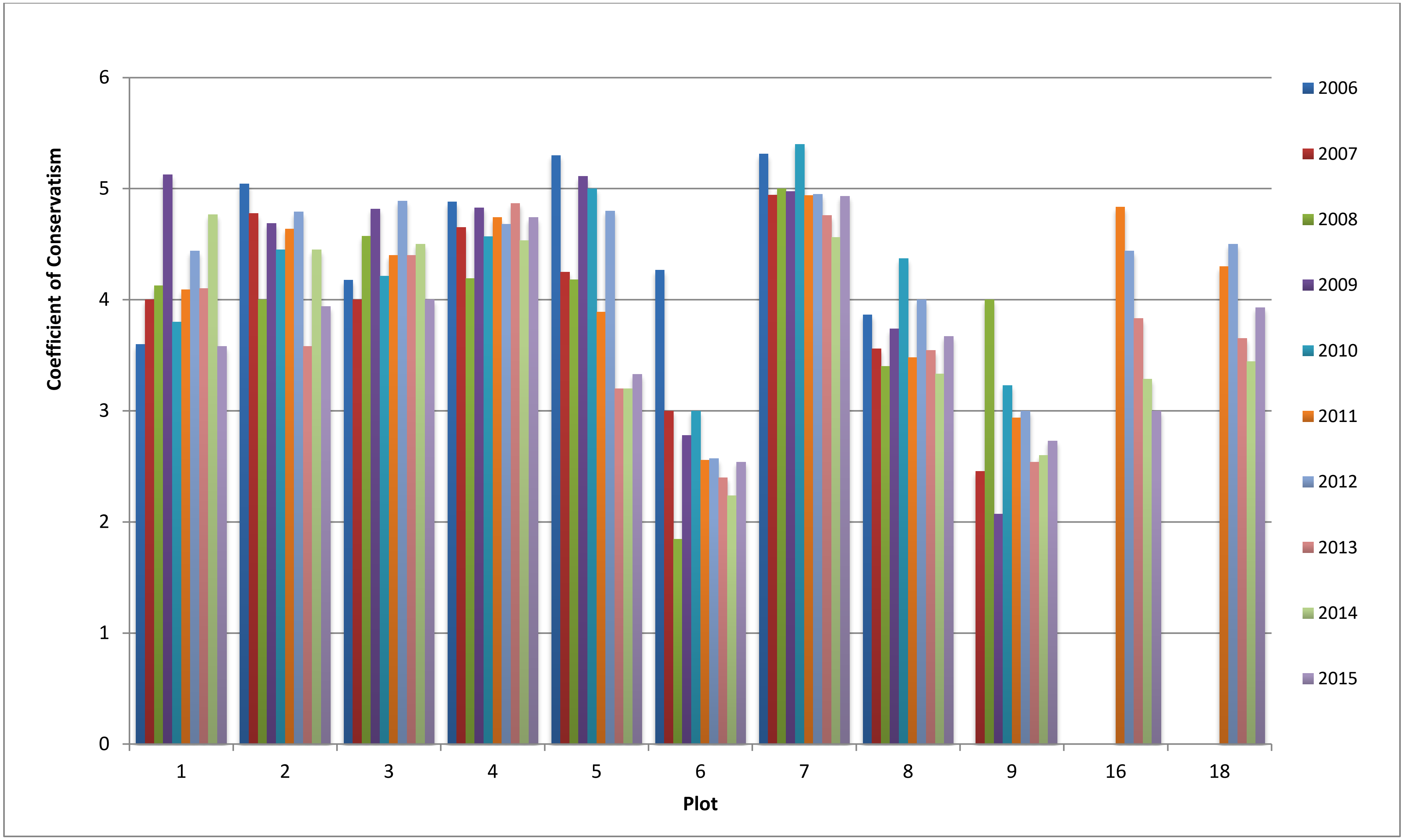

Figure 2. Coefficient of Conservatism by Plot 2006 - 2015

Natural Area Index

The NAI, or floristic quality index, allows the objective comparison of 2 or more natural areas or vegetation types (Oldham et al. 1995). The NAI is calculated by multiplying the average CC value by the square root of the total number of *native* species. Whereas the abundance and frequency of species can fluctuate greatly by season and year, the NAI is more stable and offers a more accurate picture. The NAI for each plot is shown on Figure 3.

The Ministry of Natural Resources and Forestry (MNRF) reports that natural areas with NAI values of over 35 are considered significant at the provincial level (Wilhelm and Ladd 1988 *in* MNR 1994). For comparison, an old successional field may score as low as <5 (Andreas et al. 2002). None of the plots within the HCBP score a value of 35 or higher. In 2015, none of the vegetation monitoring plots showed a notable decrease in NAI values between 2014 and 2015 with Plot 1 being the only plot to decrease in values. Plots 2, 3, 4, 7 and 8 have all shown a notable increase in NAI values over the past several years, with Plot 7 at an all-time high of 32.70 (up from 19.36 in 2014) which nears the value of 35 which would be considered significant by the MNRF. The complex micro-topography within Plot 7 which includes wetland, upland hummocks and a watercourse provides a diversity of habitat within the 10x10m plot and in turn a high number of plant species, many with higher CC values.

A number of factors will influence the parameters of the NAI equation (average CC and number of native species). Some factors include plant senescence or mortality due to drought (i.e. 2012). Given that most of the vegetation monitoring plots are located within wetlands, it is likely that the dry conditions in 2012 had a lingering effect on vegetation composition. Some species may re-appear in time through the seed bank or colonization from areas adjacent to the plot.

The lowest NAI values in 2015 were observed in Plot 5 (8.16), Plot 6 (9.50), Plot 9 (10.57) and Plot 16 (10.82). Each of these values can be attributed to different factors. The very low species diversity in Plot 5 had produced higher NAI values between 2006 and 2009 before a drop to present values. Within a low diversity plot such as this, the influence of a single species has a notable bearing on NAI values.

Plot 6 exists within an old field meadow which contains a number of non-native species and early successional species. The absence of high CC species in the plot maintains a low NAI value. This plot is unlikely to undergo notable changes in NAI for a number of years until woody species cover establishes which will subsequently lead to significant changes in the composition of the community and the herbaceous species present.

Plot 9 is dominated by Reed Canary Grass (CC 0), with abundant Broad-leaved Cattail (*Typha latifolia*) (CC3). Both species are highly aggressive and limit the ability of other herbaceous species to establish thus a consistently low NAI value is documented in this plot. Similar to Plot 6, until woody species establish canopy and change the structure of the vegetation community within the plot (to a swamp thicket or treed swamp), the plot will continue to show low species diversity and a low NAI value.

As noted in previous reports, the effects of the extremely dry spring in 2012 are likely to have lingering effects on the diversity of plants throughout the site. Further monitoring will determine to what degree the plot vegetation rebounds.

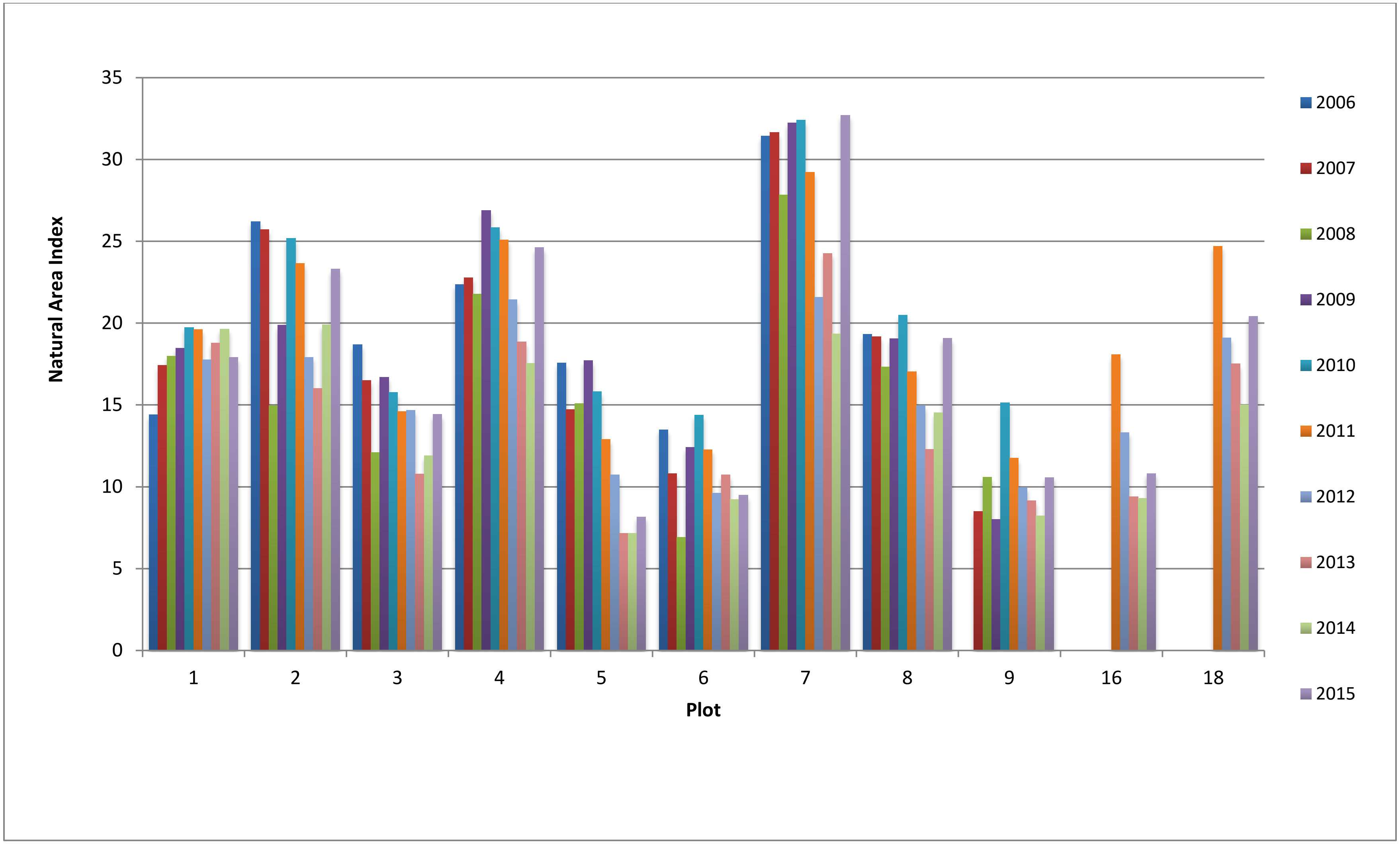

Figure 3. Natural Area Index by Plot 2006 - 2015

3.1.3 Non-Native Vegetation Species

A total of 17 non-native species were recorded within vegetation plots in 2015. The number of non-native species found in each plot is compared on Figure 4. In general, non-native species have been present in all plots over the course of monitoring with the exception of Plot 5, a low diversity plot within which Helleborine (*Epipactis helleborine*) is present in very low numbers in some years but not others. The greatest number of non-native species was recorded in Plot 8, with 9 species documented. Invasive species numbers within this plot have varied over the course of monitoring with as many as 13 species documented in 2009. The overall average number of invasive species across all monitoring years is 8.3. The location of this plot near Hanlon Creek Boulevard, coupled with the diversity of habitats within the plot (watercourse, riparian and upland) are both likely to contribute to the relatively high number of invasive species present. Some of the species documented in 2015 including Creeping Buttercup (*Ranunculus repens*), Common Dandelion (*Taraxacum officinale*) and Water-cress (*Nasturtium officinale*) do not typically create competition for native species and are not considered a threat to the native species biodiversity within the plot. The majority of invasive shrubs; Common Buckthorn (*Rhamnus cathartica*), Glossy Buckthorn (*Frangula alnus*) and Guelder Rose (*Viburnum opulus*), are located among the dense canopy of White Cedar (*Thuja occidentalis*) on the banks of the creek which limits many of these shrubs from maturing to the point of bearing fruit.

Plot 2 is located within a White Cedar-Conifer Organic Coniferous Swamp and has shown a gradual increase in invasive species presence with monitoring years 2006-2010 noting 3 to 4 invasive species and years 2011-2015 noting 5-6 species. Situated near the core of the natural feature, it is unlikely this plot has been subject to recent 'edge effect' colonization of new invasive species. Species such as Glossy Buckthorn are long-established within the plot and other such as Guelder Rose and Helleborine are noted to be rare, with only 1 to several plants present. The increase in invasive species may be attributed to new canopy openings allowing for increased sunlight in the plot or localized colonization of the plot by invasive species which are present throughout the feature but had not previously existed within the plot itself.

Plot 6 has generally exhibited the highest number of invasive species; likely attributed to a history of disturbance and adjacent agricultural practices. In 2010, 15 non-native species were documented within this plot, a number which has declined every year since. The plot exists as a graminoid-dominated mineral meadow marsh and both Smooth Brome (*Bromus inermis* ssp. *inermis*) and Coltsfoot (*Tussilago farfara*) were noted to be abundant in 2015. Given that the vegetation within the plot is very dense, some species (native and non-native) may be outcompeted, and in some cases may become senescent or be overlooked among the dense mat of vegetation.

Certain non-native species are considered particularly invasive, and are given a score of '-3' on a weediness scale ranging from '-1' to '-3'. The invasive species found within the HCBP vegetation monitoring plots include 4 shrub species (3 species with a weediness value of -3) and 14 herbaceous species. Non-native species observed in each monitoring year is provided in Table 4. The non-native species observed in 2015 do not represent any significant introductions or reductions of aggressive non-native species. In general, those species with weediness values of -2 or -3 tend to be present year after year, while less invasive species with a value of -1 are present intermittently and often in low numbers.

Garlic Mustard (*Alliaria petiolata*) was only recorded in Plot 18 during the 2011 monitoring year. This species is very common and invasive and it is rare to find areas that do not contain this plant. It is noted that this species has been observed within the study area, but for the most part has not established in high numbers within the natural features, many of which are swamp or marsh which would not support the species. Most of the non-native species present within the monitoring plots are common agricultural weeds or shrub species which produce prolific amounts of berries that are distributed by deer, birds and other wildlife.

Common Buckthorn is the most widely distributed non-native plant within the monitoring plots, with Glossy Buckthorn (*Rhamnus frangula*) also found in a number of plots with mesic to wet soils. Both species are tolerant of shading and fruiting specimens tend to be most common at the edge of wooded features where they receive ample sunlight. Due to the ability of these species to grow beneath a dense canopy, a groundcover of herbaceous vegetation is often interspersed with many young seedlings which germinate from the seedbank. Common Buckthorn is widespread throughout southern Ontario; it is often found on calcium-rich soils and occurs in a range of soil moisture and sunlight conditions (Anderson 2012). Other invasive shrubs including Tartarian Honeysuckle (*Lonicera tatarica*) and Guelder Rose are present in much smaller numbers within the study area and have not had notable impacts on native species diversity or vegetation community structure.

During vegetation surveys some species were only identified to genus as the identifying traits of the plant may not have been apparent at the time of the survey. These include an Avens species (*Geum* sp.), Sedge species (*Carex* sp.), Willow Herb species (*Epilobium* sp.) and unidentifiable grass species. These species were included in the overall species count for the plot but were not included in the non-native species totals as a positive identification of the species was not possible.

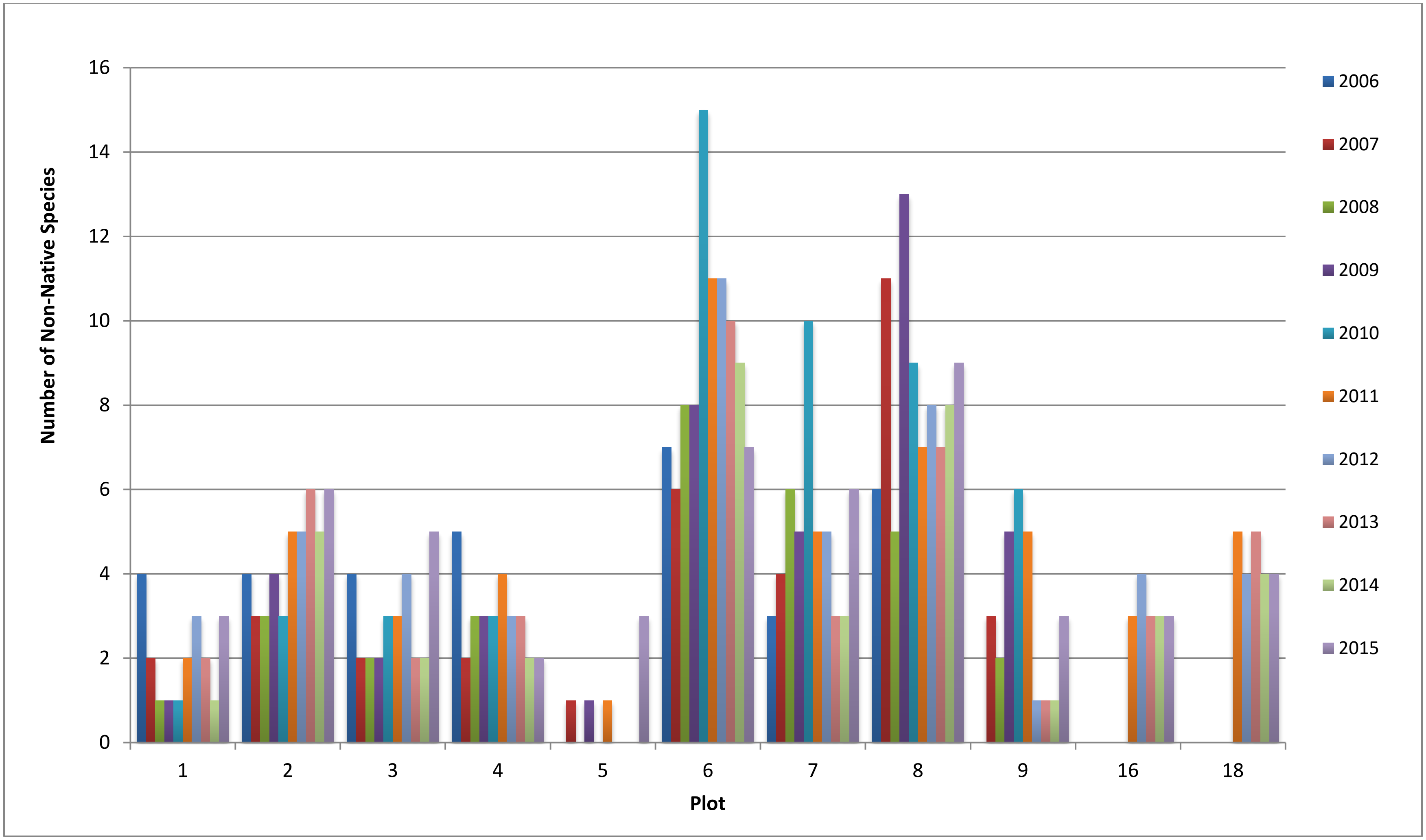

Figure 4. Non-Native Species by Plot 2006 - 2015

Table 4. Non-Native/Invasive Plant Species Observed

Scientific Name	Common Name	SRANK[1]	Weed	Year of Observation										Plot
				2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Alliaria petiolata	Garlic Mustard	SE5	-3						x					
Arctium minus	Common Burdock	SE5	-2		x									
Bromus inermis ssp. inermis	Smooth Brome	SE5	-3		x				x				x	6,9
Cerastium fontanum	Larger Mouse-ear Chickweed	SE5	-1								x			
Cirsium arvense	Canada Thistle	SE5	-1	x	x	x	x	x	x	x	x	x	x	6
Dactylis glomerata	Orchard Grass	SE5	-1							x	x	x	x	8
Daucus carota	Queen Anne's Lace	SE5	-2		x		x	x	x	x	x			
Echinochloa crusgalli	Barnyard Grass	SE5	-1				x	x				x		
Elymus repens	Quack Grass	SE5	-3			x						x		
Epilobium hirsutum	Hairy Willow-Herb	SE5	-2				x	x	x	x	x			
Epipactis helleborine	Helleborine	SE5	-2			x	x	x		x			x	2,5,7
Festuca arundinacea	Tall Fescue	SE5	-1								x	x		
Frangula alnus	Glossy Buckthorn	SE5	-3	x	x	x	x	x	x	x	x	x	x	2-8, 16,18
Geranium robertianum	Herb Robert	SE5	-2	x	x	x	x	x	x				x	7,8
Lactuca serriola	Prickly Lettuce	SE5		x			x							
Linaria vulgaris	Butter-and-eggs	SE5	-1			x								
Lonicera tatarica	Tartarian Honeysuckle	SE5	-3	x	x	x	x	x	x	x	x	x	x	6
Lotus corniculatus	Bird's-foot Trefoil	SE5	-2	x	x	x	x	x	x	x	x	x		
Lysimachia nummularia	Moneywort	SE5	-3		x									
Lythrum salicaria	Purple loosestrife	SE5	-3							x			x	1
Malva neglecta	Common Mallow	SE5	-1						x					
Medicago lupulina	Black Medick	SE5	-1					x	x	x	x			
Mentha X piperita	Pepper Mint	SE4	-1							x				

Scientific Name	Common Name	SRANK[1]	Weed	Year of Observation										Plot
				2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Nasturtium officinale	Watercress	SE?	-1				x	x	x	x	x	x	x	8
Phleum pratense	Timothy	SE5	-1			x		x	x	x		x	x	9
Plantago lanceolata	English Plantain	SE5	-1					x						
Plantago major	Common Plantain	SE5	-1					x	x					
Potentilla recta	Sulphur Cinquefoil	SE5	-2							x				
Ranunculus acris	Tall Buttercup	SE5	-2	x	x		x	x	x	x		x	x	6
Ranunculus repens	Creeping Buttercup	SE5	-1										x	8
Rhamnus cathartica	Common Buckthorn	SE5	-3	x	x	x	x	x	x	x	x	x	x	2,3,5,7-9,16,18
Ribes rubrum	Red Currant	SE5	-2			x			x					
Rumex crispus	Curled Dock	SE5	-2			x		x	x					
Silene cucubalus	Bladder Campion		-1	x										
Solanum dulcamara	Bittersweet Nightshade	SE5	-2	x	x	x	x	x	x	x	x	x	x	1-4,7, 8,16,18
Sonchus arvensis	Field Sow Thistle		-1			x		x						
Taraxacum officinale	Common Dandelion	SE5	-2	x	x	x	x	x	x	x	x	x	x	1-3,6-8
Trifolium hybridum	Alsike Clover		-1	x				x	x					
Trifolium pratense	Red Clover	SE5	-2			x								
Trifolium repens	White Clover	SE5	-1					x						
Tussilago farfara	Coltsfoot	SE5	-2	x	x	x	x	x	x	x	x	x	x	6,8
Veronica anagallis-aquatica	Water Speedwell	SE5	-1	x					x	x				
Veronica officinalis	Common Speedwell	SE5	-2			x	x		x	x				
Veronica persica	Bird's-eye Speedwell	SE4	-1							x				
Viburnum opulus	Guelder-rose	SE4	-1							x	x	x	x	2,3,8

[1]MNRF 2015a

LEGEND	
SRANK	
SE4 Uncommon but not rare	SE Exotic Species
SE5 Common, widespread, and abundant	? Rank Uncertainty

3.1.4 Herbaceous Inventory

Appendix I summarizes species observed during the plot-based monitoring in the subject property from 2006 – 2015, while Appendix II summarizes the herbaceous species observed within each monitoring plot in 2015. A total of 103 species of herbaceous plants were observed during the plot-based vegetation monitoring that was conducted in 2015.

Appendix III compares the herbaceous species recorded in each subplot between 2006 and 2015. Although the same subplot is monitored each year, the results vary as it is very difficult to monitor the exact same location from year to year, despite using the same bearing and location.

3.1.5 Shrub Inventory

The number of shrub species found within each monitoring plot and their approximate percent cover was recorded. In 2015, 22 shrub species were recorded. This number has varied over the monitoring years with low values of 15 species recorded in 2007, 2008, and 2009. Refer to Appendix IV for a comparison between all years. All shrub species documented within vegetation monitoring plots had been noted in previous years with no new species additions in 2015.

3.1.6 Tree Inventory

Following the 2014 monitoring the scope of tree inventory work was reduced to collect only canopy closure data. Data pertaining to tree health is not conducive to quantitative analysis and DBH measurements were determined to be of little value for comparison from one year to the next and was thus discontinued.

Measures of canopy closure continue to provide insight into regeneration and the establishment of naturalization plantings at Plot 8. Comparison of these values from one year to the next provide insight into the resilience of the ecosystem as naturalization plantings have yet to reach heights which would influence canopy cover readings. The filling in of canopy provides benefits to the site, including the maintenance of microhabitat conditions for riparian vegetation and helping to regulate water temperatures within Hanlon Creek. No tree species are present within Plots 1, 6 and 9. An assessment of tree canopy change is outlined in further detail in Section 3.2.3.

Signs of Emerald Ash Borer (*Agrilus planipennis*) (EAB) were observed among Ash (*Fraxinus* spp.) trees within the larger natural feature, including those within monitoring plots. The presence of EAB has been noted over the past several monitoring years. All of Plots 2, 3, 4, 7 and 18 contain Ash trees larger than 10cm DBH and these plots are experiencing or will experience changes in canopy cover as Ash decline and other tree species fill out. A loss of canopy cover due to Ash decline is likely to make for a temporary increase in herbaceous species both in numbers and in vigour. In time the canopies of existing trees including White Cedar, Red Maple (*Acer rubrum*) and Yellow Birch (*Betula alleghaniensis*) will fill in those areas where Ash was once present. Canopy openings will also spur the growth of shrub and tree saplings..

3.2 Vegetation Threshold Assessment

The thresholds for vegetation and soils established in the *HCBP Consolidated Monitoring Program* (NRSI 2010) are as follows:

- A change in herbaceous cover by more than 25%.
- A change in species diversity by more than 25%.
- A change in canopy cover by more than 25%.

3.2.1 Herbaceous Cover

The average herbaceous cover per year and plot is shown on Figure 5. The herbaceous cover fluctuates annually, with large fluctuations observed even in the pre-construction monitoring years (2006 - 2009). Herbaceous cover in 2015 was generally consistent with the overall average among monitoring years.

In 2015, Plot 1 showed a marked increase in cover from 39.3% to 87.6%. This plot has shown a high degree of variability in herbaceous cover which is likely attributed to the fluctuation in seasonal standing water within the plot. Years in which snowmelt and spring rainfall are abundant maintain a water depth of 10-20cm in the plot by July monitoring. Other years where rainfall is less abundant allow for more exposed detritus and soil as well as larger hummocks which allow for greater cover of herbaceous vegetation. Additionally, the location of the plot adjacent to mixed meadow habitat may allow for some colonization of meadow species into the edge of the plot.

Plot 2, which had peaked at 77.8% cover in 2014, decreased slightly to 55.2% in 2015. This value remains higher than 2006-2012 values which averaged 14.2% during that period. Situated within a White Cedar-Conifer Organic Coniferous Swamp, 3 declining Black Ash (*Fraxinus nigra*) were recorded in this plot in 2014. The decline of Ash trees is very likely to result in increases in herbaceous species cover as sunlight reaching the ground layer increases. Within Plot 2, Spotted Jewelweed (*Impatiens capensis*) and Marsh Marigold (*Caltha palustris*) comprise much of the herbaceous cover within the plot, potentially due to favourable soil moisture and sunlight levels for these species. The plot remains well above the pre-construction average which is interpreted as a positive trend.

Herbaceous cover in Plot 3 continued to rebound in 2015 from a low of 9.1% in 2013 to 16.3% in 2014 and 28.2% in 2015. Herbaceous cover in this plot is primarily influenced by the presence of Ostrich Fern (*Matteuccia struthiopteris*) which prior to 2011 had comprised a significant portion of herbaceous cover within the plot before values dropped significantly. 2015 vegetation plot surveys documented Ostrich Fern in all 5 of the 1x1m sub-plots with coverage varying from 10% to 60%. Previous monitoring reports have inferred that these changes in cover may have been the result of deer browsing or varying climatic conditions, in particular seasonal precipitation and soil moisture. The increase in native herbaceous cover within the plot is a positive trend which will continue to be analyzed in coming monitoring years.

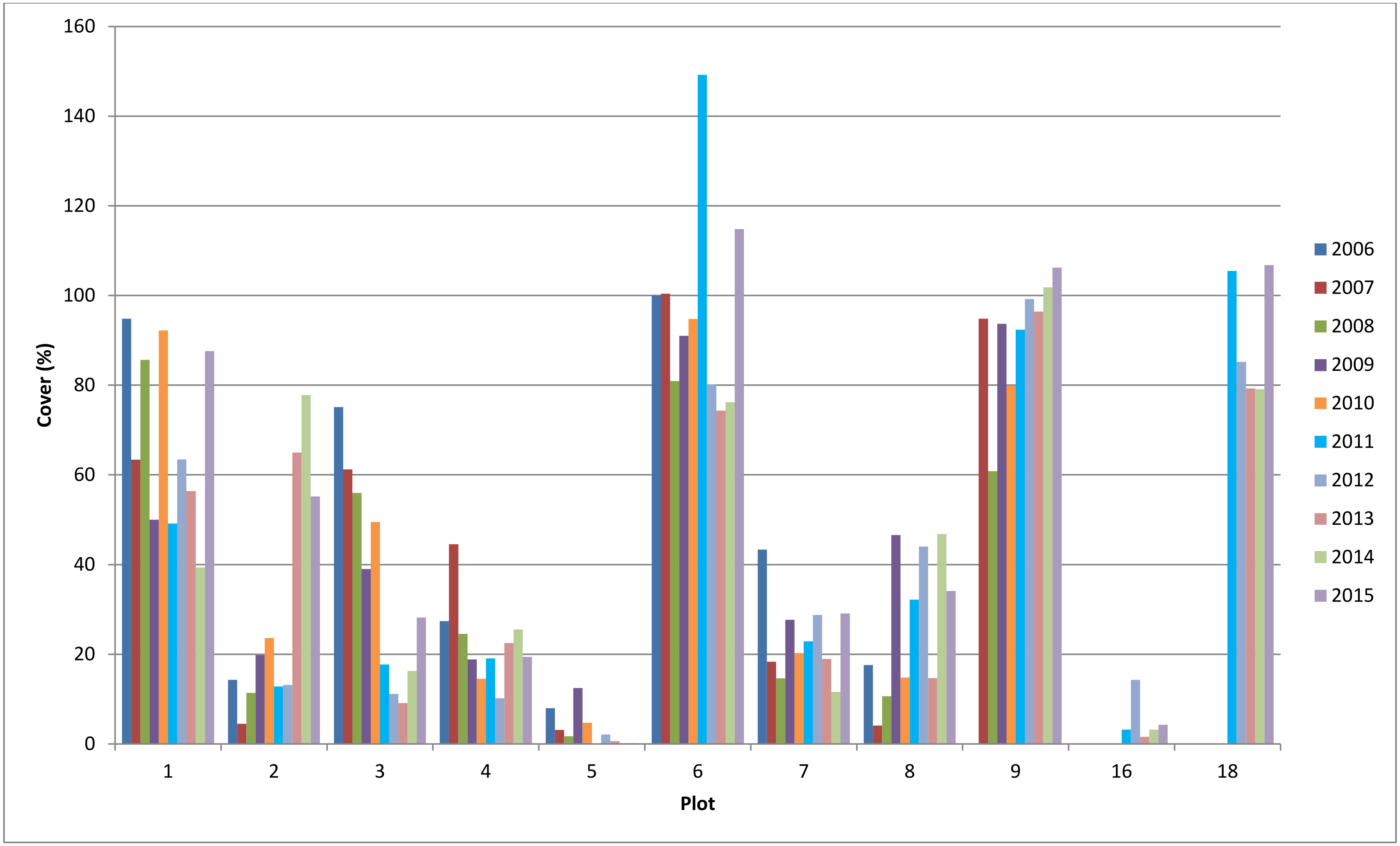

Figure 5. Change in Herbaceous Cover from 2006 to 2015

Figure 6 represents the change in herbaceous cover from 2010 to 2015 in comparison to the preconstruction year average (2006 - 2009). A range bar on the preconstruction average column on Figure 6 shows an increase and decrease of 25% herbaceous cover. An increase in herbaceous cover is generally ecologically positive, as it means greater plant matter for foraging and refuge for wildlife, as well as a generally well-being of the plant species. An increase can be negative if the increase is due to an introduction or expansion of a non-native and/or invasive species. A decrease in herbaceous cover is generally negative as it means removal of soil protection, forage and refuge material, as well as a potential decrease in biodiversity. A decrease in herbaceous cover can be due to direct vegetation removal, annual fluctuation in climatic conditions, trampling, erosion, flooding, or the effects of sun (sun scald) or salt, among other reasons.

Variation in the percentage cover of any given species may also vary from year-to-year as a result of observer bias. By employing standard plot sampling methodology a relatively accurate value can be obtained for the percentage cover of a species; however variability in the perception of coverage is inevitable. By having vegetation surveys completed by the same NRSI biologists from year to year (where possible), bias in the perception of cover has been minimized.

In 2015, the 25% threshold was exceeded in Plots 2 and 3. The exceedance in Plot 2 was positive with native herbaceous cover in this plot increasing substantially since the pre-construction phase. Although herbaceous cover in Plot 3 was observed to be slightly below the 25% threshold, as discussed above the herbaceous cover within the plot is showing a rebounding trend whereby cover has doubled annually over the past 2 monitoring years. Data for this plot suggests that herbaceous cover is returning to pre-construction conditions. The fluctuations in this plot have been attributed to the availability of soil moisture and the bearing that this factor can have on plant vigour and representation during plot monitoring.

Given the proportion of vegetation monitoring plots located within wetland habitats on site (9 of 11 plots); any fluctuation in groundwater levels will continue to influence changes in vegetation composition within the plots.

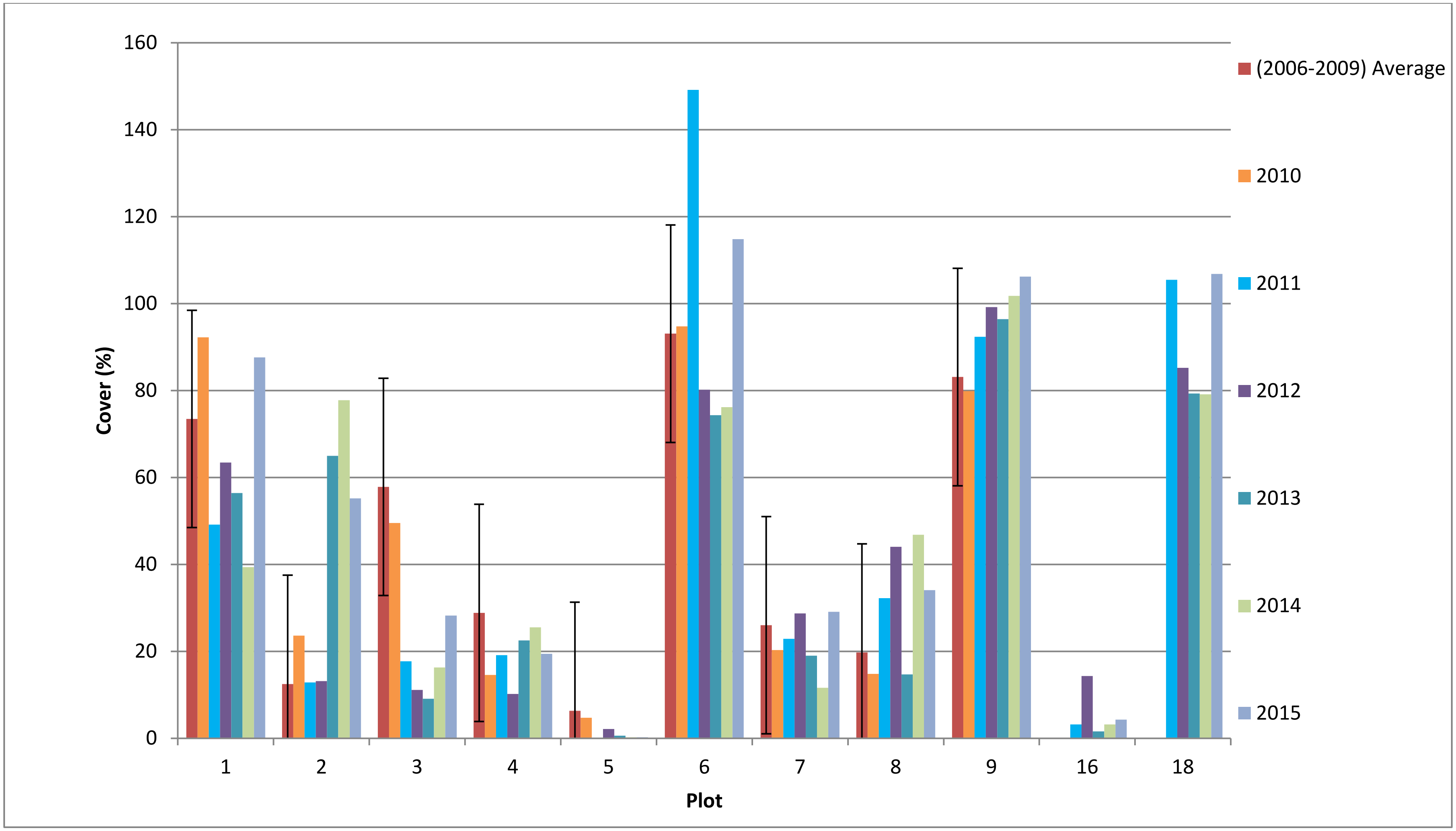

Figure 6. Change in Herbaceous Cover from 2010 to 2015 Compared to Preconstruction Average

(The range bar shows a 25% increase and decrease in herbaceous cover)

3.2.2 Vegetation Species Diversity

Species diversity is the number of species observed within each monitoring plot. Figure 7 compares vegetation species diversity per plot for each year since 2006. All species recorded in each plot are included in this data, which includes herbaceous species recorded within the overall 10x10m plot. In 2015, both Plot 2 and Plot 7 exhibited an all-time high for vegetation species diversity with 41 and 50 species respectively. These plots are situated within core areas of the natural feature and hummocky micro-topography provides a diversity of habitats for plant species.

As noted in 2014, Plot 16 continues to show a gradual decrease in species diversity. This trend is attributed to the very dry spring in 2012 which likely led to reductions in herbaceous flora within the plot. Although spring melt conditions between 2013 and 2015 have shown a return to seasonally inundated conditions, there is likely to be a lag in any recolonization of species to the plot. Plot 6 has shown a marked decrease in vegetation diversity with 43 species present in 2013, 31 in 2014 and 21 in 2015. It is noted that the 2013 value was exceptionally high and that both 2014 and 2015 values reflect pre-construction monitoring values. Additionally, the number of non-native species within this plot has decreased over the last several years. In 2015, the dominant species within the plot included Smooth Brome, Tall Goldenrod (*Solidago altissima*), Lance-leaved Aster (*Symphyotrichum lanceolatum*) and Coltsfoot. Data collected from previous monitoring years indicates that many of the documented species within the plot have been present in very small numbers. As the plot is dominated by the above species, with herbaceous cover above 110% in 2015, less common species may be outcompeted. It is foreseeable that in time this plot will colonize with additional shrubs; likely Dogwood (*Cornus* ssp.) and Buckthorn (*Rhamnus* ssp.) and ultimately Poplar trees (*Populus* ssp.). Given the agricultural past within the plot, and considering the proportion of non-native species and successional changes occurring, the decrease in diversity within this plot is not concerning at this time.

Overall, species diversity in 2015 is representative of the 10 year average with some minor increases and decreases within various plots. Variation in species diversity can likely be attributed to a number of factors including changes in climatic conditions which may encourage or discourage sensitive species. Additionally, the current approach of taking a compass bearing of 0°, 45° and 90° to determine corner locations based on the permanent t-bar stake may lead to the inclusion and exclusion of certain species located at the fringe of each plot.

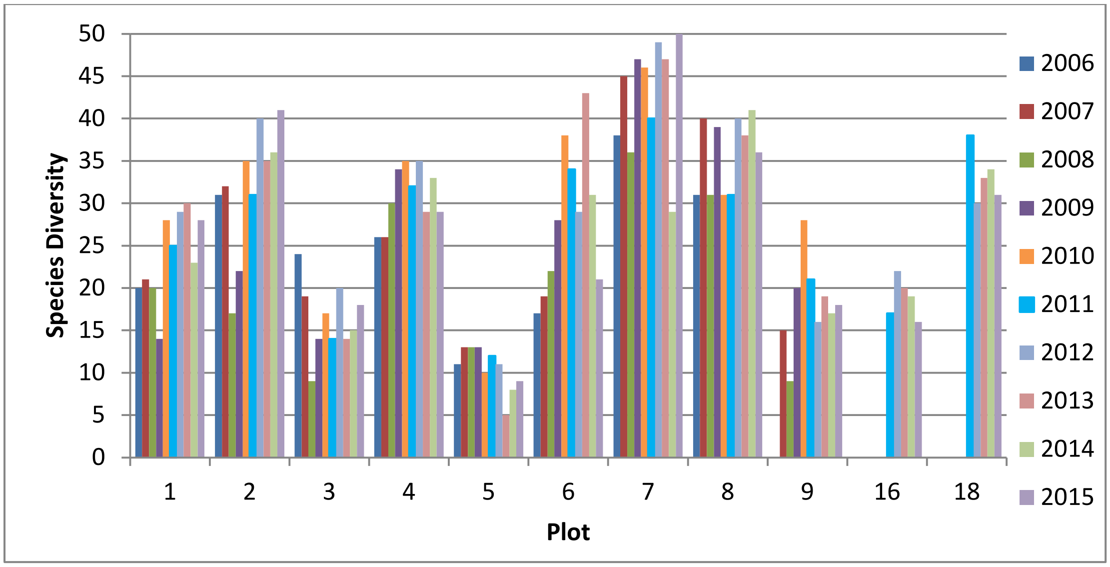

Figure 7. Change in Vegetation Diversity from 2006 to 2015

Figure 8 shows the vegetation diversity during the construction period (2010 to 2015) compared to the pre-construction average (2006 – 2009). Plots 1 and 2 both exceeded the pre-construction average positively; Plot 1 with 28 species in 2015 (18.8 pre-construction average) and Plot 2 with 41 species in 2015 (25.5 pre-construction average). Plot 5 was the only plot below the pre-construction average with 9 species in 2015 (12.5 pre-construction average). This plot has been below the average every year between 2012 to 2015; however as noted previously in this report the plot has always exhibited very low diversity. Several species are often represented within the plot by 1 or 2 underdeveloped stems as a result of the dense White Cedar canopy which limits the groundcover and species diversity.

Overall, the 2015 monitoring data highlights several positive increases in species diversity with no notable concerns relating to decreases in species diversity. An increase in species diversity is generally associated with a benefit to the natural environment, unless the increase is due to an introduction of a non-native, invasive species. Abundance data for non-native, invasive species does not indicate any notable increases in any one species over the course of the 10 year monitoring period. As indicated on Figure 4, the number of non-native species has generally remained steady from 2006 to 2015, often with the addition or removal of a single species from 1 year to the next. Monitoring will continue to document the presence of non-native, invasive species and will specifically assess their abundance within the plots.

To date, no stands of the aggressive invasive species Common Reed (*Phragmites australis ssp. australis*) have been observed within the site. This species has been known to establish following earth-moving works in ditches and has profound impacts on native species diversity. Annual monitoring will continue to watch for this species, in particular within SWM ponds and ditches.

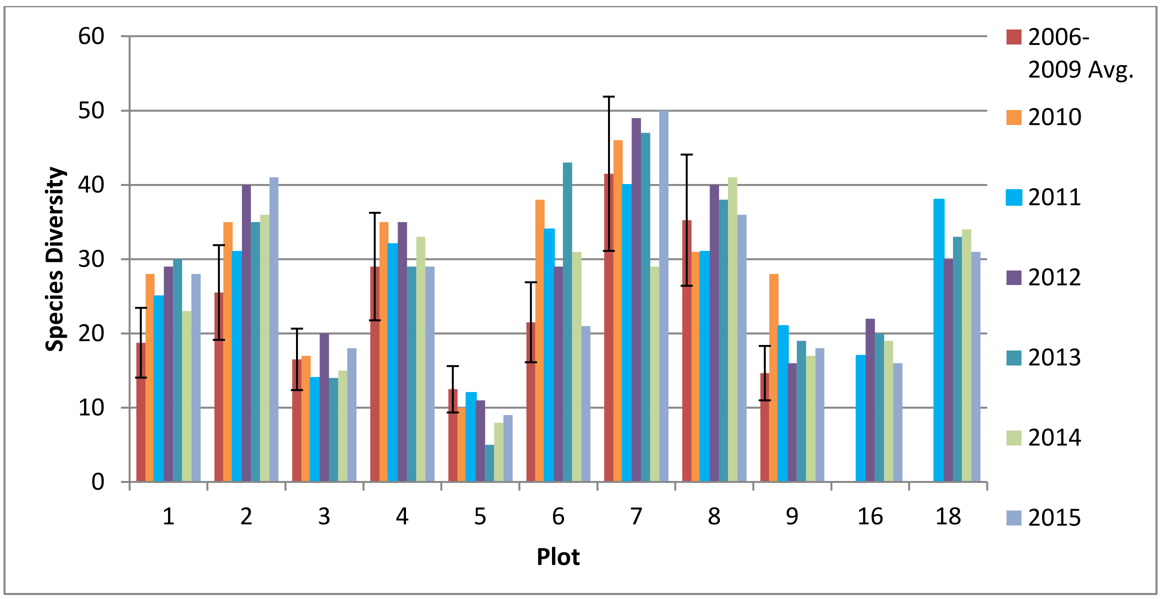

Figure 8. Change in Vegetation Diversity During 2010 to 2015 Compared to Preconstruction Average

(The preconstruction average column shows a 25% range bar)

3.2.3 Canopy Cover

The canopy cover per plot is shown on Figure 9. Plots 1, 6, and 9 have no trees and therefore canopy cover is 0%. The canopy cover in most plots has remained relatively similar over the 10 years of monitoring, with Plot 8 recovering from tree removal to the south of the plot in 2010 in preparation for the installation of the Hanlon Creek Boulevard

(Road A) culvert. Plot 8 is bisected by Tributary A, with tree cover limited to the western, eastern and northern extent of the plot. Trees and shrubs were installed in the riparian area to the south of the plot in fall 2010, as detailed in the HCBP EIR Restoration Plans. It is anticipated that in time these plantings, coupled with natural succession, will begin to increase canopy cover of the plot and facilitate a return to pre-2010 conditions. The presence of EAB is also likely responsible for some of the slight changes observed in canopy cover for plot which contain Ash trees.

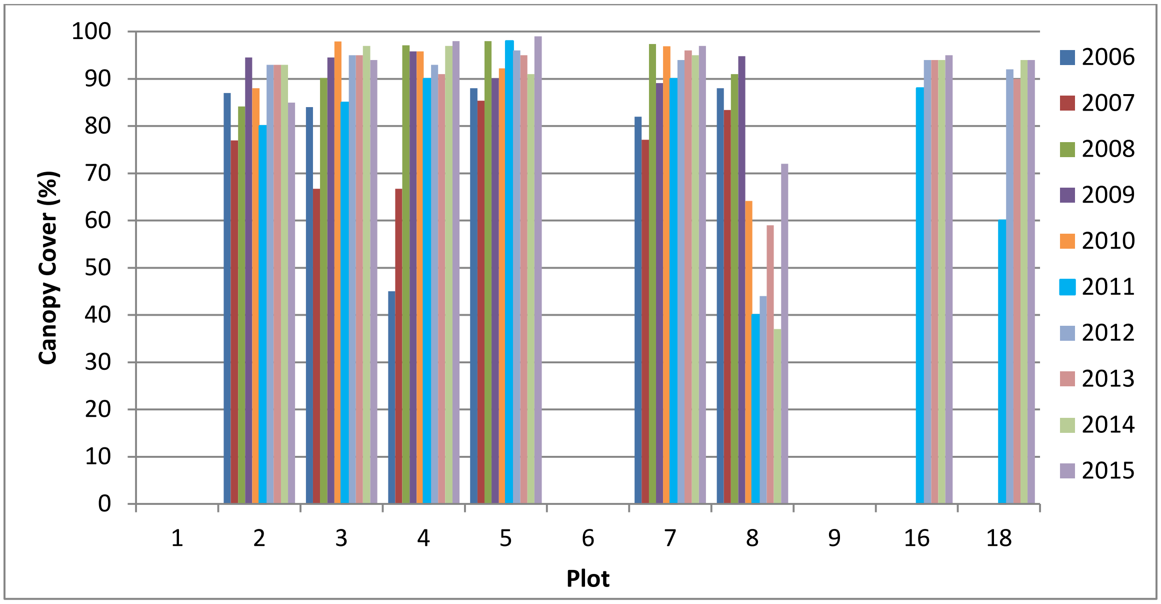

Figure 9. Change in Canopy Cover from 2006 to 2015

Figure 10 compares the canopy cover during the construction period (2010 to 2015) to the pre-construction average (2006 – 2009). A range bar shows a 25% increase and decrease from the average in canopy cover for each plot on the pre-construction column. All plots are within the threshold range including Plot 8 which showed a rebound in canopy cover to within the threshold range. Given the presence of a watercourse which bisects the plot, a percentage of open tree canopy is to be expected. The increase in canopy appears to be the result of the canopies of existing trees filling out; restoration plantings have not yet established to the point of providing canopy to the plot.

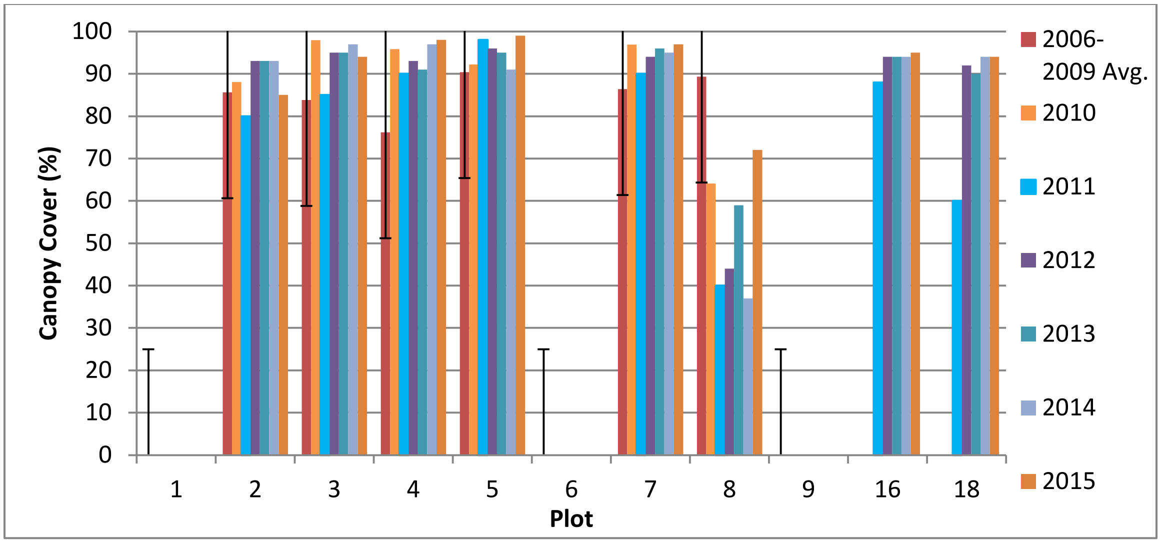

Figure 10. Change in Canopy Cover During 2010 to 2015 Compared to Preconstruction Average

(The range bar shows a 25% increase and decrease in canopy cover)

3.2.4 Vegetation Threshold Summary and Contingency Measures

The HCBP Consolidated Monitoring Program (NRSI 2010, p. 37) suggests the following measures when there is a change in vegetation or a shift in species composition beyond the established threshold:

- *"Initiate restoration efforts to enhance number of native wetland/woodland species.*
- *Provide educational material to neighbouring properties outlining importance of natural features and their protection.*
- *Provide additional signage regarding trail closures, etc.*
- *Refer to Section 6.1 Groundwater for the contingency measures associated with groundwater thresholds."*

Although several vegetation thresholds were exceeded during the 2015 monitoring season, it is not recommended that any of the above-mentioned contingency measures be carried out at this time. As explained in further detail below, a variety of causes are likely responsible for these threshold exceedances; however potentially major or irreversible changes are not being observed. Continued monitoring is recommended to ensure that vegetation communities remain intact and diverse.

Although CW is not used as a specific threshold for the vegetation monitoring, it is noteworthy that the CW values have shown a drying trend between 2011 and 2015 at Plots 16 and 18. These plots are located in close proximity to recent development (Block 9 and Block 10) and Hanlon Creek Boulevard. Groundwater levels at adjacent monitoring wells indicate that the drought year in 2012 is the only obvious groundwater effect. Furthermore, it appears that fluctuations in groundwater levels would have little to no effect on the soil wetness in the wetlands because their elevations have never been above the ground surface of the wetlands. It should also be considered that an abundance of 'wet' CW value plants within a plot one year, followed by these species disappearing from the plot in subsequent years due to prolonged seasonal standing water will indicate a graphical trend of drying, when in fact it is simply a reduction in 'wet' CW species due to exceedingly wet conditions. Groundwater levels in the vicinity of Plots 16 and 18 do not show a trend that matches the declining trend in CW values. Monitoring of vegetation and groundwater should continue at these plots in order to determine whether there is a relationship between groundwater and the CW values.

Herbaceous Cover

Herbaceous cover exceeded the threshold positively in Plot 2 which is seen as a positive trend for this plot. Although Plot 3 exceeded the lower reach of the threshold in 2015 for the fifth consecutive year, herbaceous cover values show a steady increase between 2013 and 2015.

The changes in cover being observed in Plot 2 are attributed to the decline of Black Ash and Green Ash trees within the plot as a result of EAB. With additional sunlight reaching the groundcover within the plot, forbs including Spotted Jewelweed and Marsh Marigold have responded positively with increases in overall cover. It is noted that the decrease in canopy may also lead to increased growth of non-native Glossy Buckthorn within the plot. Where a closed canopy will normally limit a proportion of Buckthorn plants to small saplings, the opening of a canopy can result in a flush of growth which could have negative impacts for herbaceous cover and diversity.

In Plot 3, the decline of Ostrich Fern cover in 2011 has maintained this plot below the pre-construction threshold. Monitoring between 2013 and 2015 showed that cover has doubled annually and suggests that Ostrich Fern (and other herbaceous species within the plot) are increasing and may fall within the lower end of the threshold during 2016 monitoring. The herbaceous cover within the plot increased by 19.1% between 2013 and 2015; a figure that shows improvement but is still well below the pre-construction average of 57.83%.

Species Diversity

Species diversity positively exceeded the pre-construction threshold in both Plots 1 and 2. Given that these increases were not based on the addition of aggressive non-native species to the plots, these changes are considered positive. Plot 5 remained below the threshold in 2015. With consistently low species diversity, the threshold for Plot 5 is based on a small number of species and is thus easily exceeded. Had the 9 species observed in 2015 monitoring been raised to 10, the plot would have been within the lower reach of the threshold. As a dense conifer stand, it is not anticipated that species diversity will change drastically within this plot in the near future.

Some discrepancy has been attributed to the potential shifting of the monitoring plot; the hummocky terrain means that a shift of several degrees in either direction for the 5, 1x1, sub-plots can include or exclude several species from the plot list.

On-going monitoring will continue to assess the increase or decrease in species diversity including an analysis of non-native species within each plot. Similar to previous monitoring years, non-native species were recorded in all plots in 2015, except Plot 5.

Canopy Cover

Plot 8 remains the only plot which exceeded the canopy cover threshold. As reported in the 2011 HCBP Consolidated Monitoring Report (NRSI 2012a), canopy cover has been reduced in Plot 8, but the area of impact, adjacent to the plot has been restored through native plantings according to the HCBP EIR Restoration Plans. These plantings are being monitored for success and will increase shading to Tributary A that bisects Plot 8 as they mature.

3.3 Breeding Bird Surveys

A total of 49 species of birds were observed during the breeding bird monitoring that was conducted in 2015 (Appendix V). Including those species which were noted outside of point counts or incidentally during other surveys, a total of 58 bird species were documented within the study area in 2015 (Appendix VI). Table 5 summarizes the number of birds observed during breeding bird point count surveys under each breeding evidence code.

Table 5. Breeding Bird Evidence

Breeding Evidence	Number of Species									
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Possible	30	12	20	21	20	21	25	21	15	19
Probable	11	15	14	20	18	22	21	24	23	25
Confirmed	0	11	2	4	2	2	4	3	2	3
None*	0	8	4	0	5	2	1	2	2	3
TOTAL	**41**	**46**	**40**	**45**	**46**	**47**	**51**	**50**	**42**	**49**

*Species observed with no breeding evidence (i.e. flying overhead)

The most abundant species observed during 2015 surveys were Red-winged Blackbird (*Agelaius phoeniceus*), and Song Sparrow (*Melospiza melodia*), comprising 14% and 10% of the observations during breeding bird point counts respectively. These were followed by American Robin (*Turdus migratorius*) and American Goldfinch (*Spinus tristis*) at 7% each. These species are consistently the most abundant within the point counts largely due to the presence of suitable habitat and the large populations of these species within Southern Ontario. Figure 11 represents the 10 most abundant species observed in 2015, with all other birds observed less frequently compiled as ‘other’.

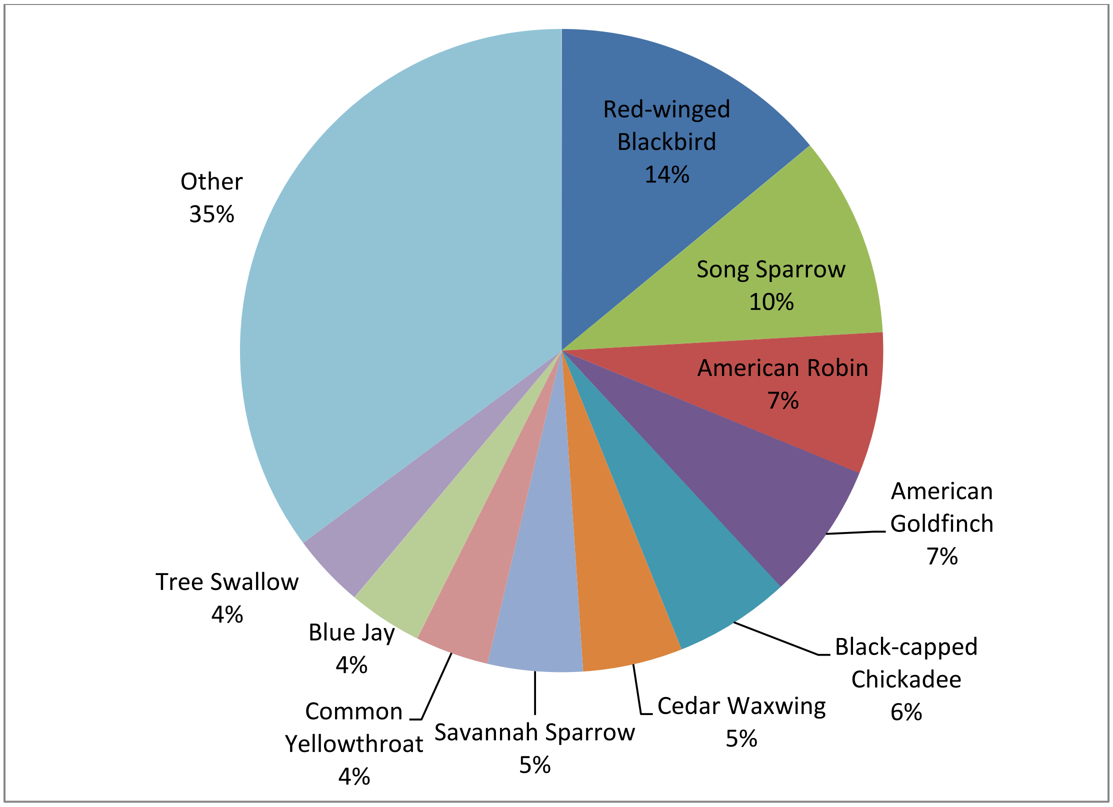

Figure 11. Most Abundant Bird Species Observed in 2015

3.3.1 Breeding Bird Species Diversity

Figure 12 graphs the species diversity of breeding birds at each plot since monitoring began in 2006. A total of 49 bird species were recorded during breeding bird surveys in 2015. In 2012, 51 species were recorded which stands as the highest diversity to date; the low tally for diversity of 40 species was documented in 2008 (pre-construction monitoring year). Including the observation of incidental bird species throughout 2015, the overall bird species diversity was 58 species.

In 2015, notable increases in bird diversity (over 2014 values) were observed at Plots 3-7, 9 and 16. Plot 11 and Plot 20 have both shown steady decreases in diversity since 2013.

At Plot 11, only 4 species were documented on the first breeding bird survey, with 11 recorded on the second visit. The 22 species documented in 2013 appears to have been well above the 7-year average of 15.86. In 2015 there was no construction activity in the vicinity of Plot 11. Although the previously existing hedgerows have been removed, the lands surrounding the plot (including the Forestell Road berm) have developed into early successional meadow habitat which has value for bird species. The understorey of the Heritage Maple Grove within which Plot 11 is situated is dominated by European Buckthorn which has been present since monitoring began here in 2009.

Bird species diversity in Plot 20 had decreased to 10 species in 2015, down from 21 in 2012, 20 in 2013 and 16 in 2014. A cause for this trend is not clear given that the plot is situated among agricultural fields which have gone fallow and support a variety of grassland bird species. As in years prior to 2015, species including Eastern Meadowlark (Sturnella magna), Bobolink (*Dolichonyx oryzivorus*) and Savannah Sparrow (*Passerculus sandwichensis*) all utilize the fallow field habitat for foraging and nesting. No construction has occurred in this area to date. The decrease in diversity may simply be a result of point-in-time observations of species during the breeding bird surveys. Previous years had recorded species including Black-capped Chickadee, American Crow, Blue Jay, Ring-billed Gull and Downy Woodpecker, none of which would explicitly utilize the open country habitat. Despite the reduction in diversity recorded within the plot, the maintained presence of grassland birds from one year to the next supports that the plot continues to provide functional habitat for those species which would require grassland for foraging and breeding.

In 2015, no bird species new to the site were recorded either during breeding bird surveys or as an incidental observation.

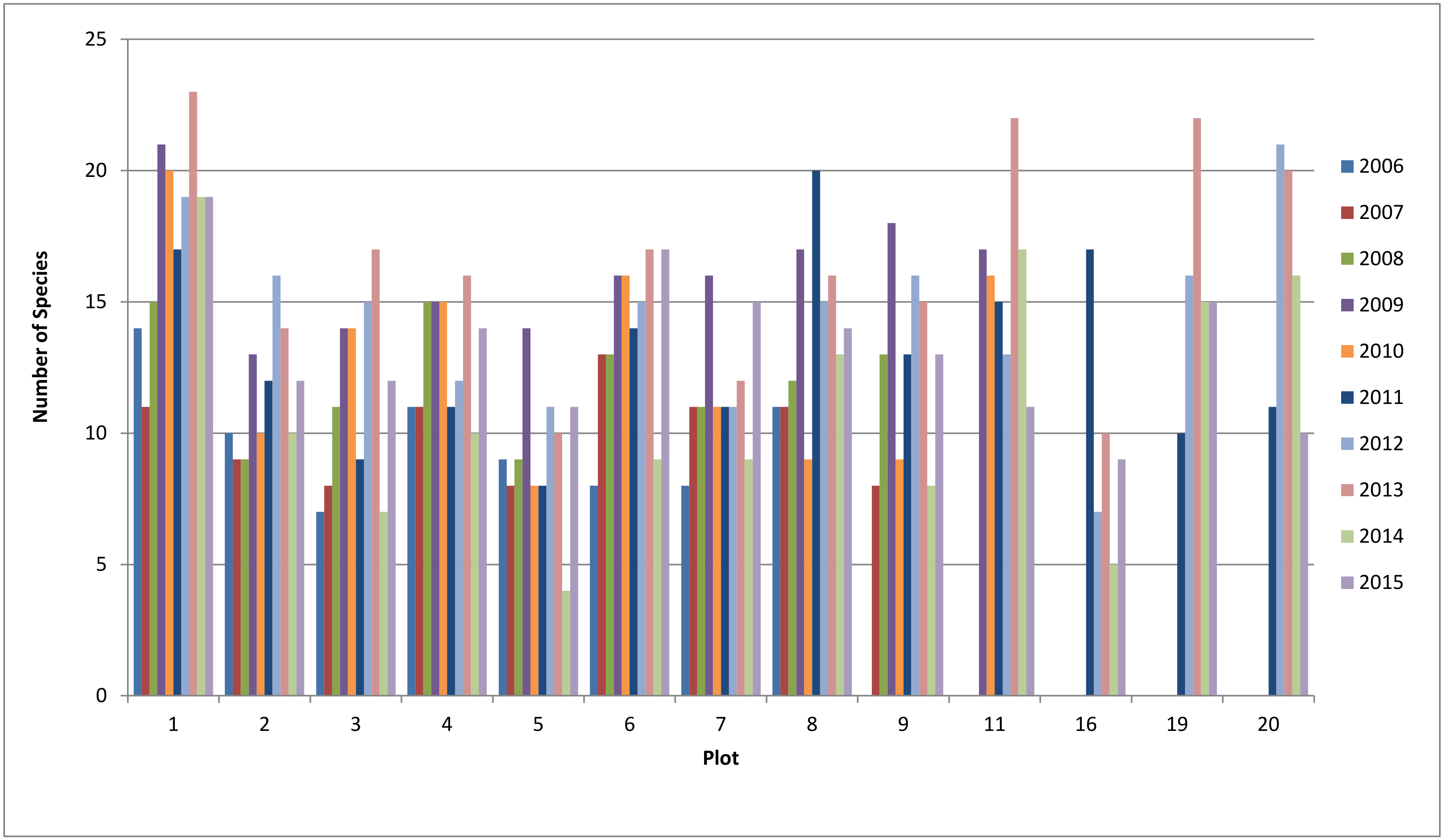

Figure 12. Breeding Bird Species Diversity 2006 – 2015

3.3.2 Breeding Bird Abundance

The breeding bird abundance (the number of individual birds) since 2006 is shown on Figure 13. In general the 2015 abundance reflects the overall average since monitoring began in 2006. Those species which have tended to comprise much of the abundance value for each plot including Red-winged Blackbird, American Goldfinch, Song Sparrow, Black-capped Chickadee and American Robin continue to comprise the bulk of individuals observed. Spikes in bird abundance have been observed in past monitoring years due to large flocks of a single species which have included Red-winged Blackbirds in Plot 6 in 2006 and Canada Goose (*Branta canadensis*) in Plot 9 in 2007.

Plot 1 showed a decrease in bird abundance in 2015 with 31 individuals recorded. The 2013 and 2014 monitoring years had recorded 70 and 51 species respectively. Situated at the transition between a Slender Willow Mineral Deciduous Thicket Swamp and Mixed Meadow, this plot documents a range of bird species as a result of varied habitats. While bird abundance was lower in 2015 than the previous 7 years, bird species diversity remained generally consistent with previous year at 19 species.

Plots 4, 5, 6 and 16 all exhibited notable increases in bird abundance over 2014 values. The 2015 values generally reflect the overall average for each plot over the course of monitoring.

Plot 6 continues to have the highest bird abundance with 50 individuals recorded during 2015 surveys. This plot is likely to yield higher bird abundance due to a combination of treed and open upland and wetland habitats present within the immediate survey area. Additionally, the marsh vegetation within this plot provides good sight lines to forest and swamp edges, the skyline and distant features which allow biologists to observe species well beyond the formal 100m breeding bird plot. Those plots which consistently show the lowest bird abundance, particularly Plot 5 are situated well within wooded features and are thus less likely to have species that prefer edge or open country habitat.

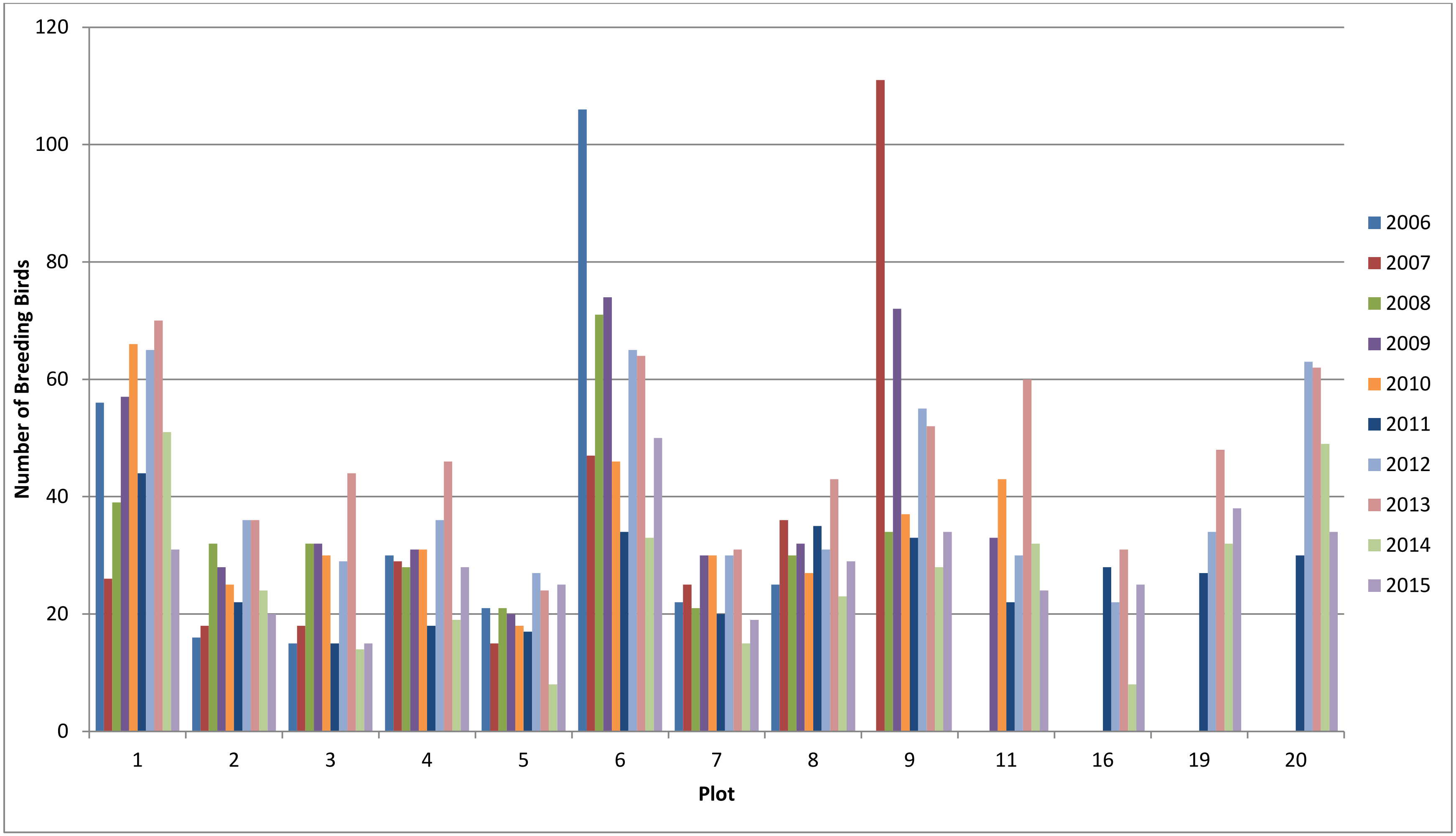

Figure 13. Breeding Bird Abundance 2006 - 2015

3.3.3 Significant Bird Species

NRSI observed 5 species that are considered Threatened federally and provincially (COSEWIC 2016, MNRF 2015b): Bobolink, Eastern Meadowlark, Barn Swallow (*Hirundo rustica*), Bank Swallow (*Riparia riparia*), and Chimney Swift (*Chaetura pelagica*). Additionally, Eastern Wood-pewee (*Contopus virens*), a species listed as Special Concern federally and provincially (COSEWIC 2016, MNRF 2015b) was documented during 2015 breeding bird surveys.

In Plot 20, Bobolink and Eastern Meadowlark were noted showing probable breeding evidence with as many as 3 individuals of each species present. Incidental observations of Bobolink were also made from the vicinity of Plot 1 and 9 with Eastern Meadowlark documented in the vicinity of Plot 1. Bobolink requires large, open expansive grasslands (>50ha) with dense ground cover; hayfields, meadows or fallow fields; marshes (OMNR 2000). This species has been observed each monitoring year with probable breeding evidence documented in 2010 and 2012 through 2015. Eastern Meadowlark requires grassy meadows, farmland, pastures or hayfields at least 10ha in size (OMNR 2000). Suitable habitat is found within the southwest portion of the subject property (Phase 3) as well as within the retained open meadow habitat associated with Plot 19 (Map 1).

Barn Swallows were observed at 4 breeding bird plots within the Phase 3 lands (Plots 1, 9, 19 and 20). Based on breeding bird surveys, the species was documented showing confirmed breeding evidence with as many as 4 individuals present at Plot 19 on the June 29th survey. It is possible that individuals are now beginning to nest upon newly built structures within the business park. Barn Swallows are found in farmlands and rural areas, and generally use buildings (such as barns) or other man-made structures for nesting. They are often found foraging in open country near water (Brown and Bomberger-Brown 1999, OMNR 2000). Suitable nesting habitat for this species is present at the Crawley farmhouse within Phase 3. Barn Swallow may also be nesting outside of the subject property in barns along Forestell Road or Downey Road and utilizing the subject property for foraging habitat.

A single Bank Swallow was observed in suitable habitat at Plot 6 during the June 17th survey. This species nests within eroding banks of streams and rivers and forages within open and water-associated habitats (Garrison 1999). Suitable nesting habitat for this species may be present to the east of Plot 6 where a pile of screened topsoil has been present for several years and may provide suitable nesting habitat. The SWM ponds present may provide suitable foraging habitat.

A pair of Chimney Swifts were documented foraging above Plot 2 during the June 17th survey. This species roosts and nests in chimneys, predominantly within urban landscapes and feeds above forests and open country (Steeves et al. 2014). While suitable nesting and roosting habitat is not present within the study area, the fields and treed habitats provide foraging habitat.

A single singing male Eastern Wood-pewee was documented at Plot 3 and was also noted as an incidental at Plot 19. Eastern Wood-Pewee prefers open forest (deciduous, coniferous or mixed) often predominated by oak with little understorey or forest clearings, edges, farm woodlots or parks (OMNR 2000). The open understorey habitat present at Plot 3 provides ideal habitat for this species which may also utilize other treed and edge habitats throughout the study area.

A total of 17 bird species were observed which are considered significant within the City of Guelph (Dougan & Associates 2009). Of these 15 species, 1 showed confirmed breeding evidence; Baltimore Oriole (*Icterus galbula*) at Plot 19. A total of 6 species showed probable breeding evidence, including American Redstart (*Setophaga ruticilla*) Bobolink, Chimney Swift, Eastern Meadowlark, Savannah Sparrow, and Willow Flycatcher (*Empidonax traillii*). Additionally, 10 species showed possible breeding evidence and 1 did not show any breeding evidence (i.e. flying over habitat). Chimney Swift was the only species considered significant in Wellington County which had not been recorded within the subject property previously.

Table 6 lists the nationally, provincially, and locally significant bird species that were observed by NRSI in 2015.

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Table 6. Significant Bird Species Observed in 2015

Common Name	Scientific Name	SRANK[1]	COSEWIC[2]	COSSARO[3]	Local Status[4]	2015 Breeding Evidence
American Redstart	*Setophaga ruticilla*	S5B			√*	PR
Baltimore Oriole	*Icterus galbula*	S4B			√*	CO
Bank Swallow	*Riparia riparia*	S4B	T	THR	√*[1]	PO
Barn Swallow	*Hirundo rustica*	S4B	T	THR		CO
Black-billed Cuckoo	*Coccyzus erythropthalmus*	S5B			√*	PO
Bobolink	*Dolichonyx oryzivorus*	S4B	T	THR	√*	PR
Chimney Swift	*Chaetura pelagica*	S4B, S4N	T	THR	√	PR
Eastern Kingbird	*Tyrannus tyrannus*	S4B			√*	PO
Eastern Meadowlark	*Sturnella magna*	S4B	T	THR	√*	PR
Eastern Wood-Pewee	*Contopus virens*	S4B	SC	SC		PO
Grasshopper Sparrow	*Ammodramus savannarum*	S4B			√	PO
Northern Flicker	*Colaptes auratus*	S4B			√*	PO
Red-bellied Woodpecker	*Melanerpes carolinus*	S4			√	PO
Red-breasted Nuthatch	*Sitta canadensis*	S5			√*	PO
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	S4B			√*	PO
Savannah Sparrow	*Passerculus sandwichensis*	S4B			√*	PR
Turkey Vulture	*Cathartes aura*	S5B			√	X
Willow Flycatcher	*Empidonax traillii*	S5B			√	PR
Yellow-bellied Sapsucker	*Sphyrapicus varius*	S5B			√*	PO

[1]MNRF 2015a; [2]COSEWIC 2016; [3]MNRF 2015b; [4]Dougan and Associates 2009

LEGEND
SRANK
S4 Apparently Secure
S5 Secure
B Breeding Population
N Non-breeding Population
COSEWIC/COSSARO
T/THR Threatened
SC/SC Special Concern
Local Status (Wellington)
√ Significant and rare
√* Significant but not rare
Breeding Evidence Codes
CO Confirmed
PO Possible
PR Probable
X No breeding evidence

3.4 Bird Threshold Assessment

3.4.1 Breeding Bird Species Diversity

The threshold for breeding birds established in the HCBP Consolidated Monitoring Program (NRSI 2010) is a change of 25% in species diversity (number of different species). A decrease in species diversity beyond the threshold is considered to represent a potential concern. An increase beyond the threshold is considered to be positive and does not warrant that any remedial action be taken. Figure 12 graphs the species diversity for breeding birds since monitoring began in 2006. Figure 14 compares the 2010 to 2015 breeding bird species diversity to the preconstruction (2006-2009) average species diversity.

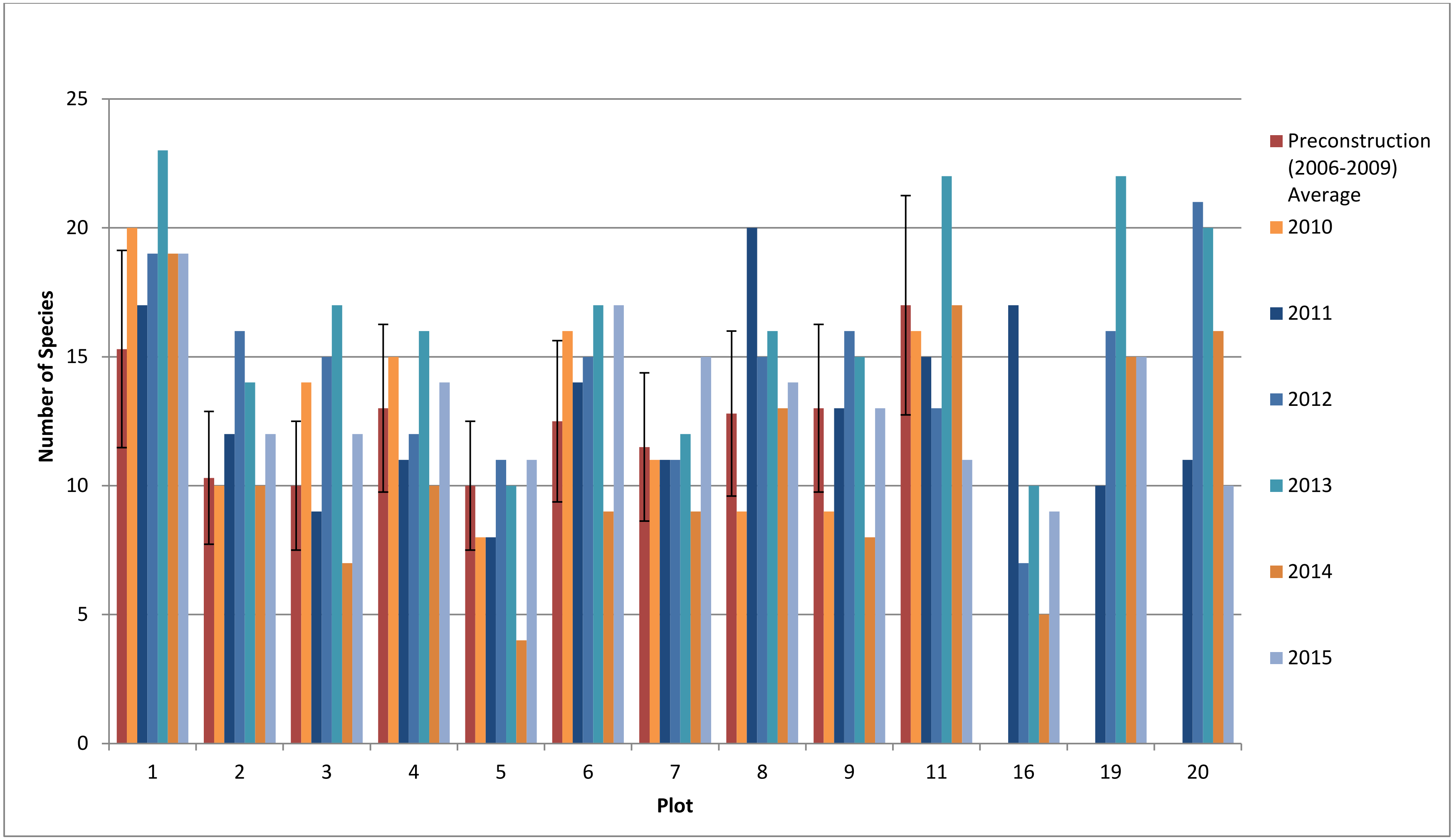

Figure 14. Breeding Bird Species Diversity During 2010 to 2015 Compared to Preconstruction Average

(The range bar shows a 25% change in the number of breeding bird species)

3.4.2 Breeding Bird Abundance

The threshold for breeding birds established in the HCBP 2010 Consolidated Monitoring Report (NRSI 2010) is a change of 25% in breeding bird abundance (the number of individual birds). Figure 13 graphs breeding bird abundance since 2006. Bird abundance in 2015 reflected average to low numbers in comparison with the pre-construction average as well as the 2010-2014 monitoring period. Figure 15 compares 2010 to 2015 during construction data with breeding bird abundance from the preconstruction years (2006 – 2009). The preconstruction average column shows the 25% range bar, indicating the threshold.

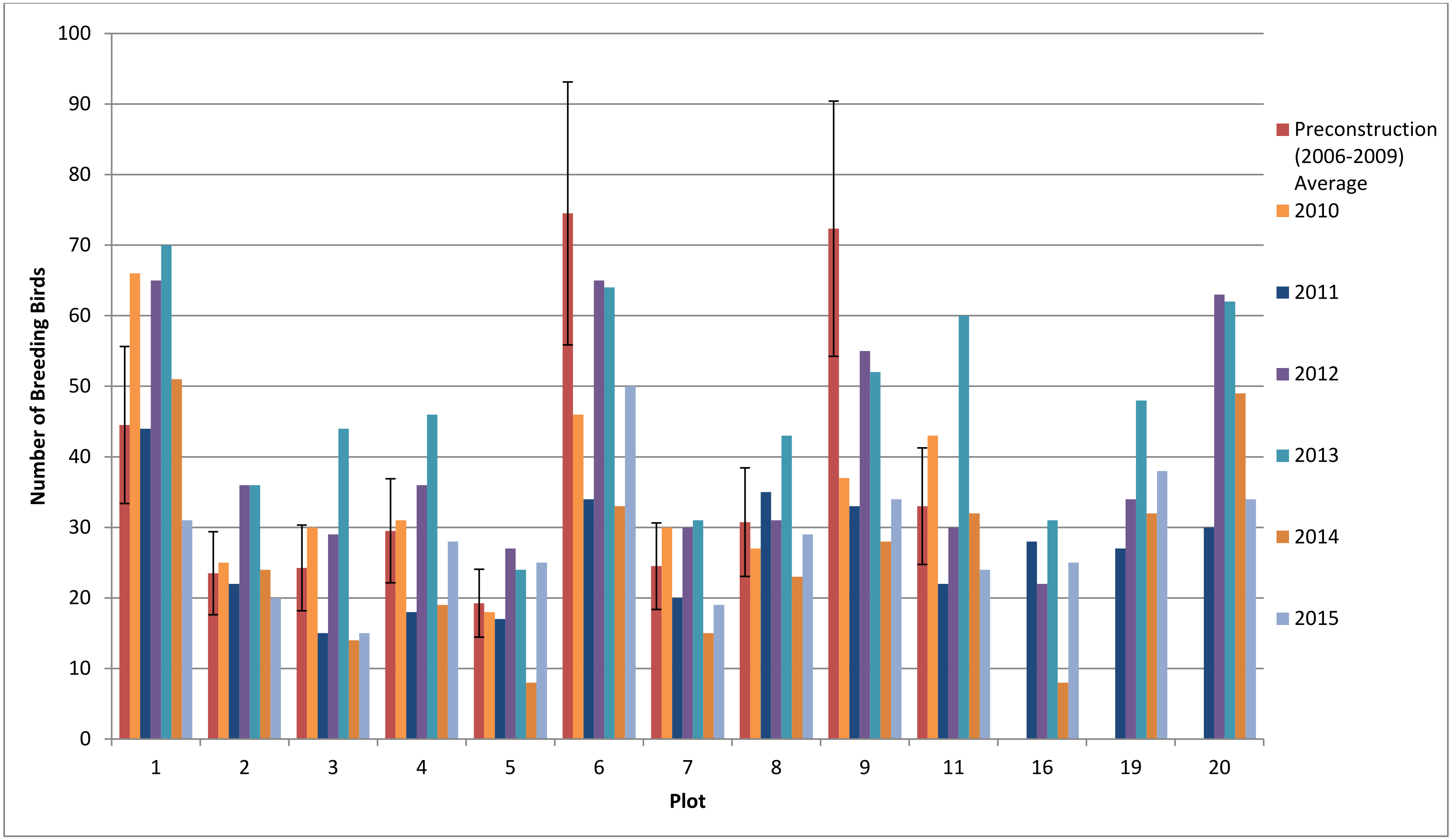

Figure 15. Breeding Bird Abundance 2006 - 2015

(The range bar shows a 25% change in the number of breeding birds)

3.4.3 Bird Threshold Summary and Contingency Measures

The HCBP Consolidated Monitoring Program (NRSI 2010, p. 39) suggests the following measures when bird species decline beyond the established threshold:

- *"Assess success of naturalization/restoration plantings. If plantings are not establishing, increase buffer/natural area plantings.*
- *Assess status of restoration plantings (e.g. if shrub and tree species are beginning to proliferate in open meadow areas, return naturalized area to intended habitat type).*
- *Increase buffer plantings or alter if necessary.*
- *Provide educational material to neighbouring properties outlining importance of natural features, wildlife and their protection.*
- *Provide additional signage regarding trail closures, etc."*

In 2015, bird species diversity was average overall with abundance variable but lower than the pre-construction average overall. A negative threshold exceedance for bird species diversity occurred at Plot 11, with Plot 16 and 19 reflective of the 5 year average for those plots and Plot 20 lower than the figures from the previous 3 years. The threshold for bird abundance was negatively exceeded in Plots 1, 3, 6, 9 and 11 with Plot 16 showing a notable rebound and Plots 19 and 20 reflective of the 5 year average for those plots. The thresholds that were exceeded are summarized as follows along with recommendations for continued monitoring.

<u>Breeding Bird Species Diversity</u>

In 2015, Plot 11 was the only plot which fell below the bird species threshold at 11 species. This plot has shown fluctuation in bird species abundance over the monitoring period with as many as 22 species documented in 2013 and an average of 16 species between 2007 and 2015. No construction work occurred in the vicinity of Plot 11 in 2015 which had a series of hedgerows present to the north prior to the installation of roads and servicing in recent years. The lands surrounding Plot 11 now include a naturalized berm and graded lands which have recolonized with early successional forbs. Given that Plot 11 does not provide core forest habitat, species which require larger tracts of forest would not be expected at this location and this area is not likely to support a high diversity of bird species. This exceedance is likely a natural fluctuation in bird species diversity and does not require any mitigation at this time. Continued monitoring is recommended and mitigation strategies will be developed should this declining trend continue.

Plot 6 and plot 7 positively exceeded the threshold by approximately 1 species during 2015 breeding bird surveys. This is interpreted as a positive trend and may, in part, be the result of the passive and active restoration occurring within the Phase 2 lands adjacent to these plots. The remaining pre-construction plots fell within the mid to upper reach of the threshold range. Similar to 2014 data, Plots 16, 19 and 20 showed decreases from 2013 values. All 3 of these plots have been monitored for the past 5 years with 2015 data somewhat reflective of an overall average over this period. Plot 16 has been subject to recent construction on the adjacent lots while Plots 19 and 20, within Phase 3 lands, have naturalized in the absence of agricultural practices. It is noted that Plots 19 and 20 continue to support significant species including Bobolink, Eastern Meadowlark and Barn Swallow. Trends within these plots should continue to be monitored; however no action is required at this time.

<u>Breeding Bird Abundance</u>

In 2015, breeding bird abundance was average to below average across most of the monitoring plots. Plots 1, 3, 6, 9 and 11 were all below the threshold in 2015 with Plot 5 positively exceeding the threshold and the remaining pre-construction plots within the low end of the threshold range. In 2015, small flocks of certain species such as Red-winged Blackbird and European Starling were noted occasionally, but no exceptionally large flocks were noted and these figures are small in comparison to bird numbers documented in previous years. As discussed in monitoring reports from previous years, the threshold set within Plots 6 and 9 for pre-construction (2006-2009) both include very large numbers of Red-winged Blackbird or Canada Geese which inflated the threshold substantially.

Monitoring should continue to assess breeding bird abundance to determine if bird abundance is being maintained across the site and within the different vegetation communities.

3.5 Amphibian Surveys

3.5.1 Call Count Surveys

Five amphibian species were recorded during evening call count surveys in 2015; Spring Peeper (*Pseudacris crucifer crucifer*), Wood Frog (*Lithobates sylvatica*), American Toad (*Anaxyrus americanus*), Green Frog (*Rana clamitans melanota*) and Gray Treefrog (*Hyla versicolor*). Since 2006, the number of species recorded during the calling anuran surveys has fluctuated. The 5 anuran species recorded calling in 2015 is above average among species numbers recorded in previous years.

Amphibian species abundance is shown in Table 7. These fluctuations may be correlated with changing weather conditions from year to year, such as spring precipitation and night-time air temperatures, which strongly influence amphibian breeding activity.

It should be noted that although 2006 surveys studied 6 amphibian monitoring stations, additional stations were added in subsequent years bringing the total number of stations monitored since 2011 to 16. Appendix VII provides a list of amphibian species and their associated call count information observed by NRSI biologists during surveys from 2006 to 2015.

Table 7. Number of Calling Anuran Species Recorded During Call Count Surveys

Year	# of Species
2006	0
2007	5
2008	4
2009	6
2010	3
2011	4
2012	3
2013	4
2014	5
2015	5

In order to compare species abundance over time and between stations, the maximum call code is used. The maximum call code is used to provide an estimate of abundance, as estimating numbers of individuals is not accurate. The three call codes as per the Marsh Monitoring Protocol (BSC 2008) are:

Call Level 1. Calls can be counted; not simultaneous

Call Level 2. Some simultaneous calls; yet distinguishable

Call Level 3. Calls not distinguishable; overlapping (i.e. “full chorus”)

By comparing the number of stations at which a species was observed, and the maximum call code over time, increases or decreases in species abundance can be determined (see Tables 8 and 9). The following is a brief discussion of trends observed by species:

Spring Peeper

- consistently one of the most abundant calling anurans within the study area, the species remained widely distributed and somewhat abundant in 2015,
- a full chorus (many individuals; too many to count accurately) recorded at Plot 9,
- no individuals recorded at Plot 16 which has had Spring Peeper document each year between 2009-2014.

Green Frog

- an estimated 2 individuals noted calling at Plot 14 in 2015 (the first time this species has been recorded at this plot),
- documented sporadically between 2007 and 2015, always in low numbers.

Gray Treefrog

- was the most widely distributed species in 2015 at 9 of 16 stations,
- was the most abundant calling species in 2015 with an estimate of 56 individuals calling
- has been recorded in high numbers at Plot 1 since 2013. Plot 1 exists within Willow thicket swamp and is regularly subject to seasonal flooding. Other plots with high numbers in 2015 included Plot 10, Plot 12 and Plot 16.

Wood Frog

- since 2006 this species has shown a pattern of higher numbers in one season followed by lower numbers (or none calling) in the next,

- with an estimated 14 individuals calling between 4 plots, 2015 data reflects a year of higher Wood frog abundance,

American Toad

- a single frog was documented during calling anuran surveys at Plot 4,
- throughout the monitoring period (2006-2014) this species has been limited in numbers and distribution throughout the study area.

Other Species

- no Leopard Frog (*Lithobates pipiens*), Pickerel Frog (Lithobates *palustris*) or Western Chorus Frog (*Pseudacris triseriata*) were observed in 2015, either during call counts or incidentally.
- all of these species have been recorded intermittently within the subject property in previous years, with a call code of 1 or 2 and in low numbers,
- Pickerel Frog and Western Chorus Frog have not been documented since 2012.

With regard to the plots:

- 11 of the 16 plots recorded calling anuran species in 2015,
- in 2015, Plots 6, 9 and 16 recorded 3 species of anuran,
- no calling anurans were recorded in 2014 at Plots 4, 8, 13, 17 and 18. These plots often lack standing water and do not always provide ideal anuran breeding habitat.

Table 8. Maximum Call Code Recorded

(insert pdf from excel file)

Table 9. Number of Individual Anurans Recorded During Call Count Surveys

(insert pdf from excel file)

3.5.2 Amphibian Call Survey Site Conditions

Amphibians breed in several types of wetland habitat. All require the presence of water for some duration of the spring. Some species, such as Spring Peeper, Western Chorus Frog, and Wood Frog, take advantage of temporary, seasonal pools created by spring rains and melting snow. The temporary pools dry up by mid to late summer, at which time the tadpoles have metamorphosed into adults and moved to upland habitats. Some species of anurans, such as Leopard Frog, Green Frog, and Bullfrog (*Lithobates catesbeianus*), require semi-permanent to permanent water bodies in order for the tadpoles to develop into adults, which can take up to 2 years.

Since monitoring of calling anurans began in 2006 the hydroperiod, depth and spatial extent of pooled water has varied greatly from one year to the next. These factors are subject to seasonal weather patterns including snow melt and spring precipitation. Research shows that prolonged periods of dry weather may reduce adult breeding populations either directly or through reduced juvenile recruitment and a shortened larval period (Berven 1990). Permanent standing water is present within the constructed SWM ponds for the Business Park in Phase 2 (SWM Pond 4) and SWM Ponds 1 and 2 in Phase 1 (Map 2), as well as the 2 manicured ponds within the residential property north of Laird Road. Incidental observations of amphibians continue to be recorded within the SWM ponds and the maturation of buffer plantings surrounding these features will help to improve these habitats and increase the presence of frog and toad species, in particular American Toad and Spring Peeper.

Weather on the first visit in 2015 (April 29), was 14°C, dropping down to 11°C by the end of the evening. Skies were partly cloudy to overcast with a gentle breeze and no precipitation. The second visit, May 21, had no precipitation, partly cloudy skies, with an air temperature of 14°C dropping to 12°C, with a slight breeze. During the final visit on June 16, air temperature was 20°C dropping to 18°C, with clear skies, no precipitation and low wind.

Water temperatures ranged from 6.0 to 13.2°C on the first visit. During the second visit, water temperatures ranged from 9.1 to 12.5°C. No standing water could be located in the vicinity of any of the plots on the last visit and thus temperature and pH data was not collected. Temperatures and hydroperiod throughout the spring of 2015 were favourable to anuran breeding with mild temperatures between April and June and periodic rainfall to maintain breeding pool features into early June.

Anurans are known to prefer habitats that are pH neutral (pH 7) (Audubon International, 2000). When pH values decrease, becoming acidic, or increase, becoming alkaline, it can impact their survival. Seburn and Seburn (1998) stated that the northern leopard frog breeds successfully at a pH range of 8.5-9.5 and that fertilization of eggs is reduced at a pH of less than 6.5.

Chemical processes such as photosynthesis and drying out that occur daily and throughout the breeding season result in fluctuations of water pH and other water chemistry values (Wetzel 1983). A study of 180 ponds across southwestern Ontario found that pH averaged 8.3 +/-0.05 with a range of 7.2-10.2 (Hecnar and M'Closkey 1996). According to this study, ponds in southwestern Ontario, are generally alkaline, hard, and well buffered with high pH values. Hecnar and M'Closkey (1996) did not find any correlation between amphibian species richness and water chemistry. Several studies have found that amphibian species richness is not related to water chemistry (pH, conductivity, and hardness) (Hecnar and M'Closkey 1996). The presence or absence of anuran species is more commonly related to hydroperiod and the presence of predatory fish.

pH values recorded during the April and May surveys ranged from 7.1 to 8.9 with most in the range of 7.3 to 7.8. This range aligns with average pH values recorded in previous monitoring years. Similar to previous years, pH values in 2015 were based upon all plots which contained water and it should be noted that a number of plots were dry on one or more of the calling amphibian survey dates. The pH values found during the monitoring period are within the normal range for southern Ontario. The recorded pH levels have not been recognized as having harmful effects on the presence of amphibian species.

3.6 Amphibian Threshold Assessment

The thresholds for amphibians established in the HCBP Consolidated Monitoring Program (NRSI 2010) and the HCBP 2011 Consolidated Monitoring Report (NRSI 2012a) are a decrease in species diversity (number of species) by more than 2 species and a significant change in species abundance, measured by a decrease in 2 call codes. Such changes may constitute a concern.

3.6.1 Amphibian Species Diversity

Figure 16 graphs the species diversity for anurans since 2006. In 2015, no plots showed a reduction in species by more than 2 species between 2014 and 2015 or between the pre-construction average and 2015. Plots 4 and 17 showed a reduction of 2 species between 2014 and 2015; however this is considered to be within the threshold limits. Plots 6, 9 and 16 all showed increases in diversity from 1 species documented in 2014 to 3 species in 2015.

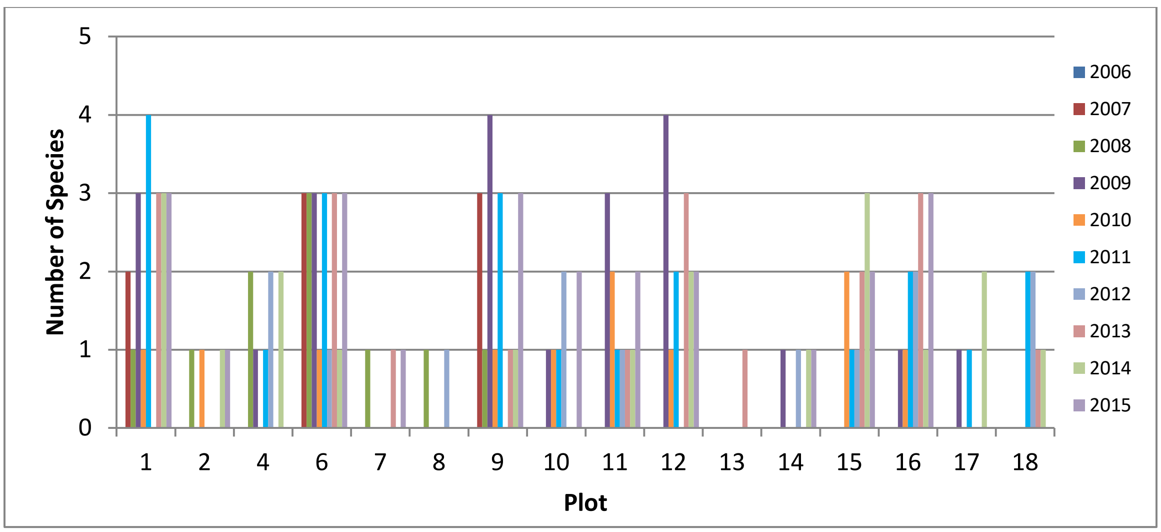

Figure 16. Amphibian Species Diversity 2006 - 2015

3.6.2 Amphibian Species Abundance

A drop in 2 calling codes was established as the threshold in the HCBP Consolidated Monitoring Program (NRSI 2010). Only 2 of these drops were observed in 2015 including:

- Spring Peeper in Plots 12 and 14 – no individuals recorded in 2015, down from a call code 2 recorded at each of these plots in 2014.

It should be noted that Spring Peeper remains widespread and abundant within the study area. Additionally, Spring Peeper was only documented for the first time in Plot 14 in 2014. As the wetland at Plot 12 is now separated from the core natural area by the Laird Road overpass (including soil berm and curb barriers), anuran activity at this plot should continue to be analyzed to determine if development-related effects have occurred.

As previous monitoring reports have noted, the creation and naturalization of the SWM ponds on site has led to increased use of these features for anuran breeding and foraging, in particular by Spring Peepers and American Toads.

The remaining identified species, Green Frog, Northern Leopard Frog, Pickerel Frog and Western Chorus Frog have all been observed intermittently within the study area dating back to the 2007 monitoring year. Generally these species have been observed in low numbers at a call code of 1 or 2. It is likely that these species have always existed in low numbers within the property and are subject to natural population fluctuations.

As noted above, 2 of the 6 species abundance decreases which surpassed the threshold occurred in Plot 16 which was noted previously for decreases in herbaceous vegetation and bird species diversity. Previous monitoring reports have noted the drier conditions being observed at the plot in recent years; during 2015 calling anuran surveys, water was present throughout April and May but had dried up by June. All 3 survey dates note calling anurans from the adjacent SWM swale including approximately 30 Gray Tree Frog, Spring Peeper and American Toad during the May 21 survey. While calling anurans have decreased within the Silver Maple swamp where Plot 16 is located, the vegetated ditches to the west of the plot have become particularly valuable to breeding anurans.

It is difficult to determine the cause of the observed changes at Plot 16. The reduction in seasonal standing water within the central portion of the swamp has undoubtedly made the Plot less suitable for anuran breeding. There is not a clear correlation between the observed changes in Plot 16 and the observed groundwater levels at MW103. It could be that the change is largely related to fluctuations in rainfall from one year to the next. It is also possible that the new road, stormwater conveyance trenches and the development of the adjacent blocks are altering the hydrology sufficiently to reduce the seasonal standing water in the swamp. The swamp and surrounding lands should be investigated in the spring to determine whether there are substantial changes in hydrology.

3.6.3 Amphibian Threshold Summary and Contingency Measures

The HCBP Consolidated Monitoring Program (NRSI 2010, p. 41) suggests the following measures when amphibian species decline beyond the established threshold:

- *"Wetland creation where feasible.*
- *Enhancement plantings to improve wetland condition.*
- *Additional monitoring – broaden range of parameters (i.e. water quality).*
- *Increase buffer plantings or alter if necessary.*
- *Provide educational material to neighbouring properties outlining importance of natural features, wildlife and their protection.*
- *Provide additional signage regarding trail closures, etc."*

In 2015, the only exceedance noted was the drop in Spring Peeper abundance at Plot 12 and Plot 14. As a species which utilizes a variety of habitats and remains abundant across the site, it is not recommended that any contingency measures should be enacted at this time. The thresholds that were exceeded are summarized as follows along with recommendations for continued monitoring.

<u>Amphibian Species Diversity</u>

A reduction in species number by more than 2 (between the preconstruction average and 2015 as well as between 2014 and 2015) was not observed during 2015 monitoring. Plots 4 and 17 both showed a decrease of 2 species; however this decrease is within the threshold limit. Plots 6, 9 and 16 all showed increases in diversity from 1 species documented in 2014 to 3 species in 2015.

Amphibian Species Abundance

A decrease in species abundance beyond the established threshold was recorded at Plots 12 and 14. Spring Peeper was not noted in either plot during the 2015 calling anuran surveys. Plot 12 is now separated from the larger natural area by the Laird Road overpass and associated curbs. As an isolated feature Spring Peepers may have relocated to larger and more suitable habitats in the vicinity or the localized population may have disappeared following several years of drier conditions which may have limited successful reproduction. It should be noted that this species was only recorded within Plot 14 for the first time in 2014.

Monitoring of all anuran plots should continue with a particular focus on changes observed within Plot 16. In the case that anuran diversity and abundance is found to be impacted by development activities, management recommendations may be made in order to mitigate or reverse negative trends.

3.7 Incidental Wildlife Observations

Surveys conducted throughout 2015 resulted in the documentation of a variety of incidental wildlife observations. These observations included birds, herpetofauna, butterflies and mammals that were recorded during the monitoring surveys. Incidental wildlife are summarized below.

3.7.1 Birds

The birds that were observed incidentally in 2015 are listed in Appendix VI. The following species were observed on site incidentally during calling anuran surveys, vegetation surveys or during breeding bird point count surveys but beyond the 100m limit of the survey station. Only those species which were not recorded during breeding bird surveys are listed in Table 10.

Table 10. Incidental Bird Species Observed in the Subject Property

Common Name	Scientific Name	COSEWIC[1]	COSSARO[2]	Wellington County[3]
Chimney Swift	*Chaetura pelagica*	THR	T	√
Cuckoo species	*Coccyzus* sp.			√*
Eastern Bluebird	*Sialia sialis*			
Grasshopper Sparrow	*Ammodramus savannarum*			√
Nashville Warbler	*Oreothlypis ruficapilla*			
Turkey Vulture	*Cathartes aura*			√

[1]COSEWIC 2016; [2]MNRF 2015b; [3]Dougan and Associates 2009

LEGEND
COSEWIC/COSSARO
THR/T – Threatened
Local Status (Wellington)
√ Significant and rare

3.7.2 Amphibians

A consolidated list of all herpetofaunal species observed by NRSI within the subject property since 1998 is included in Appendix VIII. Similar to previous monitoring years, numerous calling individuals of both American Toad and Spring Peeper were noted from within the SWM ponds present on site. SWM ponds with regular mention of calling anuran activity include those directly east of Downey Road (SWM Pond 2), the SWM swale directly north of Plot 7, and SWM Pond 4 south of Laird Road near Plot 13. Although these features are relatively new and in the early stages of naturalization, this observed amphibian use indicates that these features may provide suitable breeding habitat for amphibian species. SWM pond locations are shown on Map 2.

3.7.3 Snakes

No snakes were observed within the study area during 2015 surveys. Several species of snake have been observed in previous monitoring years (Appendix VIII).

3.7.4 Butterflies

A number of butterfly species were observed during the 2015 surveys including; Viceroy (*Limenitis archippus*), Red Admiral (*Vanessa atalanta*), Common Wood-Nymph (*Cercyonis pegala*), Northern Crescent (*Phyciodes cocyta*), Cabbage White (*Pieris rapae*), Summer Azure (*Celastrina neglecta*), European Skipper (*Thymelicus lineola*), and Clouded Sulphur (*Colias philodice*). Many of these species were observed along the recreational trail system where a variety of forbs provide nectar sources throughout the year.

3.7.5 Odonates

During 2015 surveys a Chalk-fronted Corporal (*Ladona julia*) was documented within the study area. No other odonates (dragonflies or damselflies) were documented in 2015.

3.7.6 Mammals

Table 11 lists the mammals that were observed incidentally in 2015, either directly or through their signs (i.e. trails, tracks, scat, dens, etc.).

Table 11. Incidental Mammal Species Observed in the Subject Property

Common Name	Scientific Name	Observation Type
Coyote	*Canis latrans*	Direct observation
Meadow Vole	*Microtus pennsylvanicus*	Direct observation
Eastern Gray Squirrel	*Sciurus carolinensis*	Direct observation
Eastern Red Squirrel	*Tamiasciurus hudsonicus*	Direct observation
White-tailed Deer	*Odocoileus virginianus*	Direct observation
Unidentified bat species	*n/a*	Several individuals foraging near Plot 1 and 15 during calling anuran surveys

4.0 Conclusions and Recommendations

The 2015 monitoring year was successful in providing the sixth year of during construction data, contributing to a useful data set that can be compared to pre-construction data and data from future during construction years.

Vegetation

Vegetation plot surveys in 2015 identified 12 species which had not been previously recorded on site. Of these 12 species, 11 were native including the regionally rare Hay-scented Fern. The average CC values for plots have remained relatively stable and no notable changes have occurred in terms of non-native species presence within the plots.

Average CW values indicate that Plot 1 and Plot 4 remain the wettest plots; however the drying trend across the site remains apparent with 8 of 11 vegetation plots showing drier average CW values in 2015 over 2014 values. As discussed previously, it is inferred that the exceptionally dry spring of 2012 has had lingering effects on the composition of vegetation. Groundwater monitoring suggests that the watertable had returned to an average depth by 2013 and the representation and vigour of vegetation within plot may lag for several years before rebounding.

Several vegetation thresholds were exceeded in 2015 both in herbaceous cover and species diversity. At this time no contingency measures have been recommended. For herbaceous cover Plot 2 showed a positive exceedance with a flush of Spotted Jewelweed and Marsh Marigold within the plot. This change may be influenced by the decline of Ash trees in the plot and the increase in native herbaceous groundcover is a positive result. While the decline of Ash is not related to the development, the establishment of non-native species such as Glossy Buckthorn will be monitored in coming years as increases in sunlight as a result of canopy opening can allow them to proliferate. Plot 3 showed a negative threshold exceedance but the herbaceous cover within this plot has doubled annually in each of the past 2 monitoring years. The changes in this plot, focused largely around Ostrich Fern, are likely the result of natural changes in available soil moisture as well as impacts due to deer browse.

The species diversity threshold was positively exceeded in both Plot 1 and Plot 2. As the increases were native species this is interpreted as a positive change. Situated among a dense stand of White Cedar, Plot 5 showed a negative exceedance in species diversity based on 9 species recorded in the plot in 2015. The low species count makes this plot susceptible to exceeding the threshold regularly; for example, had 10 species been recorded the diversity would have fallen within threshold limits.

Birds

In 2015 bird species diversity figures were reflective of the overall average throughout the monitoring period. Plot 11, situated within the Heritage Maple Grove showed a negative threshold exceedance; however there was no nearby construction in 2015 and the Forestell Road berm has naturalized with successional meadow species and young trees and shrubs. Both Plot 19 and Plot 20 have shown a decrease in diversity, yet these plots continue to provide suitable habitat for a variety of grassland bird species. Plot 6 and Plot 7 showed a positive threshold exceedance in bird species diversity which may be attributed to improved edge habitat through restoration and naturalization of areas adjacent to these plots.

Bird abundance has shown some variation from year to year and within individual plots. The inclusion of large flocks in some years has influenced the threshold ranges and these occurrences should be considered when analyzing the during-construction data set. At this time no contingency measures have been recommended.

Amphibians

Anuran surveys in 2015 did not identify any exceedances in species diversity thresholds. Both Plot 4 and Plot 17 decreased by 2 species from 2014 data but these changes are within the identified threshold range.

The threshold for species abundance was negatively exceeded in Plot 12 and Plot 14 in 2015. Plot 12 is now separated from the larger natural feature by the Laird Road overpass and associated roads and curbs. It is possible that individuals relocated to the core feature or seasonally dry conditions have impacted reproductive success resulting in lower numbers of anurans being present in this feature.

The exceedance in Plot 14 is a result of large amounts of Spring Peepers calling in 2014 but none during 2015 surveys. It is noted that this species was only recorded from Plot 14 in 2014 and it does not appear that the species had utilized this area in the years prior (2009-2013).

Discussion of the observed fluctuations in amphibian data focus largely on climatic conditions including temperature and the extent of vernal pools during the April to June amphibian breeding period. Amphibian breeding may fluctuate as individuals relocate based upon suitable breeding habitat within the study area.

Monitoring of all anuran plots should continue with a particular focus on changes observed within Plot 12 and Plot 16. In the case that anuran diversity and abundance is found to be impacted by development activities, management recommendations may be made in order to mitigate or reverse negative trends. In addition, the swamp and surrounding lands should be investigated in the spring to determine whether there are substantial changes in hydrology.

In 2016, it is anticipated that further building construction will occur within Phase 1, Stage 3. No works are anticipated to occur within Phase 1, Stage 2, Phase 2 or Phase 3.

It is recommended that during-construction monitoring continue in 2016 as done in 2015, with vegetation, breeding bird, and anuran call count surveys. NRSI will continue to document all incidental observations of wildlife species within the Business Park.

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APPENDIX I

Vegetation Species Observed in the Subject Property 2006 - 2015

Appendix I. Vegetation Species Observed in the Study Area (2006 - 2015)

									Wellington	NRSI									
Scientific Name	Common Name	CC	CW	Weed	+	SRANK[1]	COSEWIC[2]	COSSARO[3]	County[4]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Abies balsamea	Balsam Fir	5	-3			S5				√	√	√	√	√	√	√	√	√	√
Acer rubrum	Red Maple	4	0			S5				√	√	√	√	√	√	√	√	√	√
Acer saccharinum	Silver Maple	5	-3			S5				√	√	√	√	√	√	√	√	√	√
Acer saccharum ssp. saccharum	Sugar Maple	4	3			S5				√	√	√	√	√	√	√	√	√	√
Actaea spp.	Baneberry species										√		√					√	
Agrostis stolonifera	Redtop		-3			S5												√	
Alisma spp.	Water Plantain species											√							
Alliaria petiolata	Garlic Mustard	*	0	-3	+	SE5									√				
Allium tricoccum	Wild Leek	7	2			S5					√								
Amelanchier arborea	Downy Serviceberry	5	3			S5											√		
Arabis glabra	Tower-mustard	0	0			S5						√							
Aralia nudicaulis	Wild Sarsaparilla	4	3			S5				√	√	√	√	√	√	√	√	√	√
Aralia racemosa ssp. racemosa	Spikenard	7	5			S5													√
Arctium minus	Common Burdock	*	5	-2	+	SE5					√						√		
Arctium species	Burdock species															√			
Arisaema triphyllum	Jack-in-the-pulpit	5	-2			S5				√	√	√	√	√	√	√	√	√	√
Aronia melanocarpa	Black Chokeberry	7	-3			S5										√			
Asclepias incarnata ssp. Incarnata	Swamp Milkweed	6	-5			S5				√	√						√	√	√
Asclepias syriaca	Common Milkweed	0	5			S5				√								√	√
Aster species	Aster species												√		√		√		
Athyrium filix-femina var. angustum	Northeastern Lady Fern	4	0			S5							√	√					√
Betula alleghaniensis	Yellow Birch	6	0			S5				√	√	√	√	√	√	√	√	√	√
Bidens cernua	Nodding Beggarticks	2	-5			S5								√				√	
Bidens frondosa	Devil's beggarticks	3	-3			S5										√	√	√	√
Bidens tripartita	Beggarticks	4	-3			S5					√	√							
Boehmeria cylindrica	False Nettle	4	-5			S5										√		√	√
Bromus inermis ssp. inermis	Smooth Brome	*	5	-3	+	SE5					√				√			√	√
Calamagrostis canadensis	Canada Blue-joint	4	-5			S5				√	√	√	√	√	√	√	√	√	√
Caltha palustris	Marsh Marigold	5	-5			S5				√	√	√	√	√	√	√	√	√	√
Cardamine pensylvanica	Pennsylvania Bitter Cress	6	-3			S5							√						
Carex albursina	White bear Sedge	7	5			S5										√			
Carex aquatilis	Water Sedge	7	-5			S5							√	√	√	√	√	√	√
Carex arctata	Compressed Sedge	5	5			S5							√						
Carex bebbii	Bebb's Sedge	3	-5			S5											√		
Carex blanda	Smooth Sedge	3	0			S5										√	√	√	
Carex eburnea	Bristle-leaved Sedge	6	4			S5													√
Carex flava	Yellow Sedge	5	-5			S5										√	√		
Carex gracillima	Graceful Sedge	4	3			S5							√	√		√	√	√	√
Carex hystercina	Porcupine Sedge	5	-5			S5										√			
Carex intumescens	Bladder Sedge	6	-4			S5							√		√	√			
Carex lacustris	Lake Sedge	5	-5			S5				√		√	√	√	√	√	√	√	√
Carex laxiflora	Loose-flowered Sedge	5	0			S5							√				√	√	√
Carex lupulina	Hop Sedge	6	-5			S5										√	√	√	
Carex pedunculata	Long-stalked Sedge	5	5			S5													√
Carex pensylvanica	Pennsylvania Sedge	5	5			S5										√			√
Carex radiata	Radiate Sedge	4	5			S5													√
Carex species	Sedge species									√	√	√	√	√	√		√		√
Carex stipata	Awl-fruited Sedge	3	-5			S5				√	√	√	√	√	√	√		√	√
Carex stricta	Stiff Sedge	4	-5			S5						√	√	√			√		√
Carex utriculata	Beaked Sedge	7	-5			S5					√		√		√				
Carex vulpinoidea	Fox Sedge	3	-5			S5						√	√	√	√	√	√	√	
Carpinus caroliniana	Blue Beech	6	0			S5										√			
Cerastium fontanum	Mouse-eared Chickweed	*	3	-1	+	SE5											√		
Chelone glabra	Turtlehead	7	-5			S5										√	√	√	√

Scientific Name	Common Name	CC	CW	Weed	+	SRANK[1]	COSEWIC[2]	COSSARO[3]	Wellington County[4]	NRSI 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cicuta bulbifera	Bulbous Water-hemlock	5	-5			S5						√	√	√	√	√		√	√
Cicuta maculata	Spotted Water Hemlock	6	-5			S5				√	√	√	√	√	√	√	√	√	√
Circaea alpina	Dwarf Enchanter's Nightshade	6	-3			S5				√			√			√	√	√	√
Circaea lutetiana ssp. canadensis	Yellowish Enchanter's Nightshade																√	√	√
Circaea quadrisulcata	Enchanter's Nightshade	3	3			S5				√	√	√	√	√	√	√			
Cirsium arvense	Canada Thistle	*	3	-1	+	SE5				√	√	√	√	√	√	√	√	√	√
Cirsium muticum	Swamp Thistle	8	-5			S5											√	√	
Cirsium species	Thistle species															√			
Cirsium vulgare	Bull Thistle	4	5			S5											√		
Clintonia borealis	Bluebead Lily	7	-1			S5					√	√	√	√	√	√	√	√	√
Coptis trifolia	Goldthread	7	-3			S5					√								
Cornus alternifolia	Alternate-leaved Dogwood	6	5			S5				√	√	√	√	√	√	√	√	√	√
Cornus amomum	Silky Dogwood	5	-4			S5										√	√	√	√
Cornus foemina	Gray Dogwood	2	-2			S5											√		√
Cornus stolonifera	Red-Osier Dogwood	2	-3			S5				√	√	√	√	√	√	√	√	√	√
Corylus americana	American Hazel	5	4			S5								√					
Crataegus species	Hawthorn species									√	√				√				
Cypripedium calceolus var. parviflorum	Small Yellow Lady's Slipper	7	-1			S5							√						
Cysptopteris tenuis	Mackay's Fragile Fern	6	5									√						√	
Cystopteris bulbifera	Bulblet Fern	5	-2			S5				√	√		√	√	√	√	√	√	√
Dactylis glomerata	Orchard Grass	*	3	-1	+	SE5										√	√	√	√
Daucus carota	Queen Anne's Lace	*	5	-2	+	SE5					√		√	√	√	√	√	√	
Dennstaedtia punctilobula	Hay-scented fern					S5			R										√
Doellingeria umbellata	Flat-top White Aster	6	-3			S5										√			
Dryopteris carthusiana	Spinulose Wood Fern	5	-2			S5				√	√	√	√	√	√	√	√	√	√
Dryopteris clintoniana	Clinton's Wood Fern	7	-4			S4			R		√			√	√				
Dryopteris cristata	Crested Wood Fern	7	-5			S5				√	√	√	√	√	√		√	√	√
Dryopteris intermedia	Evergreen Wood Fern	5	0			S5													√
Dryopteris marginalis	Marginal Wood Fern	5	3			S5							√	√	√	√	√	√	√
Dryopteris sp.	Wood Fern Species																	√	
Echinochloa crusgalli	Barnyard Grass	*	3	-1	+	SE5							√	√				√	
Echinocystis lobata	Wild Cucumber	3	-2			S5					√	√	√		√	√	√	√	√
Eleocharis smallii	Small's Spike-rush	6	-5			S5								√					
Elymus repens	Quack Grass	*	3	-3	+	SE5						√					√		
Epilobium ciliatum ssp. glandulosum	Willow-herb	6	3			SU										√		√	
Epilobium hirsutum	Hairy Willow-Herb	*	-4	-2	+	SE5							√	√	√	√	√		√
Epilobium sp.	Willow-Herb species																√		√
Epipactis helleborine	Helleborine	*	5	-2	+	SE5						√	√	√		√		√	√
Equisetum arvense	Field Horsetail	0	0			S5					√	√	√	√	√	√	√	√	√
Equisetum palustre	Marsh Horsetail	10	-3			S5			R	√	√				√				
Equisetum pratense	Meadow Horsetail	8	-3			S5			R	√		√	√	√	√	√		√	√
Equisetum scirpoides	Dwarf Scouring-rush	7	-1			S5								√			√	√	√
Erigeron annuus	Daisy Fleabane																	√	
Erigeron philadelphicus	Philadelphia Fleabane	1	-3			S5													√
Erigeron species	Fleabane species										√					√			
Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5							√	√	√	√	√	√	√	√	√	√
Eupatorium perfoliatum	Boneset	2	-4			S5					√	√				√	√	√	√
Eurybia macrophylla	Large-leaved Aster	5	5			S5				√			√						
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2			S5						√	√	√	√	√	√	√	√
Fagus grandifolia	American Beech	6	3			S5					√								
Festuca arundinacea	Tall Fescue	*	2	-1	+	SE5											√	√	
Festuca pratensis	Meadow Fescue	*	4	-1	+	SE5													√
Fragaria vesca	Woodland Strawberry	4	4							√	√	√	√		√	√	√	√	
Fragaria virginiana	Wild Strawberry	2	1			S5					√	√	√	√	√	√	√	√	
Fraxinus americana	White Ash	4	3			S5				√	√	√	√	√	√	√	√	√	√
Fraxinus nigra	Black Ash	7	-4			S5				√	√	√	√	√	√	√	√	√	√

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Fraxinus pennsylvanica var. subintegerrina	Green Ash	3	-3												√	√	√	√	√
Galium asprellum	Rough Bedstraw	6	-5			S5				√		√	√						
Galium palustre	Marsh Bedstraw	5	-5			S5				√	√	√	√	√	√	√	√	√	√
Galium triflorum	Sweet-scented Bedstraw	4	2			S5				√		√	√	√					
Geranium robertianum	Herb Robert	*	5	-2	+	SE5				√	√	√	√	√	√		√	√	√
Geum aleppicum	Yellow Avens	2	-1			S5						√	√	√	√	√	√	√	√
Geum canadense	White Avens	3	0			S5					√						√	√	
Geum laciniatum	Rough Avens	4	-3			S4			R		√				√	√			
Geum species	Avens species									√							√	√	√
Glyceria species	Manna Grass species														√				
Glyceria striata	Fowl Manna Grass	3	-5			S5					√		√		√	√	√	√	√
Gymnocarpium dryopteris	Oak Fern	7	0			S5					√	√	√	√		√	√		√
Hamamelis virginiana	Witch Hazel	6	3			S5			R						√				
Heracleum lanatum	Cow Parsnip	3	-3			S5										√			
Hieracium species	Hawkweed species											√							
Hydrocotyle americana	Marsh-Water Pennywort	7	-5			S5				√			√						√
Hydrophyllum virginianum	Virginia Waterleaf	6	-2			S5						√		√					
Ilex verticillata	Winterberry	5	-4			S5									√	√	√	√	√
Impatiens capensis	Spotted Jewelweed	4	-3			S5				√	√		√	√	√	√	√	√	√
Impatiens pallida	Pale Jewelweed	7	-3			S5			R		√	√			√				
Iris species	Iris species	0	0								√								
Juncus effusus	Soft Rush	4	-5										√	√			√		
Juncus dudleyi	Dudley's Rush	1	0			S5													√
Juncus species	Rush species									√	√								
Juncus tenuis	Path Rush	0	0			S5				√		√	√	√	√	√	√	√	
Lactuca serriola	Prickly Lettuce	*	0			SE5				√			√						
Leersia oryzoides	Rice Cutgrass	3	-5			S5				√			√		√	√	√	√	√
Linaria vulgaris	Butter-and-eggs	*	5	-1	+	SE5						√							
Liparis loeselii	Fen Twayblade	5	-4			S4S5											√		
Lobelia siphilitica	Great Lobelia	6	-4			S5								√		√			
Lonicera canadensis	Fly Honeysuckle	6	3			S5										√			
Lonicera tatarica	Tartarian Honeysuckle	*	3	-3	+	SE5				√	√	√	√	√	√	√	√	√	√
Lotus corniculatus	Bird's-foot Trefoil	*	1	-2	+	SE5				√	√	√	√	√	√	√	√	√	
Lycopus americanus	American Water-horehound	4	-5			S5											√	√	
Lycopus uniflorus	Northern Bugleweed	5	-5			S5				√	√	√	√	√	√	√	√	√	√
Lysimachia ciliata	Fringed Loosestrife	4	-3			S5					√	√	√	√	√	√	√	√	√
Lysimachia nummularia	Moneywort	*	-4	-3	+	SE5					√								
Lysimachia terrestris	Swamp Candles	6	-5			S5					√		√		√	√	√		
Lysimachia thyrsiflora	Tufted Loosestrife	7	-5								√	√	√	√	√	√		√	√
Lythraceae spp.	Loosestrife species											√							
Lythrum salicaria	Purple loosestrife	*	-5	-3	+	SE5										√			√
Maianthemum canadense	Canada Mayflower	5	0			S5				√	√	√	√	√	√	√	√	√	√
Maianthemum racemosum	False Solomon's Seal	4	3							√	√	√			√	√		√	
Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1			S5						√	√	√					√
Malva neglecta	Common Mallow	*	5	-1	+	SE5									√				
Marchantia polymorpha	Common Liverwort					S5										√			
Matteuccia struthiopteris	American Ostrich Fern	5	-3							√	√	√	√	√	√	√	√	√	√
Medicago lupulina	Black Medick	*	1	-1	+	SE5								√	√	√	√		
Mentha arvensis	Common Mint	3	-3							√	√		√	√	√	√	√	√	√
Mentha X piperita	Pepper Mint	*	-5	-1		SE4										√			
Mitella nuda	Naked Miterwort	6	-3			S5										√	√	√	
Myosotis sp.	Forget-me-not species																	√	
Nasturtium officinale	Watercress	*	-5	-1	+	SE?							√	√	√	√	√	√	√
Onoclea sensibilis	Sensitive Fern	4	-3			S5				√	√	√	√	√	√	√	√	√	√
Osmunda cinnamomea	Cinnamon Fern	7	-3			S5					√		√	√	√	√	√	√	√
Ostrya virginiana	Ironwood	4	4			S5				√		√							

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Oxalis stricta	Upright Yellow Wood Sorrel	0	3			S5										√			
Parthenocissus vitacea	Woodbine	3	3			S5											√	√	√
Parthenocissus quinquefolia	Virginia Creeper	6	1			S4?				√	√	√	√	√	√	√			√
Phalaris arundinacea	Reed Canary Grass	0	-4			S5					√	√	√	√	√	√	√	√	√
Phleum pratense	Timothy	*	3	-1	+	SE5						√		√	√	√	√	√	√
Physocarpus opulifolius	Ninebark	5	-2			S5													√
Picea glauca	White Spruce	6	3			S5				√	√	√	√	√	√				√
Pilea pumila	Clearweed	5	-3			S5			R			√					√		√
Pinus strobus	Eastern White Pine	4	3			S5				√	√	√	√	√	√	√	√		
Plantago lanceolata	English Plantain	*	0	-1	+	SE5								√					
Plantago major	Common Plantain	*	-1	-1	+	SE5								√	√				
Poa nemoralis	Woodland Spear Grass	0	0	-1		SE3							√						
Poa palustris	Fowl Meadow Grass	5	-4			S5									√	√	√	√	√
Poa pratensis	Kentucky Blue Grass	0	1								√	√	√	√	√	√	√	√	√
Poa sp.	Grass species									√	√	√	√	√	√	√	√	√	√
Polygonatum pubescens	Hairy Solomon's Seal	5	5			S5					√	√			√	√	√		√
Polygonum amphibium	Water Smartweed	5	-5												√				
Polygonum species	Smartweed species																√		
Polygonum virginianum	Jumpseed	6	0			S4										√			
Polystichum acrostichoides	Christmas Fern	5	5			S5				√		√	√	√	√				
Populus balsamifera	Balsam Poplar	4	-3			S5													√
Populus tremuloides	Trembling Aspen	2	0			S5										√		√	
Potentilla recta	Sulphur Cinquefoil	*	5	-2	+	SE5										√	√		
Prenanthes alba	White Rattlesnake-root	6	3			S5				√									
Prunella vulgaris ssp. lanceolata	Selfheal	5	5			S5								√	√	√	√	√	√
Prunus pensylvanica	Pin Cherry	3	4			S5								√					
Prunus serotina	Black Cherry	3	3			S5				√	√	√	√	√	√	√	√	√	
Prunus virginiana	Chokecherry	2	1									√	√		√		√	√	√
Quercus macrocarpa	Bur Oak	5	1			S5												√	√
Quercus rubra	Red Oak	6	3			S5								√					
Quercus sp.	Oak species																√	√	
Ranunculus abortivus	Small-flowered Buttercup	2	-2			S5				√	√						√		
Ranunculus acris	Tall Buttercup	*	-2	-2	+	SE5				√	√		√	√	√	√	√	√	√
Ranunculus flabellaris	Yellow Water-crowfoot	7	-5			S4?			R			√			√				
Ranunculus hispidus var caricetorum	Swamp Buttercup	5	-5							√			√			√	√	√	
Ranunculus pensylvanicus	Bristly Buttercup	3	-5			S5						√							
Ranunculus recurvatus	Hooked Buttercup	4	-3								√	√				√			√
Ranunculus repens	Creeping Buttercup	0	-1	-1		SE5					√			√		√	√		√
Ranunculus sceleratus	Cursed Crowfoot	2	-5								√		√	√					
Ranunculus species	Buttercup species														√				
Rhamnus cathartica	Common Buckthorn	*	3	-3	+	SE5				√	√	√	√	√	√	√	√	√	√
Rhamnus frangula	Glossy Buckthorn	*	-1	-3	+					√	√	√	√	√	√	√	√	√	√
Rhynchospora alba	White Beaked-rush	10	-5			S5										√			
Ribes americanum	Wild Black Currant	4	-3			S5				√	√	√		√	√	√		√	√
Ribes hirtellum	Smooth Gooseberry	6	-3			S5			R				√						
Ribes lacustre	Bristly Black Currant	7	-3			S5					√								
Ribes rubrum	Red Currant	*	5	-2	+	SE5						√			√				
Ribes species	Currant species									√	√			√	√				
Ribes triste	Swamp Red Currant	6	-5			S5									√	√			
Rubus allegheniensis	Common Blackberry	2	2			S5					√				√				
Rubus idaeus	Red Raspberry	0	-2							√	√	√	√	√	√		√	√	√
Rubus occidentalis	Black Raspberry	2	5			S5							√			√			
Rubus parviflorus	Sparse-flowered Thimbleberry	7	2			S4									√				
Rubus pubescens	Dwarf Raspberry	4	-4			S5				√	√	√	√	√	√	√	√	√	√
Rumex crispus	Curled Dock	*	-1	-2	+	SE5						√		√	√				

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Sagittaria latifolia	Common Arrowhead	4	-5			S5										√	√	√	√
Salix bebbiana	Bebb's Willow	4	-4			S5						√			√				
Salix eriocephala	Heart-leaved Willow	4	-3			S5								√	√	√	√	√	
Salix exigua	Sandbar Willow	3	-5			S5				√									
Salix lucida	Shining Willow	5	-4			S5									√				
Salix petiolaris	Slender Willow	3	-4			S5				√		√	√	√	√	√	√	√	√
Salix species	Willow species										√			√	√				
Sambucus canadensis	Common Elderberry	5	-2			S5				√				√	√		√	√	√
Sanguinaria canadensis	Bloodroot	5	4			S5									√				
Scirpus americanus	Common Three Square	6	-5							√									
Scirpus atrovirens	Dark Green Bulrush	3	-5			S5						√	√	√	√	√	√	√	√
Scirpus cyperinus var. cyperinus	Wool-grass	4	-5			S5												√	
Scutellaria galericulata	Common Skullcap	6	-5			S5				√		√	√		√	√	√	√	√
Scutellaria lateriflora	Mad-dog Skullcap	5	-5			S5				√	√			√		√			√
Scutellaria species	Skullcap species									√									
Silene cucubalus	Bladder Campion	*	5	-1	+					√									
Sium suave	Water Parsnip	4	-5			S5				√	√	√		√	√		√	√	√
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	+	SE5				√	√	√	√	√	√	√	√	√	√
Solidago altissima	Tall Goldenrod	1	3							√				√	√	√	√	√	√
Solidago caesia	Blue-stem Goldenrod	5	3			S5										√			
Solidago canadensis	Canada Goldenrod	1	3			S5				√	√	√	√	√	√	√	√	√	√
Solidago flexicaulis	Zig-zag Goldenrod	6	3			S5				√				√	√	√	√	√	√
Solidago gigantea	Late Goldenrod	4	-3			S5									√		√	√	√
Solidago nemoralis	Gray Goldenrod	2	5									√							
Solidago patula	Rough-leaved Goldenrod	8	-5			S5			R		√	√			√	√		√	√
Solidago rugosa	Rough-stemmed Goldenrod	4	-1			S5										√	√	√	√
Solidago species	Goldenrod species									√	√	√	√	√					
Solidago uliginosa	Bog Goldenrod	9	-5			S5											√		
Sonchus arvensis	Field Sow Thistle	*	1	-1	+							√		√			√		
Sorbus americana	Mountain Ash	8	-1			S5			R					√					√
Spirodela polyrhiza	Duckweed	4	-5			S5					√		√	√					
Stachys species	Hedge Nettle species															√			
Symphyotrichum lanceolatum	Panicled Aster	3	-3											√	√	√	√	√	√
Symphyotrichum lateriflorum	Calico Aster	3	-2												√	√	√	√	√
Symphyotrichum novae-angliae	New England Aster	2	-3			S5					√	√		√	√	√	√	√	√
Symphyotrichum puniceum	Purple Stemmed Aster	6	-5			S5				√	√		√	√	√	√	√	√	√
Taraxacum officinale	Common Dandelion	*	3	-2	+	SE5				√	√	√	√	√	√	√	√	√	√
Thelypteris palustris	Marsh Fern	5	-4							√	√	√	√		√	√	√	√	√
Thuja occidentalis	Eastern White Cedar	4	-3			S5				√	√	√	√	√	√	√	√	√	√
Tiarella cordifolia	Foam Flower	6	1			S5					√			√	√				√
Tilia americana	Basswood	4	3			S5													√
Toxicodendron radicans ssp. negundo	Poison Ivy	5	-1							√	√		√		√	√		√	
Toxicodendron rydbergii	Western Poison-ivy	0	0			S5											√		√
Trientalis borealis	Starflower	6	-1							√	√		√		√	√	√		√
Trifolium hybridum	Alsike Clover	*	1	-1	+					√				√	√		√		
Trifolium pratense	Red Clover	*	2	-2	+	SE5						√							
Trifolium repens	White Clover	*	2	-1	+	SE5								√					
Trillium sp.	Trillium species																√	√	
Tsuga canadensis	Eastern Hemlock	7	3			S5				√	√	√	√	√	√	√	√	√	√
Tussilago farfara	Coltsfoot	*	3	-2	+	SE5				√	√	√	√	√	√	√	√	√	√
Typha angustifolia	Narrow-leaved Cattail	3	-5			S5								√	√		√	√	√
Typha latifolia	Common Cattail	3	-5			S5				√	√	√	√	√			√		
Ulmus americana	White Elm	3	-2			S5				√	√	√	√	√	√	√	√	√	√
Urtica dioica ssp. gracilis	American Stinging Nettle	2	-1			S5											√		
Verbascum thapsus	Common Mullein	*	5	-2	+	SE5											√		
Veronica americana	American Brooklime	6	-5			S5										√			

Scientific Name	Common Name	CC	CW	Weed	+	SRANK[1]	COSEWIC[2]	COSSARO[3]	Wellington County[4]	NRSI 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Veronica anagallis-aquatica	Water Speedwell	*	-5	-1	+	SE5				√					√	√			
Veronica officinalis	Common Speedwell	*	5	-2	+	SE5						√	√		√	√	√		√
Veronica persica	Bird's-eye Speedwell	*	5	-1	+	SE4										√			
Veronica scutellata	Marsh Speedwell	7	-5			S5				√		√							√
Veronica species	Speedwell species										√	√	√	√					
Viburnum trilobum	High-bush Cranberry	5	-3			S5				√			√	√	√		√	√	
Viburnum opulus	Guelder-rose	*	0	-1	+	SE4										√	√		√
Viola species	Violet Species														√				
Vitis riparia	Riverbank Grape	0	-2			S5				√	√	√	√	√	√	√	√	√	√
Waldsteinia fragarioides	Barren Strawberry	5	5			S5					√			√	√				
Total					**44**				**12**	**96**	**109**	**108**	**117**	**123**	**138**	**147**	**146**	**135**	**141**

[1]MNRF 2016a; [2]COSEWIC 2016; [3]MNRF 2016b, [4]Dougan & Associates 2009

LEGEND	
Floristic Information	
CC	Coefficient of Conservatism
CW	Coefficient of Wetness
Weed	Weediness Index
+	non-native species
SRANK	
S3	Vulnerable
S4	Apparently Secure
S5	Secure
?	Uncertainty about rank
SE	Exotic species
Wellington Status	
R	Rare

APPENDIX II
Herbaceous Species Observed by Plot 2015

Appendix II. Vegetation Species Observed by Plot (2015)

* Frequency is the percent chance the species is found in the 5 subplots. E.g. If the species was found in only one subplot, its frequency is 20%. If it was found in 4 subplots, its frequency is 80%.

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)*
Vegetation Plot 001		MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh					
1	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	20	30	80
	Lysimachia thrysiflora	Tufted Loosestrife	7	-5	0	4	4	20
	Carex stricta	Tussock Sedge	4	-5	0		10	40
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	6	10	40
	Equisetum arvense	Field Horsetail	0	0	0	3	5	40
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	1	2	60
	Carex lacustris	Lake Sedge	5	-5	0		50	80
2	*Lythrum salicaria*	Purple Loosestrife	*	-5	-3	2	2	20
	Solidago canadensis	Canada Goldenrod	1	3	0	5	5	60
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	3	5	40
	Impatiens capensis	Spotted Jewelweed	4	-3	0	15	10	80
	Cicuta bulbifera	Bulbous Water-hemlock	5	-5	0	15	5	40
	Dryopteris cristata	Crested Wood Fern	7	-5	0	1	1	20
3	*Solanum dulcamara*	Bittersweet Nightshade	*	0	-2	5	5	40
	Carex lacustris	Lake Sedge	5	-5	0		100	80
	Solidago canadensis	Canada Goldenrod	1	3	0	2	2	60
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	1	1	60
4	*Solanum dulcamara*	Bittersweet Nightshade	*	0	-2	2	5	40
	Carex lacustris	Lake Sedge	5	-5	0		100	80
	Impatiens capensis	Spotted Jewelweed	4	-3	0	3	3	80
5	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	10	20	80
	Cicuta bulbifera	Bulbous Water-hemlock	5	-5	0	10	2	40
	Solidago canadensis	Canada Goldenrod	1	3	0	4	4	60
	Carex lacustris	Lake Sedge	5	-5	0		20	80
	Taraxacum officinale	Common Dandelion	*	3	-2	2	5	20
	Carex stricta	Tussock Sedge	4	-5	0		25	40
	Equisetum arvense	Field Horsetail	0	0	0	2	5	40
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	1	1	60
	Epilobium hirsutum	Hairy Willow-Herb	*	-4	-2	1	1	20

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 002		SWCO1-2	White Cedar - Conifer Organic Coniferous Swamp					
1	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	5	20	100
	Caltha palustris	Marsh marigold	5	-5	0	4	25	60
	Circaea lutetiana ssp. canadensis	Yellowish Enchanter's Nights	3	3	0	2	10	40
2	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	40	95	100
	Caltha palustris	Marsh marigold	5	-5	0	1	5	60
3	*Taraxacum officinale*	Common Dandelion	*	3	-2	2	5	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	9	40	100
	Scutellaria lateriflora	Mad-dog Skullcap	5	-5	0	3	5	40
	Glyceria striata	Fowl Manna grass	3	-5	0		1	20
4	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	8	40	100
	Solidago canadensis	Canada Goldenrod	1	3	0	3	5	20
	Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5	0	1	2	20
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	2	3	40
5	*Caltha palustris*	Marsh Marigold	5	-5	0	2	10	60
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	2	2	40
	Circaea lutetiana ssp. canadensis	Yellowish Enchanter's Nights	3	3	0	1	2	40
	Impatiens capensis	Spotted Jewelweed	4	-3	0	2	5	100
	Scutellaria lateriflora	Mad-dog Skullcap	5	-5	0	1	1	40

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 003		FODM6	Fresh-Moist Sugar Maple Deciduous Forest					
1	*Matteuccia struthiopteris*	Ostrich Fern	5	-3	0	3	10	80
	Arisaema triphyllum	Jack-in-the-pulpit	5	-2	0	2	1	20
2	*Matteuccia struthiopteris*	Ostrich Fern	5	-3	0	8	60	80
3	*Matteuccia struthiopteris*	Ostrich Fern	5	-3	0	4	30	80
4	*Onoclea sensibilis*	Sensitive Fern	4	-3	0	4	30	20
5	*Matteuccia struthiopteris*	Ostrich Fern	5	-3	0	1	10	80

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 004		**SWMM1-1**	**White Cedar - Hardwood Mineral Mixed Swamp**					
1	*Asclepias incarnata*	Swamp Milkweed	6	-5	0	1	2	40
2	*Onoclea sensibilis*	Sensitive Fern	4	-3	0	15	40	40
	Dryopteris cristata	Crested Wood Fern	7	-5	0	3	1	20
	Galium palustre	Marsh Bedstraw	5	-5	0	2	0.5	20
	Scutellaria lateriflora	Mad-dog Skullcap	5	-5	0	1	0.5	20
3	*Asclepias incarnata*	Swamp Milkweed	6	-5	0	3	2	40
	Leersia oryzoides	Rice Cutgrass	3	-5	0		5	20
	Onoclea sensibilis	Sensitive Fern	4	-3	0	2	2	40
	Carex lacustris	Lake Sedge	5	-5	0		2	40
	Osmunda cinnamomea	Cinnamon Fern	7	-3	0	2	2	20
4	*Carex aquatilis*	Water Sedge	7	-5	0		25	20
	Carex lacustris	Lake Sedge	5	-5	0		5	40
	Bidens frondosa	Devil's Beggarticks	3	-3	0	9	4	20
	Scutellaria galericulata	Common Skullcap	6	-5	0	2	2	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	3	2	20
	Sium suave	Water Parsnip	4	-5	0	1	2	20
5	None							0

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 005		**FOMM6**	**Fresh-Moist White Cedar Coniferous Forest**					
1	None							0
2	None							0
3	None							0
4	*Equisetum arvense*	Field Horsetail	0	0	0	1	0.5	20
	Carex spp.	Sedge species	0	0	0		0.5	20
5	None							0

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 006		**MAMM1-3**	**Reed-canary Grass Graminoid Mineral Meadow Marsh**					
1	*Solidago altissima*	Tall Goldenrod	1	3	0	50	95	100
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	10	5	80
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	3	1	60
	Tussilago farfara	Coltsfoot	*	3	-2	5	1	100
	Mentha arvensis	Common Mint	3	-3	0	1	1	20
2	*Solidago altissima*	Tall Goldenrod	1	3	0	20	50	100
	Asclepias syriaca	Common Milkweed	0	5	0	2	3	60
	Tussilago farfara	Coltsfoot	*	3	-2	8	10	100
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	5	5	80
	Bromus inermis ssp. inermis	Smooth Brome	*	5	-3		20	80
	Juncus dudleyi	Dudley's Rush	1	0	0		2	20
	Festuca pratensis	Meadow Fescue	*	4	-1		5	60
3	*Symphyotrichum lanceolatum*	Panicled Aster	3	-3	0	5	5	80
	Tussilago farfara	Coltsfoot	*	3	-2	20	60	100
	Asclepias syriaca	Common Milkweed	0	5	0	2	5	60
	Solidago altissima	Tall Goldenrod	1	3	0	12	20	100
	Bromus inermis ssp. inermis	Smooth Brome	*	5	-3		60	80
	Festuca pratensis	Meadow Fescue	*	4	-1		1	60
4	*Solidago altissima*	Tall Goldenrod	1	3	0	25	50	100
	Tussilago farfara	Coltsfoot	*	3	-2	20	40	100
	Asclepias syriaca	Common Milkweed	0	5	0	1	1	60
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	3	5	80
	Bromus inermis ssp. inermis	Smooth Brome	*	5	-3		20	80
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	3	2	60
	Taraxacum officinale	Common Dandelion	*	3	-2	1	1	20
5	*Symphyotrichum puniceum*	Purple Stemmed Aster	6	-5	0	5	5	60
	Solidago altissima	Tall Goldenrod	1	3	0	25	50	100
	Tussilago farfara	Coltsfoot	*	3	-2	20	30	100
	Bromus inermis ssp. inermis	Smooth Brome	*	5	-3		20	80
	Festuca pratensis	Meadow Fescue	*	4	-1		1	60

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
Vegetation Plot 007		**SWMM1-1**	**White Cedar - Hardwood Mineral Mixed Swamp**					
1	*Dryopteris carthusiana*	Spinulose Wood Fern	5	-2	0	1	0.5	100
	Cicuta maculata	Spotted Water Hemlock	6	-5	0	1	2	40
2	*Cicuta maculata*	Spotted Water Hemlock	6	-5	0	6	35	40
	Arisaema triphyllum	Jack-in-the-pulpit	5	-2	0	1	0.5	20
	Dryopteris carthusiana	Spinulose Wood Fern	5	-2	0	4	0.5	100
	Cystopteris bulbifera	Bulblet fern	5	-2	0	1	3	20
	Prunella vulgaris ssp. lanceolata	Selfheal	5	5	0	2	4	40
	Impatiens capensis	Spotted Jewelweed	4	-3	0	1	1	40
	Hydrocotyle americana	Marsh-Water Pennywort	7	-5	0	2	1	20
	Bidens frondosa	Devil's Beggarticks	3	-3	0	4	2	20
3	*Aralia nudicaulis*	Wild Sarsaparilla	4	3	0	6	15	60
	Impatiens capensis	Spotted Jewelweed	4	-3	0	2	0.5	40
	Dryopteris intermedia	Evergreen Wood Fern	5	0	0	5	3	40
	Dryopteris carthusiana	Spinulose Wood Fern	5	-2	0	1	2	100
	Carex laxiflora	Loose-flowered Sedge	5	0	0		2	20
	Maianthemum canadense	Canada Mayflower	5	0	0	4	0.5	60
	Scutellaria lateriflora	Mad-dog Skullcap	5	-5	0	1	0.5	20
4	*Aralia nudicaulis*	Wild Sarsaparilla	4	3	0	10	20	60
	Dryopteris carthusiana	Spinulose Wood Fern	5	-2	0	1	0.5	100
	Maianthemum canadense	Canada Mayflower	5	0	0	4	1	60
	Carex pensylvanica	Pennsylvania Sedge	5	5	0		8	20
5	*Aralia nudicaulis*	Wild Sarsaparilla	4	3	0	12	30	60
	Taraxacum officinale	Common Dandelion	*	3	-2	1	1	20
	Prunella vulgaris ssp. lanceolata	Selfheal	5	5	0	1	0.5	40
	Tiarella cordifolia	Foam Flower	6	1	0	1	0.5	20
	Glyceria striata	Fowl Manna grass	3	-5	0		5	20
	Maianthemum canadense	Canada Mayflower	5	0	0	6	2	60
	Dryopteris intermedia	Evergreen Wood Fern	5	0	0	3	2	40
	Dryopteris carthusiana	Spinulose Wood Fern	5	-2	0	1	1	100
	Carex gracillima	Graceful Sedge	4	3	0		1	20

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
Vegetation Plot 008		**SWMM1-1**	**White Cedar - Hardwood Mineral Mixed Swamp**					
1	*Mentha arvensis*	Common Mint	3	-3	0	18	12	20
	Tussilago farfara	Coltsfoot	*	3	-2	25	90	40
	Impatiens capensis	Spotted Jewelweed	4	-3	0	1	0.5	40
	Leersia oryzoides	Rice Cutgrass	3	-5	0		0.5	20
	Ranunculus repens	Creeping Buttercup	0	-1	-1	1	0.5	40
	Solidago canadensis	Canada Goldenrod	1	3	0	1	7	40
2	*Taraxacum officinale*	Common Dandelion	*	3	-2	1	1	20
3	*Solidago canadensis*	Canada Goldenrod	1	3	0	1	1	40
	Tussilago farfara	Coltsfoot	*	3	-2	2	2	40
4	None							0
5	*Ranunculus repens*	Creeping Buttercup	0	-1	-1	25	50	40
	Phalaris arundinacea	Reed Canary Grass	0	-4	0		0.5	20
	Veronica scutellata	Marsh Speedwell	7	-5		2	2	20
	Nasturtium officinale	Watercress	*	-5	-1	3	3	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	1	0.5	40

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 009		**MASM1-1**	**Cattail Mineral Shallow Marsh**					
1	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		90	100
	Typha latifolia	Cattail	3	-5	0		25	60
	Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5	0	1	8	40
2	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		15	100
	Typha latifolia	Cattail	3	-5	0		75	60
	Poa palustris	Fowl Meadow Grass	5	-4	0		2	20
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	1	2	60
3	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		98	100
	Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5	0	1	4	40
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	1	2	40
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	2	2	60
4	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		98	100
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	6	7	60
	Lysimachia ciliata	Fringed Loosestrife	4	-3	0	4	3	20
5	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		90	100
	Typha latifolia	Cattail	3	-5	0		6	60
	Mentha arvensis	Common Mint	3	-3	0	3	2	20
	Equisetum arvense	Field Horsetail	0	0	0	1	1	20
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	1	1	40

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 016		**SWDM3-2**	**Silver Maple Mineral Deciduous Swamp**					
1	None							0
2	*Onoclea sensibilis*	Sensitive Fern	4	-3	0	9	6	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	1	0.5	20
3	None							0
4	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		15	20
5	None							0

Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Vegetation Plot 018		**SWDO2-2**	**Silver Maple Organic Deciduous Swamp**					
1	*Caltha palustris*	Marsh Marigold	5	-5	0	10	30	80
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	2	5	20
	Glyceria striata	Fowl Manna grass	3	-5	0		10	80
	Equisetum pratense	Meadow Horsetail	8	-3	0	15	25	80
	Onoclea sensibilis	Sensitive Fern	4	-3	0	1	1	100
	Mentha arvensis	Common Mint	3	-3	0	1	1	40
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	4	5	100
2	*Caltha palustris*	Marsh Marigold	5	-5	0	5	25	80
	Onoclea sensibilis	Sensitive Fern	4	-3	0	8	25	100
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	3	5	100
	Equisetum pratense	Meadow Horsetail	8	-3	0	3	10	80
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	1	1	40
3	*Onoclea sensibilis*	Sensitive Fern	4	-3	0	4	20	100
	Caltha palustris	Marsh Marigold	5	-5	0	4	30	80
	Equisetum pratense	Meadow Horsetail	8	-3	0	3	5	80
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	3	5	100
	Glyceria striata	Fowl Manna grass	3	-5	0		45	80
4	*Caltha palustris*	Marsh Marigold	5	-5	0	4	15	80
	Equisetum pratense	Meadow Horsetail	8	-3	0	10	40	80
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	5	10	100
	Solidago gigantea	Late Goldenrod	4	-3	0	1	1	20
	Glyceria striata	Fowl Manna grass	3	-5	0		50	80
	Onoclea sensibilis	Sensitive Fern	4	-3	0	6	40	100
	Mentha arvensis	Common Mint	3	-3	0	5	5	40
	Maianthemum stellatum	Star Flowered False Solomo	6	1	0	3	2	40
5	*Symphyotrichum lanceolatum*	Panicled Aster	3	-3	0	10	20	40
	Onoclea sensibilis	Sensitive Fern	4	-3	0	5	20	100
	Maianthemum stellatum	Star Flowered False Solomo	6	1	0	7	15	40
	Glyceria striata	Fowl Manna grass	3	-5	0		60	80
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	2	5	100
	Aralia nudicaulis	Wild Sarsaparilla	4	3	0	1	1	20
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	4	2	20

APPENDIX III

Herbaceous Species Observed by Subplot 2006 - 2015

Appendix III. Herbaceous Species Observed by Sub-Plot (2006 - 2015)

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
VEG-001	1	*Asclepias incarnata*	Swamp Milkweed								√	√	
		Calamagrostis canadensis	Canada Blue-joint		√	√	√	√	√		√	√	
		Carex aquatilis	Water Sedge				√		√	√	√	√	
		Carex lacustris	Lake Sedge	√									√
		Carex stipata	Awl-fruited Sedge			√		√					
		Carex stricta	Tussock Sedge										√
		Cicuta bulbifera	Bulbous Water-hemlock						√				
		Cirsium arvense	Canada Thistle	√									
		Epilobium species	Willow-Herb species								√	√	
		Equisetum arvense	Field Horsetail		√	√					√	√	√
		Equisetum pratense	Meadow Horsetail	√						√			
		Galium palustre	Marsh Bedstraw								√	√	
		Impatiens capensis	Spotted Jewelweed		√	√	√	√	√	√	√	√	√
		Lycopus uniflorus	Northern Bugleweed					√	√				√
		Lysimachia thrysiflora	Tufted Loosestrife					√	√				√
		Phalaris arundinacea	Reed Canary Grass							√			
		Poa palustris	Fowl Meadow Grass								√	√	
		Poa sp.	Grass species	√									
		Scutellaria galericulata	Common Skullcap							√			
		Solidago canadensis	Canada Goldenrod	√									
		Solidago sp.	Goldenrod species			√							
		Symphyotrichum lanceolatum	Panicled Aster							√			√
		Symphyotrichum novae-angliae	New England Aster							√			
		Symphyotrichum sp.	Aster species		√	√	√						
		Veronica sp.	Speedwell species				√						
			Moss species		√				√				
	2	*Asclepias incarnata*	Swamp Milkweed								√	√	
		Calamagrostis canadensis	Canada Blue-joint	√	√								
		Carex aquatilis	Water Sedge				√		√	√	√	√	
		Carex lacustris	Lake Sedge			√	√						
		Carex stipata	Awl-fruited Sedge	√	√								
		Carex utriculata	Beaked Sedge		√								
		Cicuta bulbifera	Bulbous Water-hemlock					√	√	√			√
		Dryopteris cristata	Crested Wood Fern										√
		Epilobium hirsutum	Hairy Willow-Herb							√	√	√	
		Epilobium leptophyllum	Narrow-leaved Willow-herb					√					
		Equisetum arvense	Field Horsetail		√						√	√	
		Equisetum pratense	Meadow Horsetail	√						√			
		Galium palustre	Marsh Bedstraw			√		√			√	√	
		Impatiens capensis	Spotted Jewelweed	√	√	√		√		√	√	√	√
		Juncus sp.	Rush species	√									
		Lemna sp.	Duckweed species				√						
		Lycopus uniflorus	Northern Bugleweed			√		√	√				
		Lysimachia thrysiflora	Tufted Loosestrife					√		√			
		Lythrum salicaria	Purple Loosestrife							√			√
		Phalaris arundinacea	Reed Canary Grass						√	√			
		Poa sp.	Grass species	√				√					
		Sium suave	Water Parsnip								√	√	
		Solanum dulcamara	Bittersweet Nightshade	√									
		Solidago canadensis	Canada Goldenrod	√									√
		Symphyotrichum lanceolatum	Panicled Aster										√
			Moss species					√		√			
	3	*Bidens frondosa*	Devil's Beggarticks							√			
		Calamagrostis canadensis	Canada Blue-joint	√	√								
		Carex aquatilis	Water Sedge						√		√	√	
		Carex lacustris	Lake Sedge	√		√	√				√	√	√
		Carex stipata	Awl-fruited Sedge	√									
		Carex utriculata	Beaked Sedge		√								
		Carex vulpinoidea	Fox Sedge								√	√	
		Cicuta bulbifera	Bulbous Water-hemlock							√			
		Cirsium sp.	Thistle species							√			
		Epilobium hirsutum	Hairy Willow-Herb							√			
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum pratense	Meadow Horsetail	√									
		Galium palustre	Marsh Bedstraw							√	√	√	
		Impatiens capensis	Spotted Jewelweed	√	√	√				√	√	√	
		Lycopus americanus	American Water-horehound								√	√	
		Lycopus uniflorus	Northern Bugleweed		√			√		√			√
		Lysimachia terrestris	Swamp Candles							√			
		Lysimachia thrysiflora	Tufted Loosestrife		√								
		Phalaris arundinacea	Reed Canary Grass					√	√	√			
		Poa sp.	Grass species	√									
		Scutellaria galericulata	Common Skullcap							√			
		Sium suave	Water Parsnip		√						√	√	
		Solidago canadensis	Canada Goldenrod	√							√	√	√
		Solidago sp.	Goldenrod species				√						
		Spirodela polyrhiza	Duckweed					√					
		Symphyotrichum lanceolatum	Panicled Aster							√			
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√	
		Symphyotrichum sp.	Aster species				√						
	4	*Asclepias incarnata*	Swamp Milkweed		√								
		Bidens frondosa	Devil's Beggarticks							√			
		Calamagrostis canadensis	Canada Blue-joint	√	√								
		Carex aquatilis	Water Sedge							√	√	√	
		Carex lacustris	Lake Sedge			√	√	√	√		√	√	√
		Carex stipata	Awl-fruited Sedge	√	√								
		Cicuta bulbifera	Bulbous Water-hemlock							√			
		Dryopteris cristata	Crested Wood Fern								√	√	
		Epilobium hirsutum	Hairy Willow-Herb							√			
		Equisetum arvense	Field Horsetail						√				
		Galium palustre	Marsh Bedstraw					√		√	√	√	

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Impatiens capensis	Spotted Jewelweed	√	√			√		√	√	√	√
		Leersia oryzoides	Rice Cutgrass	√									
		Lycopus uniflorus	Northern Bugleweed		√			√	√	√			
		Lysimachia terrestris	Swamp Candles								√	√	
		Lysimachia thyrsiflora	Tufted Loosestrife						√				
		Lythraceae	Loosestrife species										
		Scutellaria galericulata	Common Skullcap	√						√			
		Sium suave	Water Parsnip			√		√					
		Spirodela polyrhiza	Duckweed					√					
		Symphyotrichum lanceolatum	Panicled Aster								√	√	
		Symphyotrichum novae-angliae	New England Aster							√			
			Moss species							√			
	5	*Asclepias incarnata*	Swamp Milkweed								√	√	
		Calamagrostis canadensis	Canada Blue-joint	√	√	√	√	√	√				
		Carex aquatilis	Water Sedge				√			√	√	√	
		Carex lacustris	Lake Sedge		√				√				√
		Carex stipata	Awl-fruited Sedge	√	√	√	√	√	√				
		Carex stricta	Stiff Sedge		√								√
		Cicuta bulbifera	Bulbous Water-hemlock										√
		Cirsium arvense	Canada Thistle	√									
		Epilobium hirsutum	Hairy Willow-Herb										√
		Equisetum arvense	Field Horsetail		√	√					√	√	√
		Equisetum palustre	Marsh Horsetail						√				
		Impatiens capensis	Spotted Jewelweed		√	√	√	√	√	√	√	√	√
		Lycopus americanus	American Water-horehound								√	√	√
		Lysimachia terrestris	Swamp Candles							√			
		Lysimachia thyrsiflora	Tufted Loosestrife					√	√				
		Phalaris arundinacea	Reed Canary Grass							√	√	√	
		Sium suave	Water Parsnip								√	√	
		Solidago altissima	Tall Goldenrod							√			
		Solidago canadensis	Canada Goldenrod	√									√
		Solidago sp.	Goldenrod species		√								
		Symphyotrichum lanceolatum	Panicled Aster							√			
		Symphyotrichum sp.	Aster species		√								
		Taraxacum officinale	Common Dandelion										√
VEG-002	1	*Caltha palustris*	Marsh Marigold	√		√	√	√	√	√	√	√	√
		Circaea lutetiana ssp. canadensis	Yellowish Enchanter's Nightshade								√	√	√
		Circaea quadrisulcata	Enchanter's Nightshade							√			
		Cirsium sp.	Thistle species							√	√	√	
		Epilobium hirsutum	Hairy Willow-Herb							√	√	√	
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum palustre	Marsh Horsetail		√			√					
		Impatiens capensis	Spotted Jewelweed										√
		Lycopus uniflorus	Northern Bugleweed					√	√	√			
		Scutellaria galericulata	Common Skullcap							√			
		Solidago canadensis	Canada Goldenrod								√	√	
		Symphyotrichum novae-angliae	New England Aster								√	√	
		Symphyotrichum sp.	Aster species		√								
			Moss species	√		√							
	2	*Caltha palustris*	Marsh Marigold	√				√	√				√
		Cirsium sp.	Thistle species							√	√	√	
		Cysptopteris tenuis	Mackay's Fragile Fern		√								
		Dryopteris carthusiana	Spinulose Wood Fern								√	√	
		Epipactis helleborine	Helleborine				√						
		Equisetum pratense	Meadow Horsetail	√				√		√			
		Fragaria vesca	Woodland Strawberry	√									
		Impatiens capensis	Spotted Jewelweed								√	√	√
		Lycopus uniflorus	Northern Bugleweed	√									
		Maianthemum canadense	Wild Lily-of-the-Valley	√	√	√	√			√			
		Onoclea sensibilis	Sensitive Fern					√	√				
		Poa sp.	Grass species		√								
		Solidago sp.	Goldenrod species		√			√					
		Taraxacum officinale	Common Dandelion		√	√				√			
		Thelypteris palustris	Marsh Fern					√					
			Moss species	√	√		√			√			
	3	*Caltha palustris*	Marsh Marigold	√	√		√	√		√			
		Cirsium muticum	Swamp Thistle								√	√	
		Cirsium sp.	Thistle species							√			
		Epilobium hirsutum	Hairy Willow-Herb							√			
		Equisetum pratense	Meadow Horsetail	√									
		Eupatorium perfoliatum	Boneset								√	√	
		Glyceria striata	Fowl Manna Grass										√
		Impatiens capensis	Spotted Jewelweed							√	√	√	√
		Lycopus uniflorus	Northern Bugleweed	√									
		Mitella nuda	Naked Miterwort							√			
		Pilea pumila	Clearweed								√	√	
		Scutellaria lateriflora	Mad-dog Skullcap							√			√
		Taraxacum officinale	Common Dandelion										√
			Moss species	√	√					√			
	4	*Caltha palustris*	Marsh Marigold		√	√		√					
		Epilobium hirsutum	Hairy Willow-Herb							√			
		Erigeron sp.	Fleabane species							√			
		Eupatorium maculatum	Spotted Joe-Pye Weed										√
		Impatiens capensis	Spotted Jewelweed							√	√	√	√
		Maianthemum canadense	Canada Mayflower						√				
		Poa sp.	Grass species						√				
		Scutellaria lateriflora	Mad-dog Skullcap							√			
		Solidago canadensis	Canada Goldenrod										√
		Taraxacum officinale	Common Dandelion							√			
			Moss species		√				√				
	5	*Arctium sp.*	Burdock species							√			
		Bidens frondosa	Devil's Beggarticks							√			

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Caltha palustris	Marsh Marigold	√	√	√	√	√	√		√	√	√
		Circaea lutetiana ssp. canadensis	Yellowish Enchanter's Nightshade										√
		Cirsium var	Thistle species							√		√	
		Dryopteris carthusiana	Spinulose Wood Fern		√								
		Eupatorium perfoliatum	Boneset								√	√	
		Impatiens capensis	Spotted Jewelweed							√	√	√	√
		Lycopus americanus	American Water-horehound								√	√	
		Lycopus uniflorus	Northern Bugleweed		√								
		Maianthemum canadense	Canada Mayflower	√		√		√	√				
		Scutellaria lateriflora	Mad-dog Skullcap										√
		Solidago sp.	Goldenrod species								√	√	
		Taraxacum officinale	Common Dandelion		√				√				
			Moss species	√	√	√		√	√	√			
VEG-003	1	*Arisaema triphyllum*	Jack-in-the-pulpit				√	√	√				√
		Circaea lutetiana ssp. canadensis	Yellowish Enchanter's Nightshade								√	√	
		Circaea quadrisulcata	Enchanter's Nightshade						√				
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	√
		Solanum dulcamara	Bittersweet Nightshade	√									
		Solidago canadensis	Canada Goldenrod						√				
		Solidago flexicaulis	Zig-zag goldenrod						√				
		Taraxacum officinale	Common Dandelion						√	√			
		Thelypteris palustris	Marsh Fern			√							
		Trillium var	Trillium species								√	√	
			Moss species	√			√		√	√			
	2	*Arisaema triphyllum*	Jack-in-the-pulpit						√				
		Dryopteris marginalis	Marginal Wood Fern							√			
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	√
		Taraxacum officinale	Common Dandelion							√			
			Moss species	√					√	√			
	3	*Arisaema triphyllum*	Jack-in-the-pulpit				√	√		√			
		Circaea quadrisulcata	Enchanter's Nightshade							√			
		Dryopteris cristata	Crested Wood Fern						√				
		Dryopteris marginalis	Marginal Wood Fern				√						
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√		√	√	√	√	√
		Taraxacum officinale	Common Dandelion							√			
	4	*Arisaema triphyllum*	Jack-in-the-pulpit				√			√			
		Dryopteris clintoniana	Clinton's Wood Fern		√								
		Dryopteris marginalis	Marginal Wood Fern				√			√			
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	
		Onoclea sensibilis	Sensitive Fern										√
		Taraxacum officinale	Common Dandelion							√			
	5	*Arisaema triphyllum*	Jack-in-the-pulpit				√		√				
		Dryopteris clintoniana	Clinton's Wood Fern		√								
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	√
		Trillium var	Trillium species								√	√	
			Moss species				√						
VEG-004	1	*Asclepias incarnata*	Swamp Milkweed										√
		Dryopteris clintoniana	Clinton's Wood Fern		√								
		Dryopteris cristata	Crested Wood Fern					√					√
		Galium palustre	Marsh Bedstraw										√
		Onoclea sensibilis	Sensitive Fern								√	√	√
		Parthenocissus quinquefolia	Virginia Creeper	√									
			Moss species				√	√		√			
	2	*Cicuta maculata*	Spotted Water hemlock		√								
		Circaea quadrisulcata	Enchanter's Nightshade		√			√					
		Cystopteris bulbifera	Bulblet Fern		√								
		Dryopteris carthusiana	Spinulose Wood Fern			√				√	√	√	
		Dryopteris marginalis	Marginal Wood Fern								√	√	
		Equisetum arvense	Field Horsetail		√								
		Equisetum pratense	Meadow Horsetail	√									
		Galium palustre	Marsh Bedstraw		√								
		Maianthemum canadense	Wild Lily-of-the-Valley			√				√			
		Onoclea sensibilis	Sensitive Fern	√	√	√		√	√	√	√	√	
		Pilea pumila	Clearweed			√							
		Scirpus americanus	Common Three Square		√								
		Scutellaria lateriflora	Mad-dog Skullcap	√									√
		Thelypteris palustris	Marsh Fern								√	√	
			Moss species		√	√	√	√		√			
	3	*Asclepias incarnata*	Swamp Milkweed										√
		Carex aquatilis	Water Sedge								√	√	
		Carex lacustris	Lake Sedge								√	√	√
		Cystopteris bulbifera	Bulblet Fern		√								
		Dryopteris carthusiana	Spinulose Wood Fern	√				√	√	√			
		Dryopteris cristata	Crested Wood Fern			√	√	√	√				
		Dryopteris marginalis	Marginal Wood Fern							√			
		Equisetum arvense	Field Horsetail		√								
		Equisetum pratense	Meadow Horsetail	√			√						
		Galium palustre	Marsh Bedstraw		√								
		Impatiens capensis	Spotted Jewelweed		√								
		Leersia oryzoides	Rice Cutgrass								√	√	√
		Lysimachia terrestris	Swamp Candles						√				
		Maianthemum canadense	Canada Mayflower				√						
		Onoclea sensibilis	Sensitive Fern	√	√	√	√	√	√	√	√	√	√
		Osmunda cinnamomea	Cinnamon Fern										√
		Poa sp.	Grass species	√		√	√	√					
		Scirpus americanus	Common Three Square	√	√								
		Taraxacum officinale	Common Dandelion				√						
		Thelypteris palustris	Marsh Fern	√		√	√			√			
		Tiarella cordifolia	Foam Flower		√								
	4	*Bidens frondosa*	Devil's Beggarticks										√
		Carex aquatilis	Water Sedge				√			√	√	√	√

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Carex lacustris	Lake Sedge			√	√	√	√	√	√	√	√
		Cicuta maculata	Spotted Water hemlock		√				√				
		Dryopteris carthusiana	Spinulose Wood Fern	√					√	√			
		Dryopteris clintoniana	Clinton's Wood Fern		√								
		Dryopteris cristata	Crested Wood Fern			√		√					
		Equisetum arvense	Field Horsetail		√	√							
		Equisetum pratense	Meadow Horsetail	√			√						
		Eupatorium maculatum	Spotted Joe-Pye Weed	√									
		Galium palustre	Marsh Bedstraw	√	√	√	√	√	√	√			
		Impatiens capensis	Spotted Jewelweed		√		√	√		√			√
		Leersia oryzoides	Rice Cutgrass							√			
		Lycopus uniflorus	Northern Bugleweed	√		√	√	√		√			
		Lysimachia terrestris	Swamp Candles		√								
		Onoclea sensibilis	Sensitive Fern	√	√	√	√	√		√			
		Parthenocissus quinquefolia	Virginia Creeper	√		√							
		Poa palustris	Fowl Meadow Grass								√	√	
		Poa sp.	Grass species		√	√		√		√			
		Ranunculus var	Buttercup species						√				
		Rubus pubescens	Dwarf Raspberry					√					
		Scirpus americanus	Common Three Square	√	√	√							
		Scutellaria galericulata	Common Skullcap			√	√			√	√	√	√
		Scutellaria lateriflora	Mad-dog Skullcap							√			
		Sium suave	Water Parsnip										√
		Solidago rugosa	Rough-stemmed Goldenrod							√			
		Solanum dulcamara	Bittersweet Nightshade			√							
		Symphyotrichum racemosum	Small White Aster					√					
		Taraxacum officinale	Common Dandelion	√									
		Thelypteris noveboracensis	New York Fern		√								
		Thelypteris palustris	Marsh Fern	√		√	√			√			
		Veronica scutellata	Marsh Speedwell	√				√					
			Moss species	√	√	√	√	√					
	5	*Dryopteris carthusiana*	Spinulose Wood Fern						√		√	√	
		Onoclea sensibilis	Sensitive Fern						√				
		Thelypteris palustris	Marsh Fern							√			
VEG-005	1	*Arisaema triphyllum*	Jack-in-the-pulpit		√								
		Athyrium filix-femina	Northeastern Lady Fern		√								
		Equisetum pratense	Meadow Horsetail	√	√		√	√		√			
	2	*Equisetum arvense*	Field Horsetail		√	√		√					
		Equisetum pratense	Meadow Horsetail							√			
		Maianthemum canadense	Wild Lily-of-the-Valley		√	√							
			Moss species	√	√	√	√	√		√			
	3	*Equisetum arvense*	Field Horsetail		√						√	√	
		Equisetum pratense	Meadow Horsetail	√				√		√			
			Moss species	√	√	√	√	√					
		Equisetum pratense	Meadow Horsetail										
	4	*Equisetum arvense*	Field Horsetail		√	√							√
		Equisetum pratense	Meadow Horsetail	√			√			√			
		Maianthemum canadense	Canada Mayflower				√						
		Carex sp.	Sedge species										√
		Poa sp.	Grass species				√						
			Moss species	√						√			
		Equisetum pratense	Meadow Horsetail										
	5		Moss species	√	√		√			√			
VEG-006	1	*Bromus inermis ssp. inermis*	Smooth Brome						√				
		Calamagrostis canadensis	Canada Blue-joint								√	√	
		Carex blanda	Smooth Sedge								√	√	
		Carex stipata	Awl-fruited Sedge					√					
		Carex vulpinoidea	Fox Sedge		√		√		√	√	√	√	
		Cirsium arvense	Canada Thistle	√	√				√	√			
		Dactylis glomerata	Orchard Grass							√	√	√	
		Daucus carota	Queen Anne's Lace						√				
		Echinochloa crusgalli	Barnyard Grass				√	√					
		Epilobium hirsutum	Hairy Willow-Herb					√			√	√	
		Equisetum arvense	Field Horsetail		√	√	√		√		√	√	
		Equisetum pratense	Meadow Horsetail							√			
		Euthamia graminifolia	Grass-leaved Goldenrod				√	√	√	√			
		Festuca arundinacea	Tall Fescue								√	√	
		Juncus effusus	Soft Rush								√	√	
		Juncus tenuis	Path Rush	√					√	√	√	√	
		Lotus corniculatus	Bird's-foot Trefoil		√		√	√					
		Mentha arvensis	Common Mint					√					√
		Phalaris arundinacea	Reed Canary Grass								√	√	
		Phleum pratense	Timothy							√			
		Poa pratensis	Kentucky Blue Grass			√		√		√	√	√	
		Poa sp.	Grass species	√	√								
		Scirpus atrovirens	Dark Green Bulrush						√				
		Solidago altissima	Tall Goldenrod	√					√	√			√
		Solidago canadensis	Canada Goldenrod	√	√	√	√	√	√		√	√	
		Symphyotrichum lanceolatum	Panicled Aster			√				√	√	√	√
		Symphyotrichum novae-angliae	New England Aster		√								
		Symphyotrichum puniceum	Purple Stemmed Aster		√								√
		Taraxacum officinale	Common Dandelion						√		√		
		Tussilago farfara	Coltsfoot	√	√	√	√	√	√	√	√	√	√
	2	*Asclepias syriaca*	Common Milkweed										√
		Bromus inermis ssp. inermis	Smooth Brome						√				
		Calamagrostis canadensis	Canada Blue-joint								√	√	√
		Carex stipata	Awl-fruited Sedge	√									
		Carex trisperma var. trisperma	Three-seeded Sedge		√								
		Carex vulpinoidea	Fox Sedge				√	√	√	√			
		Cirsium arvense	Canada Thistle	√	√	√	√				√	√	
		Daucus carota	Queen Anne's Lace					√		√			

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Drepanocladus sp.	Sickle Moss						√				
		Echinochloa crusgalli	Barnyard Grass				√	√					
		Epilobium hirsutum	Hairy Willow-Herb					√	√	√	√	√	
		Equisetum arvense	Field Horsetail		√	√			√		√	√	
		Equisetum pratense	Meadow Horsetail							√			
		Euthamia graminifolia	Grass-leaved Goldenrod				√	√	√	√			
		Festuca arundinacea	Tall Fescue								√	√	√
		Galium palustre	Marsh Bedstraw				√						
		Hieracium pratense	King Devil Hawkweed			√							
		Juncus dudleyii	Dudley's Rush										√
		Juncus tenuis	Path Rush				√	√	√	√	√	√	
		Lactuca serriola	Prickly Lettuce	√									
		Lotus corniculatus	Bird's-foot Trefoil			√		√		√	√	√	
		Lycopus americanus	American Water-horehound								√	√	
		Medicago lupulina	Black Medick					√	√		√	√	
		Mentha arvensis	Common Mint			√		√	√	√	√	√	
		Phalaris arundinacea	Reed Canary Grass				√						
		Plantago major	Common Plantain						√				
		Poa pratensis	Kentucky Blue Grass		√	√					√	√	
		Poa sp.	Grass species	√									
		Potentilla recta	Sulphur Cinquefoil							√			
		Scirpus atrovirens	Dark Green Bulrush						√	√			
		Solidago altissima	Tall Goldenrod	√						√			√
		Solidago canadensis	Canada Goldenrod			√			√		√	√	
		Symphyotrichum lanceolatum	Panicled Aster			√				√	√	√	√
		Symphyotrichum novae-angliae	New England Aster			√				√			
		Symphyotrichum puniceum	Purple Stemmed Aster		√				√				
		Taraxacum officinale	Common Dandelion	√	√		√		√	√	√	√	
		Trifolium hybridum	Alsike Clover					√					
		Trifolium repens	White Clover					√					
		Tussilago farfara	Coltsfoot	√	√	√	√	√	√		√	√	√
		Waldsteinia fragarioides	Barren Strawberry		√								
			Moss species		√								
	3	*Asclepias syriaca*	Common Milkweed										√
		Bromus inermis ssp. inermis	Smooth Brome						√				√
		Calamagrostis canadensis	Canada Blue-joint								√	√	
		Carex stipata	Awl-fruited Sedge	√									
		Carex stricta	Stiff Sedge			√							
		Carex vulpinoidea	Fox Sedge			√		√			√	√	
		Cirsium arvense	Canada Thistle	√	√					√			
		Dactylis glomerata	Orchard Grass								√	√	
		Daucus carota	Queen Anne's Lace								√	√	
		Echinochloa crusgalli	Barnyard Grass				√	√					
		Eleocharis smallii	Small's Spike-Rush					√					
		Epilobium hirsutum	Hairy Willow-Herb				√	√			√	√	
		Equisetum arvense	Field Horsetail		√	√	√		√		√	√	
		Equisetum pratense	Meadow Horsetail	√									
		Euthamia graminifolia	Grass-leaved Goldenrod			√	√	√	√				
		Festuca arundinacea	Tall Fescue								√	√	√
		Galium palustre	Marsh Bedstraw						√				
		Geum aleppicum	Yellow Avens						√	√			
		Juncus effusus	Soft Rush								√	√	
		Juncus tenuis	Path Rush				√	√	√	√	√	√	
		Lotus corniculatus	Bird's-foot Trefoil	√	√	√		√					
		Phalaris arundinacea	Reed Canary Grass				√				√	√	
		Phleum pratense	Timothy					√		√			
		Plantago major	Common Plantain					√					
		Poa palustris	Fowl Meadow Grass					√					
		Poa pratensis	Kentucky Blue Grass							√	√	√	
		Poa sp.	Grass species	√	√								
		Scirpus atrovirens	Dark Green Bulrush			√							
		Solidago altissima	Tall Goldenrod	√						√			√
		Solidago canadensis	Canada Goldenrod						√		√	√	
		Symphyotrichum lanceolatum	Panicled Aster			√				√			√
		Symphyotrichum novae-angliae	New England Aster							√			
		Symphyotrichum puniceum	Purple Stemmed Aster		√				√				
		Taraxacum officinale	Common Dandelion		√		√	√		√	√	√	
		Tussilago farfara	Coltsfoot	√	√	√	√		√	√	√	√	√
		Typha angustifolia	Narrow-leaved Cattail					√					
		Waldsteinia fragarioides	Barren Strawberry		√								
			Moss species		√		√			√			
	4	*Asclepias syriaca*	Common Milkweed										√
		Bromus inermis ssp. inermis	Smooth Brome						√				√
		Calamagrostis canadensis	Canada Blue-joint								√	√	
		Carex stipata	Awl-fruited Sedge						√				
		Carex vulpinoidea	Fox Sedge						√	√			
		Cirsium arvense	Canada Thistle	√	√						√	√	
		Dactylis glomerata	Orchard Grass								√	√	
		Echinochloa crusgalli	Barnyard Grass					√					
		Eleocharis smallii	Small's Spike-Rush		√								
		Epilobium hirsutum	Hairy Willow-Herb				√	√	√	√	√	√	
		Equisetum arvense	Field Horsetail		√			√	√		√	√	
		Equisetum pratense	Meadow Horsetail	√						√			
		Euthamia graminifolia	Grass-leaved Goldenrod			√	√	√	√	√			
		Festuca arundinacea	Tall Fescue								√	√	
		Galium palustre	Marsh Bedstraw						√				
		Geum aleppicum	Yellow Avens								√	√	
		Juncus tenuis	Path Rush				√		√		√	√	
		Lactuca serriola	Prickly Lettuce	√									
		Lotus corniculatus	Bird's-foot Trefoil	√	√	√				√	√	√	
		Medicago lupulina	Black Medick					√			√	√	
		Mentha arvensis	Common Mint							√			
		Phalaris arundinacea	Reed Canary Grass				√						

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Plantago major	Common Plantain					√					
		Poa pratensis	Kentucky Blue Grass					√			√	√	
		Poa sp.	Grass species	√	√	√			√				
		Scirpus atrovirens	Dark Green Bulrush						√				
		Solidago altissima	Tall Goldenrod	√									√
		Solidago canadensis	Canada Goldenrod	√	√						√	√	
		Symphyotrichum lanceolatum	Panicled Aster							√			√
		Symphyotrichum novae-angliae	New England Aster							√			
		Symphyotrichum puniceum	Purple Stemmed Aster		√				√				√
		Taraxacum officinale	Common Dandelion					√	√	√	√	√	√
		Trifolium hybridum	Alsike Clover	√				√					
		Tussilago farfara	Coltsfoot	√	√	√	√				√	√	√
		Typha angustifolia	Narrow-leaved Cattail					√					
		Typha latifolia	Common Cattail				√						
	5	*Bromus inermis ssp. inermis*	Smooth Brome						√				√
		Calamagrostis canadensis	Canada Blue-joint								√	√	
		Carex blanda	Smooth Sedge								√	√	
		Carex flava	Yellow Sedge								√	√	
		Carex sp.	Sedge species						√				
		Carex stricta	Stiff Sedge				√				√	√	
		Carex trisperma var. trisperma	Three-seeded Sedge		√								
		Carex vulpinoidea	Fox Sedge				√		√		√	√	
		Cerastium fontanum	Mouse-eared Chickweed								√	√	
		Cirsium arvense	Canada Thistle	√		√							
		Dactylis glomerata	Orchard Grass							√	√	√	
		Daucus carota	Queen Anne's Lace							√	√	√	
		Echinochloa crusgalli	Barnyard Grass				√	√					
		Eleocharis smallii	Small's Spike-Rush					√					
		Epilobium hirsutum	Hairy Willow-Herb					√			√	√	
		Epipactis helleborine	Helleborine							√			
		Equisetum arvense	Field Horsetail		√	√	√	√	√		√	√	
		Equisetum pratense	Meadow Horsetail							√			
		Erigeron philadelphicus	Philadelphia Fleabane		√								
		Euthamia graminifolia	Grass-leaved Goldenrod				√	√	√	√	√	√	
		Festuca arundinacea	Tall Fescue								√	√	√
		Juncus tenuis	Path Rush			√		√	√	√	√	√	
		Lotus corniculatus	Bird's-foot Trefoil		√		√	√					
		Medicago lupulina	Black Medick						√		√	√	
		Phalaris arundinacea	Reed Canary Grass				√						
		Phleum pratense	Timothy			√							
		Poa pratensis	Kentucky Blue Grass			√		√	√	√	√	√	
		Poa sp.	Grass species	√	√				√				
		Scirpus atrovirens	Dark Green Bulrush					√	√				
		Solidago altissima	Tall Goldenrod	√					√	√	√	√	√
		Solidago canadensis	Canada Goldenrod	√	√	√			√		√	√	
		Sonchus arvensis	Field Sow thistle					√					
		Symphyotrichum lanceolatum	Panicled Aster			√				√	√	√	
		Symphyotrichum novae-angliae	New England Aster		√								
		Symphyotrichum puniceum	Purple Stemmed Aster		√								√
		Taraxacum officinale	Common Dandelion					√	√		√	√	
		Tussilago farfara	Coltsfoot	√	√	√	√	√	√	√	√	√	√
			Moss species				√						
VEG-007	1	*Aralia nudicaulis*	Wild Sarsaparilla			√	√	√			√	√	
		Arisaema triphyllum	Jack-in-the-pulpit				√						
		Carex laxiflora	Loose-flowered Sedge								√	√	
		Carex sp.	Sedge species						√				
		Cicuta maculata	Spotted Water hemlock	√	√					√			√
		Circaea quadrisulcata	Enchanter's Nightshade		√		√						
		Cystopteris bulbifera	Bulblet Fern				√		√				
		Dryopteris carthusiana	Spinulose Wood Fern		√								√
		Geum var	Avens species								√	√	
		Impatiens capensis	Spotted Jewelweed		√					√			
		Impatiens pallida	Pale Jewelweed						√				
		Lycopus americanus	American Water-horehound	√									
		Ranunculus hispidus var caricetorum	Swamp Buttercup	√									
		Scutellaria lateriflora	Mad-dog Skullcap	√									
		Taraxacum officinale	Common Dandelion		√								
		Thelypteris palustris	Marsh Fern	√									
		Veronica americana	American Brooklime							√			
	2	*Alisma plantago*	Water Plantain			√							
		Aralia nudicaulis	Wild Sarsaparilla				√						
		Arisaema triphyllum	Jack-in-the-pulpit								√	√	√
		Bidens frondosa	Devil's Beggarticks										√
		Carex laxiflora	Loose-flowered Sedge								√	√	
		Caltha palustris	Marsh Marigold	√									
		Cicuta maculata	Spotted Water hemlock	√	√		√	√		√	√	√	√
		Circaea alpina	Dwarf Enchanter's Nightshade				√						
		Circaea quadrisulcata	Enchanter's Nightshade	√	√				√				
		Cystopteris bulbifera	Bulblet Fern				√		√		√	√	√
		Dryopteris carthusiana	Spinulose Wood Fern	√				√					√
		Fragaria vesca	Woodland Strawberry								√	√	
		Hydrocotyle americana	Marsh-Water Pennywort	√			√	√					√
		Hydrophyllum virginianum	Virginia Waterleaf			√							
		Impatiens capensis	Spotted Jewelweed	√	√	√	√	√		√	√	√	√
		Lycopus uniflorus	Northern Bugleweed			√	√						
		Lythraceae sp.	Loosestrife species			√							
		Maianthemum canadense	Canada Mayflower	√					√				
		Mitella nuda	Naked Miterwort								√	√	
		Parthenocissus quinquefolia	Virginia Creeper	√									
		Poa sp.	Grass species		√								
		Polystichum acrostichoides	Christmas Fern	√									

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Prunella vulgaris ssp. lanceolata	Selfheal								√	√	√
		Ranunculus hispidus var caricetorum	Swamp Buttercup							√			
		Scutellaria galericulata	Common Skullcap						√				
		Scutellaria lateriflora	Mad-dog Skullcap					√					
		Stachys var	Hedge Nettle species							√			
		Taraxacum officinale	Common Dandelion						√				
		Thelypteris palustris	Marsh Fern	√									
		Trientalis borealis	Starflower	√					√				
		Veronica americana	American Brooklime							√			
		Veronica officinalis	Common Speedwell			√		√					
		Viola sp.	Violet Species						√				
			Moss species	√	√		√						
			Fern species						√				
	3	*Aralia nudicaulis*	Wild Sarsaparilla		√	√	√	√	√	√	√	√	√
		Arisaema triphyllum	Jack-in-the-pulpit			√	√	√					
		Carex blanda	Smooth Sedge							√			
		Carex gracillima	Graceful Sedge					√					
		Carex laxiflora	Loose-flowered Sedge				√						√
		Clintonia borealis	Bluebead lily		√			√					
		Cystopteris bulbifera	Bulblet Fern		√					√	√	√	
		Dryopteris carthusiana	Spinulose Wood Fern					√			√	√	√
		Dryopteris intermedia	Intermediate Wood Fern										√
		Dryopteris marginalis	Marginal Wood Fern				√						
		Impatiens capensis	Spotted Jewelweed	√							√	√	√
		Impatiens pallida	Pale Jewelweed						√				
		Maianthemum canadense	Canada Mayflower		√			√	√				√
		Mitella nuda	Naked Miterwort								√	√	
		Osmunda cinnamomea	Cinnamon Fern								√	√	
		Poa sp.	Grass species		√								
		Scutellaria galericulata	Common Skullcap								√	√	
		Scutellaria lateriflora	Mad-dog Skullcap										√
		Taraxacum officinale	Common Dandelion						√				
		Trientalis borealis	Starflower						√		√	√	
			Moss species	√	√		√			√			
	4	*Aralia nudicaulis*	Wild Sarsaparilla	√	√	√	√	√	√		√	√	√
		Arisaema triphyllum	Jack-in-the-pulpit	√		√							
		Carex laxiflora	Loose-flowered Sedge								√	√	
		carex pensylvanica	Pennsylvania Sedge										√
		Carex sp.	Sedge species							√	√	√	
		Cystopteris bulbifera	Bulblet Fern						√		√	√	
		Dryopteris carthusiana	Spinulose Wood Fern	√	√								√
		Epipactis helleborine	Helleborine				√	√		√			
		Fragaria virginiana	Wild Strawberry						√				
		Gymnocarpium dryopteris	Oak Fern				√			√			
		Impatiens capensis	Spotted Jewelweed								√	√	
		Impatiens pallida	Pale Jewelweed						√				
		Maianthemum canadense	Wild Lily-of-the-Valley		√		√	√		√			√
		Maianthemum stellatum	Star Flowered False Solomon's-seal			√							
		Poa sp.	Grass species		√		√		√				
		Prunella vulgaris ssp. lanceolata	Selfheal						√				
		Taraxacum officinale	Common Dandelion					√					
		Thelypteris palustris	Marsh Fern	√									
		Trientalis borealis	Starflower						√		√	√	
			Moss species	√	√								
	5	*Aralia nudicaulis*	Wild Sarsaparilla	√	√	√	√	√	√	√	√	√	√
		Arisaema triphyllum	Jack-in-the-pulpit		√								
		Carex sp.	Sedge species		√	√		√					
		Carex laxiflora	Loose-flowered Sedge								√	√	
		Carex gracillima	Graceful Sedge										√
		Circaea quadrisulcata	Enchanter's Nightshade	√	√								
		Cystopteris bulbifera	Bulblet Fern				√		√		√	√	
		Dryopteris carthusiana	Spinulose Wood Fern		√			√		√	√	√	√
		Dryopteris clintoniana	Clinton's Wood Fern		√								
		Dryopteris intermedia	Intermediate Wood Fern										√
		Epipactis helleborine	Helleborine				√	√					
		Fragaria virginiana	Wild Strawberry						√				
		Glyceria striata	Fowl Manna Grass							√			√
		Impatiens pallida	Pale Jewelweed						√				
		Maianthemum canadense	Canada Mayflower	√	√	√	√	√	√	√	√	√	√
		Maianthemum racemosum	False Solomon's seal		√	√			√				
		Maianthemum stellatum	Star Flowered False Solomon's-seal			√	√	√					
		Prunella vulgaris ssp. lanceolata	Selfheal										√
		Taraxacum officinale	Common Dandelion	√						√			√
		Thelypteris palustris	Marsh Fern	√									
		Tiarella cordifolia	Foam Flower					√					√
		Trientalis borealis	Starflower		√						√	√	
			Moss species	√	√	√	√			√			
VEG-008	1	*Bidens frondosa*	Devil's beggarticks								√	√	
		Caltha palustris	Marsh Marigold							√			
		Carex lacustris	Lake Sedge								√	√	
		Carex stipata	Awl-fruited Sedge				√						
		Echinochloa crusgalli	Barnyard Grass				√						
		Eupatorium maculatum	Spotted Joe-Pye Weed				√						
		Galium palustre	Marsh Bedstraw				√	√					
		Geranium robertianum	Herb Robert	√									
		Glyceria striata	Fowl Manna Grass							√	√	√	
		Impatiens capensis	Spotted Jewelweed	√			√	√		√			√
		Leersia oryzoides	Rice Cutgrass										√
		Lobelia siphilitica	Great Lobelia							√			
		Lysimachia nummularia	Moneywort		√								
		Lysimachia thrysiflora	Tufted Loosestrife		√								
		Mentha arvensis	Common Mint				√	√			√	√	√

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Mentha X piperita	Pepper Mint							√			
		Nasturtium officinale	Watercress							√	√	√	
		Poa nemoralis	Wood Bluegrass				√						
		Poa palustris	Fowl Meadow Grass					√		√			
		Poa sp.	Grass species		√			√					
		Polygonum var									√	√	
		Ranunculus acris	Tall Buttercup				√						
		Ranunculus repens	Creeping Buttercup					√		√			√
		Solidago canadensis	Canada Goldenrod										√
		Symphyotrichum puniceum	Purple Stemmed Aster				√	√		√			
		Tussilago farfara	Coltsfoot							√	√	√	√
			Moss species		√								
	2	*Dryopteris carthusiana*	Spinulose Wood Fern			√							
		Geranium robertianum	Herb Robert		√	√							
		Solidago canadensis	Canada Goldenrod						√				
		Taraxacum officinale	Common Dandelion				√	√					√
			Moss species	√	√	√	√						
	3	*Caltha palustris*	Marsh Marigold						√				
		Cystopteris bulbifera	Bulblet Fern				√				√	√	
		Fragaria vesca	Woodland Strawberry			√							
		Lactuca serriola	Prickly Lettuce				√						
		Leersia oryzoides	Rice Cutgrass						√				
		Mentha X piperita	Pepper Mint							√			
		Nasturtium officinale	Watercress						√				
		Poa sp.	Grass species						√				
		Polygonum amphibium	Water Smartweed						√				
		Ranunculus flabellaris	Yellow Water-crowfoot						√				
		Scutellaria galericulata	Common Skullcap						√				
		Solidago canadensis	Canada Goldenrod										√
		Taraxacum officinale	Common Dandelion				√		√				
		Tussilago farfara	Coltsfoot				√			√	√	√	√
		Veronica anagallis-aquatica	Water Speedwell						√				
			Moss species	√	√		√						
	4	*Galium palustre*	Marsh Bedstraw						√				
		Geum laciniatum	Rough Avens						√				
		Poa sp.	Grass species		√				√				
		Ranunculus flabellaris	Yellow Water-crowfoot						√				
		Scirpus americanus	Common Three Square	√									
		Solidago canadensis	Canada Goldenrod						√				
		Taraxacum officinale	Common Dandelion	√	√								
		Tussilago farfara	Coltsfoot						√		√	√	
			Moss species	√	√	√	√						
	5	*Caltha palustris*	Marsh Marigold	√		√			√				
		Carex aquatilis	Water Sedge				√						
		Carex lacustris	Lake Sedge			√							
		Galium palustre	Marsh Bedstraw				√						
		Impatiens capensis	Spotted Jewelweed	√	√					√			√
		Leersia oryzoides	Rice Cutgrass				√						
		Lycopus uniflorus	Northern Bugleweed			√							
		Mentha arvensis	Common Mint	√	√		√	√					
		Mentha X piperita	Pepper Mint							√			
		Nasturtium officinale	Watercress					√	√	√	√	√	√
		Phalaris arundinacea	Reed Canary Grass										√
		Poa nemoralis	Wood Bluegrass				√						
		Poa sp.	Grass species		√			√					
		Ranunculus acris	Tall Buttercup				√						
		Ranunculus flabellaris	Yellow Water-crowfoot			√							
		Ranunculus repens	Creeping Buttercup					√		√	√	√	√
		Symphyotrichum lanceolatum var. lanc	Tall White Aster	√									
		Symphyotrichum puniceum	Purple Stemmed Aster				√						
		Taraxacum officinale	Common Dandelion	√				√					
		Tussilago farfara	Coltsfoot		√								
		Veronica anagallis-aquatica	Water Speedwell						√				√
		Veronica officinalis	Common Speedwell			√							
		Waldsteinia fragarioides	Barren Strawberry		√								
VEG-009	1	*Carex stipata*	Awl-fruited Sedge							√			
		Circaea quadrisulcata	Enchanter's Nightshade		√								
		Cirsium arvense	Canada Thistle							√			
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum palustre	Marsh Horsetail		√								
		Equisetum pratense	Meadow Horsetail							√			
		Eupatorium maculatum	Spotted Joe-Pye Weed								√	√	√
		Galium palustre	Marsh Bedstraw						√				
		Lysimachia ciliata	Fringed Loosestrife			√		√	√				
		Mentha arvensis	Common Mint		√				√	√			
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√
		Scirpus atrovirens	Dark Green Bulrush							√			
		Symphyotrichum novae-angliae	New England Aster		√			√	√				
		Typha angustifolia	Narrow-leaved Cattail					√	√	√	√	√	√
	2	*Carex sp.*	Sedge species			√							
		Carex stipata	Awl-fruited Sedge				√						
		Circaea quadrisulcata	Enchanter's Nightshade		√								
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum pratense	Meadow Horsetail							√			
		Mentha arvensis	Common Mint					√	√				
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√
		Poa palustris	Fowl Meadow Grass										√
		Symphyotrichum lanceolatum	Panicled Aster										√
		Typha angustifolia	Narrow-leaved Cattail					√	√	√	√	√	
		Typha latifolia	Common Cattail		√		√						√
	3	*Carex stipata*	Awl-fruited Sedge				√						
		Equisetum arvense	Field Horsetail								√	√	

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Equisetum palustre	Marsh Horsetail		√								
		Eupatorium maculatum	Spotted Joe-Pye Weed										√
		Euthamia graminifolia	Grass-leaved Goldenrod					√					
		Lysimachia ciliata	Fringed Loosestrife			√			√				
		Mentha arvensis	Common Mint				√						
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√
		Ranunculus acris	Tall Buttercup					√	√				
		Solidago canadensis	Canada Goldenrod				√	√					
		Sonchus arvensis	Field Sow thistle			√							
		Symphyotrichum lanceolatum	Panicled Aster										√
		Symphyotrichum novae-angliae	New England Aster						√				
		Symphyotrichum puniceum	Purple Stemmed Aster										√
		Taraxacum officinale	Common Dandelion				√						
		Tussilago farfara	Coltsfoot				√						
		Typha angustifolia	Narrow-leaved Cattail						√	√	√	√	
		Typha latifolia	Common Cattail		√								
	4	*Arabis glabra*	Tower-mustard			√							
		Carex sp.	Sedge species			√							
		Carex stipata	Awl-fruited Sedge		√		√	√					
		Circaea quadrisulcata	Enchanter's Nightshade		√								
		Eupatorium maculatum	Spotted Joe-Pye Weed								√	√	
		Euthamia graminifolia	Grass-leaved Goldenrod			√		√	√	√			
		Lysimachia ciliata	Fringed Loosestrife			√	√	√		√	√	√	√
		Mentha arvensis	Common Mint				√	√	√				
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√
		Poa palustris	Fowl Meadow Grass					√					
		Scutellaria lateriflora	Mad-dog Skullcap					√					
		Solidago canadensis	Canada Goldenrod						√				
		Symphyotrichum lanceolatum	Panicled Aster							√	√	√	√
		Symphyotrichum novae-angliae	New England Aster						√	√			
		Symphyotrichum puniceum	Purple Stemmed Aster		√								
		Tussilago farfara	Coltsfoot						√				
		Typha angustifolia	Narrow-leaved Cattail							√			
		Typha latifolia	Common Cattail		√		√	√			√	√	
	5	*Equisetum arvense*	Field Horsetail			√							√
		Equisetum var	Horsetail species						√				
		Galium palustre	Marsh Bedstraw					√					
		Lycopus uniflorus	Northern Bugleweed					√					
		Lysimachia ciliata	Fringed Loosestrife					√					
		Mentha arvensis	Common Mint					√	√		√	√	√
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√
		Solidago canadensis	Canada Goldenrod								√	√	
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√	√
		Typha angustifolia	Narrow-leaved Cattail					√	√	√			
		Typha latifolia	Common Cattail				√				√	√	√
VEG-016	1	*Boehmeria cylindrica*	False Nettle							√			
		Carex lupulina	Hop Sedge							√	√	√	
		Carex sp.	Sedge species						√				
		Cicuta maculata	Spotted Water Hemlock							√			
		Heracleum lanatum	Cow Parsnip							√			
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	
		Phalaris arundinacea	Reed Canary Grass							√			
		Thelypteris palustris	Marsh Fern						√	√			
	2	*Boehmeria cylindrica*	False Nettle							√			
		Cicuta maculata	Spotted Water Hemlock							√			
		Impatiens capensis	Spotted Jewelweed										√
		Onoclea sensibilis	Sensitive Fern										√
		Phalaris arundinacea	Reed Canary Grass						√	√			
		Taraxacum officinale	Common Dandelion							√			
		Thelypteris palustris	Marsh Fern						√	√			
			Moss species						√				
	3	*Cicuta maculata*	Spotted Water Hemlock							√			
		Onoclea sensibilis	Sensitive Fern						√				
		Scutellaria galericulata	Common Skullcap						√				
		Thelypteris palustris	Marsh Fern							√			
	4	*Boehmeria cylindrica*	False Nettle							√			
		Cicuta maculata	Spotted Water Hemlock							√			
		Impatiens capensis	Spotted Jewelweed							√			
		Onoclea sensibilis	Sensitive Fern						√	√	√		
		Phalaris arundinacea	Reed Canary Grass						√	√	√	√	√
		Sium suave	Water Parsnip						√				
			Moss species						√				
	5	*Boehmeria cylindrica*	False Nettle							√			
		Carex lupulina	Hop sedge							√	√	√	
		Carex sp.	Sedge species						√				
		Cicuta maculata	Spotted Water Hemlock							√			
		Onoclea sensibilis	Sensitive Fern							√			
		Phalaris arundinacea	Reed Canary Grass						√				
		Scutellaria galericulata	Common Skullcap						√				
		Thelypteris palustris	Marsh Fern						√	√	√	√	
			Moss species						√				
VEG-018	1	*Aster sp.*	Aster species						√				
		Caltha palustris	Marsh Marigold						√	√	√	√	√
		Equisetum pratense	Meadow Horsetail						√	√			√
		Glyceria striata	Fowl Manna Grass								√	√	√
		Lycopus uniflorus	Northern Bugleweed						√				
		Mentha arvensis	Common Mint										√
		Onoclea sensibilis	Sensitive Fern						√	√			√
		Rhus radicans ssp. negundo	Poison Ivy						√				
		Symphyotrichum puniceum	Purple Stemmed Aster										√
		Taraxacum officinale	Common Dandelion								√	√	

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
			Moss species						√				
	2	*Aster sp.*	Aster species						√				
		Caltha palustris	Marsh Marigold						√	√	√	√	√
		Daucus carota	Queen Anne's Lace								√	√	
		Echinocystis lobata	Wild Cucumber								√	√	
		Epilobium hirsutum	Hairy Willow-Herb						√				
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum pratense	Meadow Horsetail						√				√
		Impatiens capensis	Spotted Jewelweed						√	√			
		Lycopus uniflorus	Northern Bugleweed						√				
		Mentha arvensis	Common Mint								√	√	
		Onoclea sensibilis	Sensitive Fern						√	√		√	√
		Phalaris arundinacea	Reed Canary Grass						√				
		Solidago canadensis	Canada Goldenrod						√				
		Solidago gigantea	Late Goldenrod						√		√	√	
		Symphyotrichum lanceolatum	Panicled Aster							√	√	√	√
		Rhus radicans ssp. negundo	Poison Ivy						√				
			Moss species						√				
	3	*Caltha palustris*	Marsh Marigold						√	√	√	√	√
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum pratense	Meadow Horsetail						√	√			√
		Galium palustre	Marsh Bedstraw						√	√	√	√	
		Glyceria striata	Fowl Manna Grass							√	√	√	√
		Impatiens capensis	Spotted Jewelweed						√	√			
		Mentha arvensis	Common Mint						√		√	√	
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	√
		Poa sp.	Grass species						√				
		Symphyotrichum lanceolatum	Panicled Aster								√	√	
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√	
	4	*Caltha palustris*	Marsh Marigold						√	√	√	√	√
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum pratense	Meadow Horsetail						√	√			√
		Impatiens capensis	Spotted Jewelweed						√	√			
		Galium palustre	Marsh Bedstraw								√	√	
		Glyceria striata	Fowl Manna Grass							√	√	√	√
		Maianthemum stellatum	Star Flowered False Solomon's-seal										√
		Mentha arvensis	Common Mint						√				√
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	√
		Poa sp.	Grass species						√				
		Polygonatum pubescens	Hairy Solomon's Seal							√			
		Solidago gigantea	Late Goldenrod										√
			Moss species						√				
	5	*Aralia nudicaulis*	Wild Sarsaparilla			√	√	√			√	√	
		Cicuta maculata	Spotted Water Hemlock							√			
		Dryopteris carthusiana	Spinulose Wood Fern						√		√	√	
		Dryopteris marginalis	Marginal Wood Fern						√				
		Epilobium hirsutum	Hairy Willow-Herb						√	√			
		Equisetum arvense	Field Horsetail								√	√	
		Equisetum pratense	Meadow Horsetail						√				
		Glyceria striata	Fowl Manna Grass							√			√
		Impatiens capensis	Spotted Jewelweed								√	√	
		Lycopus uniflorus	Northern Bugleweed						√	√	√	√	
		Maianthemum stellatum	Star Flowered False Solomon's-seal										√
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	√
		Polygonatum pubescens	Hairy Solomon's Seal						√	√	√	√	
		Rhus radicans ssp. negundo	Poison Ivy						√				
		Solidago altissima	Tall Goldenrod							√			
		Solidago gigantea	Late Goldenrod								√	√	
		Solidago patula	Rough-Leaved Goldenrod						√				
		Solidago rugosa	Rough-stemmed Goldenrod							√	√	√	
		Symphyotrichum lanceolatum	Panicled Aster							√	√	√	√
		Symphyotrichum lateriflorum	Calico Aster						√				
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√	
		Taraxacum officinale	Common Dandelion								√	√	
			Moss species						√				

APPENDIX IV

Shrub Species Observed by Plot 2006 - 2015

Appendix IV. Shrub Species by Plot 2006-2015

			Year									
Plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	*Ribes americanum*	Wild Black Currant									√	
	Ribes triste	Swamp Red Currant						√	√			
	Rubus idaeus	Red Raspberry	√	√			√	√				
	Salix eriocephala	Heart-leaved Willow					√					
	Salix petiolaris	Slender Willow	√		√	√	√		√	√	√	√
	Sambucus canadensis	Common Elderberry	√									
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√
	Salix lucida	Shining Willow						√				
	Parthenocissus quinquefolia	Virginia Creeper	√	√								
	Cornus amomum	Silky Dogwood								√	√	√
2	*Cornus alternifolia*	Alternate-leaved Dogwood	√	√								
	Cornus stolonifera	Red-osier Dogwood					√					√
	Lonicera tatarica	Tartarian Honeysuckle								√	√	
	Prunus virginiana	Chokecherry										√
	Rhamnus cathartica	Common Buckthorn	√	√	√	√		√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√				√	√	√	√	√	√
	Ribes americanum	Wild Black Currant	√	√			√	√				√
	Rubus allegheniensis	Common Blackberry		√								
	Rubus idaeus	Red Raspberry	√									
	Rubus pubescens	Dwarf Raspberry	√	√		√	√	√		√	√	√
	Sambucus canadensis	Common Elderberry								√	√	
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√
	Viburnum trilobum	High-bush cranberry									√	√
	Vitis riparia	Riverbank Grape						√	√	√	√	√
	Parthenocissus quinquefolia	Virginia Creeper	√	√			√					
	Parthenocissus vitacea	Woodbine								√		
3	*Cornus alternifolia*	Alternate-leaved Dogwood	√	√	√	√	√	√	√	√		√
	Cornus stolonifera	Red-osier Dogwood					√					
	Rhamnus cathartica	Common Buckthorn	√	√	√	√	√	√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√				√	√	√	√	√	√
	Ribes triste	Swamp Red Currant					√					
	Solanum dulcamara	Bittersweet Nightshade							√			√
	Viburnum trilobum	High-bush cranberry	√									
	Vitis riparia	Riverbank Grape	√	√								
	Parthenocissus quinquefolia	Virginia Creeper	√	√	√	√	√		√			
	Carpinus caroliniana	Blue Beech							√			
4	*Cornus stolonifera*	Red-osier Dogwood	√	√	√	√	√	√				
	Rhamnus cathartica	Common Buckthorn	√		√		√	√	√	√		
	Rhamnus frangula	Glossy Buckthorn	√			√	√	√	√	√	√	√
	Ribes americanum	Wild Black Currant							√			
	Rubus pubescens	Dwarf Raspberry	√	√		√			√	√	√	√
	Sambucus canadensis	Common Elderberry					√					
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√
	Vitis riparia	Riverbank Grape					√				√	
	Ribes var	Currant species		√								
	Parthenocissus quinquefolia	Virginia Creeper	√	√		√	√	√	√			
	Cornus amomum	Silky Dogwood							√	√	√	
	Parthenocissus vitacea	Woodbine								√	√	
5	*Cornus alternifolia*	Alternate-leaved Dogwood		√								
	Rhamnus cathartica	Common Buckthorn		√		√		√				√
	Rhamnus frangula	Glossy Buckthorn										√
6	*Cornus stolonifera*	Red-osier Dogwood	√	√	√	√		√	√	√	√	√
	Lonicera tatarica	Tartarian Honeysuckle										√
	Rhamnus cathartica	Common Buckthorn							√			
	Rhamnus frangula	Glossy Buckthorn										√
	Salix bebbiana	Bebb's Willow			√			√				
	Salix eriocephala	Heart-leaved Willow							√	√	√	
	Salix petiolaris	Slender Willow							√	√	√	√
	Salix var	Willow species		√				√				
7	*Cornus alternifolia*	Alternate-leaved Dogwood	√	√	√		√		√	√	√	√
	Prunus virginiana	Chokecherry								√		
	Rhamnus cathartica	Common Buckthorn				√	√		√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√				√	√	√	√	√	√

	Ribes americanum	Wild Black Currant			√							
	Rubus pubescens	Dwarf Raspberry	√	√					√	√	√	√
	Solanum dulcamara	Bittersweet Nightshade	√	√		√	√	√	√	√		√
	Viburnum trilobum	High-bush cranberry				√				√		
	Hamamelis virginiana	Witch Hazel			√		√					
	Parthenocissus quinquefolia	Virginia Creeper	√	√	√		√	√	√			
	Parthenocissus vitacea	Woodbine									√	√
	Amelanchier arborea	Downy Serviceberry								√		
8	*Cornus alternifolia*	Alternate-leaved Dogwood	√			√		√	√	√	√	√
	Cornus amomum	Silky Dogwood										√
	Cornus stolonifera	Red-osier Dogwood	√	√	√		√	√				
	Crataegus spp.	Hawthorn species	√									
	Echinocystis lobata	Wild Cucumber		√	√							
	Lonicera tatarica	Tartarian Honeysuckle	√	√	√	√	√	√	√	√		
	Physocarpus opulifolius	Ninebark										√
	Prunus virginiana	Chokecherry			√	√				√	√	
	Rhamnus cathartica	Common Buckthorn	√	√		√			√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√	√		√	√		√	√	√	√
	Ribes americanum	Wild Black Currant		√								
	Ribes triste	Swamp Red Currant	√									
	Rubus idaeus	Red Raspberry	√	√	√		√	√				
	Rubus parviflorus	Sparse-flowered Thimbleberry				√	√					
	Rubus pubescens	Dwarf Raspberry	√									
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√
	Viburnum trilobum	High-bush cranberry				√	√					√
	Vitis riparia	Riverbank Grape	√	√	√	√	√	√	√		√	
	Rubus occidentalis	Black Raspberry							√			
	Viburnum opulus	Guelder-rose							√	√	√	
	Aronia melanocarpa	Black Chokeberry							√			
	Parthenocissus vitacea	Woodbine									√	
9	*Cornus stolonifera*	Red-osier Dogwood		√	√	√	√	√	√			√
	Rhamnus cathartica	Common Buckthorn					√	√			√	√
	Rhamnus frangula	Glossy Buckthorn			√							
	Rubus idaeus	Red Raspberry				√	√	√		√	√	
	Solanum dulcamara	Bittersweet Nightshade				√		√		√		
	Cornus amomum	Silky Dogwood								√	√	
	Rubus occidentalis	Black Raspberry									√	
	Cornus foemina	Gray Dogwood								√		√
16	*Echinocystis lobata*	Wild Cucumber						√				
	Rhamnus cathartica	Common Buckthorn						√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn						√	√	√	√	√
	Solanum dulcamara	Bittersweet Nightshade						√	√	√	√	√
	Vitis riparia	Riverbank Grape									√	√
	Parthenocissus quinquefolia	Virginia Creeper						√	√			
	Parthenocissus vitacea	Woodbine								√	√	√
18	*Rhamnus cathartica*	Common Buckthorn						√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn						√	√	√	√	√
	Rubus pubescens	Dwarf Raspberry						√	√	√	√	√
	Solanum dulcamara	Bittersweet Nightshade						√	√	√	√	√
	Vitis riparia	Riverbank Grape						√		√	√	√
	Ilex verticillata	Winterberry						√	√	√	√	√
	Parthenocissus quinquefolia	Virginia Creeper						√	√			
	Toxicodendron radicans ssp. neg	Poison Ivy							√		√	
	Parthenocissus vitacea	Woodbine								√	√	√
	Toxicodendron rydbergii	Western Poison-ivy								√		√
Total			**42**	**37**	**25**	**30**	**40**	**47**	**51**	**53**	**53**	**54**

APPENDIX V

Bird Species Observed by Plot 2015

Appendix V. Bird Species Observed by Plot in 2006 - 2015

Breeding Bird Plot 001	MAMM1-3													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	17-Jun	29-Jun	2015
Alder Flycatcher	*Empidonax alnorum*						PR	PO						Eastern Bluebird (P)
American Goldfinch	*Spinus tristis*	PR	X	PO	PO		PO	PR	PO	PO	PR		3	Bobolink >100m (S)
American Robin	*Turdus migratorius*			PR	PR	PR	PR	PO	PR	PO	PO		2	Eastern Meadowlark >100m (S)
Baltimore Oriole	*Icterus galbula*		PR			PO	PO	PR		PR				Eastern Kingbird (H)
Bank Swallow	*Riparia riparia*						PO							American Goldfinch (S)
Barn Swallow	*Hirundo rustica*	PO	PR				PR	PO	PO		PO	1		Turkey Vulture (X)
Black-billed Cuckoo	*Coccyzus erythropthalmus*									PR				Grasshopper Sparrow (S)
Black-capped Chickadee	*Poecile atricapillus*	PO			PO	PO				PR	PO		1	
Bobolink	*Dolichonyx oryzivorus*		PO		PO	PO								
Brown-headed Cowbird	*Molothrus ater*			PR			PO	PR		PO	PO		1	
Cedar Waxwing	*Bombycilla cedrorum*	PO	PO		PR	PR		PO	PR	PR	PO		2	
Chipping Sparrow	*Spizella passerina*			PR					PO					
Common Grackle	*Quiscalus quiscula*					PO	PO							
Common Yellowthroat	*Geothylpis trichas*		PO	PR	PR	PR	PO	PR	CO	PR	PO		1	
Downy Woodpecker	*Picoides pubescens*				PO				PO	PO	PR		2	
Eastern Kingbird	*Tyrannus tyrannus*	PO			PR	PO	PO	PO						
Eastern Meadowlark	*Sturnella magna*		PO	PO		PO		PO	PO		PO		1	
Eastern Wood-pewee	*Contopus virens*			PO			PO	PO						
European Starling	*Sturnus vulgaris*				X	X					PO	2		
Flycatcher species		PO		X										
Grasshopper Sparrow	*Ammodramus savannarum*								PO					
Gray Catbird	*Dumetella carolinensis*				PO		PO		PO	PO				
Hairy Woodpecker	*Picoides villosus*								PR					
House Wren	*Troglodytes aedon*					PO			PO		PO		1	
House Finch	*Carpodacus mexicanus*			CO										
Killdeer	*Charadrius vociferus*								PO					
Least Flycatcher	*Empidonax minimus*			PO										
Mallard	*Anas platyrhynchos*					X			PR	PO				
Mourning Dove	*Zenaida macroura*			PO				PO	PO	PO	PO	1		
Northern Cardinal	*Cardinalis cardinalis*				PO				PO	PO	PO		1	
Northern Flicker	*Colaptes auratus*	PR						PO	PO					
Northern Waterthrush	*Parkesia noveboracensis*									PO				
Passerine species		PO												
Red-eyed Vireo	*Vireo olivaceus*				X									
Red-winged Blackbird	*Agelaius phoeniceus*	PR	CO	PR	PR	PR	CO	PR	PR	PO	PR	4		
Ring-billed Gull	*Larus delawarensis*						X							
Rock Pigeon	*Columba livia*					X				PO				
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				PO									
Savannah Sparrow	*Passerculus sandwichensis*		PR		PO	PR		PR	PR		PO	1		
Scarlet Tanager	*Piranga olivacea*	PO												
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	1		
Swamp Sparrow	*Melospiza georgiana*	PO	PO		PO			PR			PO		1	
Tennessee Warbler	*Oreothlypis peregrina*	PO												
Tree Swallow	*Tachycineta bicolor*			PO	PO	PO						2		
Warbling Vireo	*Vireo gilvis*				PO	PR	PR	PR	PR					
Willow Flycatcher	*Empidonax traillii*				PR	PR			PR	PR	PO		1	
Yellow Warbler	*Setophaga petechia*		X	PO	PR	PR	PO	PR	PR	PR	PR	1	1	
Yellow-billed Cuckoo	*Coccyzus americanus*	PO												
Total	**43**	14	12	15	21	20	17	19	23	19	19	**13**	**18**	

Breeding Bird Plot 002	SWCO1-2													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*		PO	PO		PO			PO					Nashville Warbler (P, A)
American Goldfinch	*Spinus tristis*						PR				PO	1		Cardinal (P, A)
American Robin	*Turdus migratorius*		PR	PR	PR	PO		PO	PO	PO	PO		2	Blue Jay (H)
Baltimore Oriole	*Icterus galbula*		PR		PO									Indigo Bunting (S)
Bank Swallow	*Riparia riparia*						X							
Black-capped Chickadee	*Poecile atricapillus*		PO	PR	PO	PO	PO	PR	PR	PR	PR	2	2	
Blue Jay	*Cyanocitta cristata*	PO			PR	PO		PR	PO	PO	PO		1	
Brown-headed Cowbird	*Molothrus ater*						PO							
Cedar Waxwing	*Bombycilla cedrorum*	PO					PR	PO						
Chestnut-sided Warbler	*Setophaga pensylvanica*	PO												
Chipping Sparrow	*Spizella passerina*										PO	1		
Common Grackle	*Quiscalus quiscula*			PO				PO		PO				
Common Yellowthroat	*Geothylpis trichas*			PR	PO		PO		PR	PR	PO		2	
Downy Woodpecker	*Picoides pubescens*	PO		PO					PO					
Eastern Kingbird	*Tyrannus tyrannus*								PO					
Eastern Meadowlark	*Sturnella magna*						PO							
Eastern Wood-pewee	*Contopus virens*	PO	PO		PO	PR		PO	PR	PR				
European Starling	*Sturnus vulgaris*								PO					
Great Crested Flycatcher	*Myiarchus crinitus*		PO		PO			PO		PR	PO		1	
Hairy Woodpecker	*Picoides villosus*							PO						
House Wren	*Troglodytes aedon*		PO	PO	PO	PO		PR	PO	PR				
Indigo Bunting	*Passerina cyanea*	PO		PO										
Killdeer	*Charadrius vociferus*				PR			PO						
Mourning Dove	*Zenaida macroura*					PO		PR						
Northern Cardinal	*Cardinalis cardinalis*		PO		PO			PO	PR		PO		1	
Northern Flicker	*Colaptes auratus*				PO									
Northern Waterthrush	*Parkesia noveboracensis*					PR		PR	PR	PR	PO	1		
Passerine species		PO												
Red-bellied Woodpecker	*Melanerpes carolinus*								PO					
Red-breasted Nuthatch	*Sitta canadensis*							PO			PO		1	
Red-winged Blackbird	*Agelaius phoeniceus*	PO			PO		PO	PO			PO	3		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*					PR				PR				
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR		PR	1	1	
Turkey Vulture	*Cathartes aura*						X							
Wabler species		PO												
Warbling Vireo	*Vireo gilvis*						PO							
Yellow Warbler	*Setophaga petechia*						PO							
Total	**35**	10	9	9	13	10	12	16	14	10	12	**9**	**11**	

Breeding Bird Plot 003	FODM6													
		Breeding Evidence												Incidental Observations
											2015			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*	PR	PO		PR	PO	PO		PO					Eastern Wood Pewee
American Goldfinch	*Spinus tristis*									PO				
American Robin	*Turdus migratorius*		PR	PR	PO	PO	PO	PO	PO	PR				
Baltimore Oriole	*Icterus galbula*		PO						PO					
Black-billed Cuckoo	*Coccyzus erythropthalmus*				PO									
Black-capped Chickadee	*Poecile atricapillus*	PR		PO		PO	PO	PO	PR	PO	PO		2	
Blue Jay	*Cyanocitta cristata*			PR	PO	X		PO	PO	PO	PO	1		
Brown-headed Cowbird	*Molothrus ater*					PO	PO							
Cedar Waxwing	*Bombycilla cedrorum*						PO	PO	PO					
Common Grackle	*Quiscalus quiscula*			PO				PO						
Common Yellowthroat	*Geothylpis trichas*				PO	PR	PR	PO	PO					
Downy Woodpecker	*Picoides pubescens*					CO		PO	PO		PO		1	
Eastern Wood-pewee	*Contopus virens*	PO	PO	PR	PR	PR		PR		PO	PO	1		
European Starling	*Sturnus vulgaris*			PO				PO						
Gray Catbird	*Dumetella carolinensis*			PO										
Great Crested Flycatcher	*Myiarchus crinitus*	PO			PO	PR	PO	PO	PO		PO		1	
House Wren	*Troglodytes aedon*			PR	PR	PO		PO	PR		PR	1	1	
Indigo Bunting	*Passerina cyanea*					PO		PR						
Northern Cardinal	*Cardinalis cardinalis*	PO			PR				PR		PO		1	
Northern Flicker	*Colaptes auratus*										PO		1	
Red-bellied Woodpecker	*Melanerpes carolinus*								PO					
Red-breasted Nuthatch	*Sitta canadensis*								PO					
Red-eyed Vireo	*Vireo olivaceus*	PR	PO		PO	PR		PO	PR	PR	PO		1	
Red-tailed Hawk	*Buteo jamaicensis*		PR		PO						PO	1		
Red-winged Blackbird	*Agelaius phoeniceus*			PO	PR	PO								
Ring-billed Gull	*Larus delawarensis*								PO					
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				PO									
Song Sparrow	*Melospiza melodia*	PR	PO	PR	PO	PR	PR	PO	PR	PO	PR	1	1	
Warbling Vireo	*Vireo gilvis*							PO						
White-breasted Nuthatch	*Sitta carolinensis*						PO							
Wood Thrush	*Hylocichla mustelina*		PR											
Yellow-bellied Sapsucker	*Sphyrapicus varius*										PO		1	
Yellow Warbler	*Setophaga petechia*			PO					PO					
Total	**33**	7	8	11	14	14	9	15	17	7	12	**5**	**10**	

Breeding Bird Plot 004	**SWMM1-1**													
		Breeding Evidence												**Incidental Observations**
												2015		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*	PO	PR	PO	PO	X	PO		PO					Great-crested Flycatcher (S)
American Goldfinch	*Spinus tristis*		PO	X	PO	PO		PO	PO	PO	PO		1	Killdeer (S)
American Robin	*Turdus migratorius*	PO	PO	PO	PO	PO	PR	PR	PR	PR	PR	2	2	American Crow
Black-capped Chickadee	*Poecile atricapillus*	PO	PO	PR	CO	PO		CO		PR	PR	2	2	Northern Cardinal
Blue-gray Gnatcatcher	*Polioptila caerulea*				PO									Eastern Phoebe
Blue Jay	*Cyanocitta cristata*	PR	PR		PO	PO	PO	PO	PO	PR				Brown-headed Cowbird
Brown-headed Cowbird	*Molothrus ater*				PO	X			PO	PO	PO	1		Blue Jay
Cedar Waxwing	*Bombycilla cedrorum*			PO		PO				PO				Great Blue Heron
Chipping Sparrow	*Spizella passerina*		PO	PO					PR		PO		2	Spotted Sandpiper
Common Grackle	*Quiscalus quiscula*	PO		X	CO		PO		PO		PR	1	1	
Common Yellowthroat	*Geothylpis trichas*	CO	PO	PR	PR	PR		PR	PO	PO	PO		1	
Downy Woodpecker	*Picoides pubescens*			PO										
European Starling	*Sturnus vulgaris*						PR		CO					
Gray Catbird	*Dumetella carolinensis*				PO			PO						
Great Crested Flycatcher	*Myiarchus crinitus*										PO		1	
Hairy Woodpecker	*Picoides villosus*	PO												
House Wren	*Troglodytes aedon*								PO					
Mallard	*Anas platyrhynchos*		X											
Mourning Dove	*Zenaida macroura*								PO					
Northern Cardinal	*Cardinalis cardinalis*	PO		PO	PR	PO		PO	PO	PO				
Northern Flicker	*Colaptes auratus*					PO		PO						
Northern Waterthrush	*Parkesia noveboracensis*				PO	PO	PO				PR	1	1	
Pine Warbler	*Setophaga pinus*					PO								
Red-eyed Vireo	*Vireo olivaceus*						PO							
Red-tailed Hawk	*Buteo jamaicensis*		PO											
Red-winged Blackbird	*Agelaius phoeniceus*	PR	PR	PO	PO	PO	PO		PO	PO	PR	3	1	
Savannah Sparrow	*Passerculus sandwichensis*			PO				PO	PO		PO	1		
Scarlet Tanager	*Piranga olivacea*							PO						
Song Sparrow	*Melospiza melodia*	PO	PO	PR	PO	PR	PO	PR	PR		PR	1	2	
Swamp Sparrow	*Melospiza georgiana*	PO			PO			PR			PO	1		
White-breasted Nuthatch	*Sitta carolinensis*						PO							
Wood Thrush	*Hylocichla mustelina*			PO										
Yellow-bellied Sapsucker	*Sphyrapicus varius*						PO							
Yellow Warbler	*Setophaga petechia*			PO		PO			PO	PR	PO		1	
Total	**34**	11	11	15	15	15	11	12	16	10	14	**13**	**15**	

Breeding Bird Plot 005	FOMM6													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	17-Jun	29-Jun	2015
American Crow	*Corvus brachyrhynchos*	PO		PO	PO	PO								American Robin >100m (S)
American Goldfinch	*Spinus tristis*	PO	PO					PR	PO					
American Robin	*Turdus migratorius*	PO		PR	PO	PR	PR	PR	PR	PR	PR	2	3	
Black-capped Chickadee	*Poecile atricapillus*	PR	PR	PO	PO	PR	PO	PR	PR	PO	PR	1	4	
Blue Jay	*Cyanocitta cristata*	PR	PO	PO	PO	X	PO	PR	PR		PR	1	2	
Brown Creeper	*Certhia americana*								PO					
Cedar Waxwing	*Bombycilla cedrorum*			PO							PO	3		
Chipping Sparrow	*Spizella passerina*				PR									
Common Grackle	*Quiscalus quiscula*				CO									
Common Yellowthroat	*Geothylpis trichas*		PO		PO			PO			PO		1	
Downy Woodpecker	*Picoides pubescens*			PO										
Gray Catbird	*Dumetella carolinensis*							PO						
Great Crested Flycatcher	*Myiarchus crinitus*	PO	PR	PO	PO	PO	PR	PO		PO	PR	1	1	
Hairy Woodpecker	*Picoides villosus*								PO					
House Wren	*Troglodytes aedon*	PO												
Killdeer	*Charadrius vociferus*	PO					X		PO					
Mourning Dove	*Zenaida macroura*		PO						PO	PO				
Northern Cardinal	*Cardinalis cardinalis*	PO	PO		PO		PR	PR			PO	1		
Northern Flicker	*Colaptes auratus*					PO			PO		PO		1	
Pine Warbler	*Setophaga pinus*			PR				PO						
Red-breasted Nuthatch	*Sitta canadensis*				PO	X		PO			PO		1	
Red-eyed Vireo	*Vireo olivaceus*				PR		PO	PO						
Red-winged Blackbird	*Agelaius phoeniceus*				PO						PO	1		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*						PR							
Song Sparrow	*Melospiza melodia*			PO		PO			PO					
Swamp Sparrow	*Melospiza georgiana*				PO									
Tree Swallow	*Tachycineta bicolor*										PO		2	
White-breasted Nuthatch	*Sitta carolinensis*		PO		PO									
Total	**28**	9	8	9	14	8	8	11	10	4	11	**10**	**15**	

Breeding Bird Plot 006	MAMM1-3													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	17-Jun	29-Jun	2015
American Crow	*Corvus brachyrhynchos*					PO			PO					Great-crested Flycatcher (S)
American Goldfinch	*Spinus tristis*	PR	PR	PR	PO	PO	PO	PR	PR	PR	PR	2	3	Turkey Vulture
American Redstart	*Setophaga ruticilla*					PO								Blue Jay
American Robin	*Turdus migratorius*	PR	PO	PO	PR	CO	PO	PR	PR	PR	PO		2	American Crow
Baltimore Oriole	*Icterus galbula*			PO			PR							Killdeer
Bank Swallow	*Riparia riparia*										PO	1		Mallard
Barn Swallow	*Hirundo rustica*	PO	PR	PR										
Black-capped Chickadee	*Poecile atricapillus*			PO	PO	PO				PO	PO		1	
Blue Jay	*Cyanocitta cristata*	PO	PO					PO						
Brown-headed Cowbird	*Molothrus ater*				X	PO	PO		PR		PO	2		
Cedar Waxwing	*Bombycilla cedrorum*				X	X		PO			PR	2	4	
Common Grackle	*Quiscalus quiscula*			PO	X		PO				PO	1		
Common Yellowthroat	*Geothylpis trichas*		PO	PR	PO	PO	PO	PR	PR	PR	PO		2	
Downy Woodpecker	*Picoides pubescens*										PO		1	
Eastern Meadowlark	*Sturnella magna*								PO					
Eastern Wood-pewee	*Contopus virens*			PO				PO						
European Starling	*Sturnus vulgaris*			X	PO			PO			X		1	
Field Sparrow	*Spizella pusilla*		PO				PO							
Gray Catbird	*Dumetella carolinensis*			PO			PO		PO					
Great Crested Flycatcher	*Myiarchus crinitus*		PO						PO					
Hairy Woodpecker	*Picoides villosus*							PO						
House Wren	*Troglodytes aedon*						PO							
Indigo Bunting	*Passerina cyanea*				PO					PO				
Killdeer	*Charadrius vociferus*								PO	PO				
Mallard	*Anas platyrhynchos*	PO	PR											
Mourning Dove	*Zenaida macroura*								PO					
Northern Cardinal	*Cardinalis cardinalis*	PO	PR		PO						PO		1	
Northern Flicker	*Colaptes auratus*		CO			PO								
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*				PR			PO						
Northern Waterthrush	*Parkesia noveboracensis*					PO								
Red-tailed Hawk	*Buteo jamaicensis*						PR		PO					
Red-winged Blackbird	*Agelaius phoeniceus*	PR	CO	CO	CO	PR	PR	CO	PR	PR	PR	7	9	
Ring-billed Gull	*Larus delawarensis*		X											
Rock Pigeon	*Columba livia*					X								
Savannah Sparrow	*Passerculus sandwichensis*				PO			PO	PO					
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	2	3	
Spotted Sandpiper	*Actitis macularia*							PO						
Tree Swallow	*Tachycineta bicolor*			PO		PO		PO			PO		2	
Warbling Vireo	*Vireo gilvis*					PR	PR	PR	PO		PO		1	
Willow Flycatcher	*Empidonax traillii*								PO		PR	1	1	
Vesper Sparrow	*Pooecetes gramineus*				PO									
Yellow Warbler	*Setophaga petechia*				PR	PO	PR		PR	PO	PO	1		
Total	**42**	8	13	13	16	16	14	15	17	9	17	**19**	**31**	

Breeding Bird Plot 007	**SWMM1-1**													
		Breeding Evidence												**Incidental Observations**
											2015			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*	PR	PO											Song Sparrow
American Goldfinch	*Spinus tristis*	PO	PO	PR	PO	PO		PR			PO		1	
American Robin	*Turdus migratorius*	PR		PO	PO	PR	PR	PR	PR	PR	PR	1	1	
Baltimore Oriole	*Icterus galbula*				CO					PO				
Bank Swallow	*Riparia riparia*									PO				
Black-capped Chickadee	*Poecile atricapillus*		PR	PO	PR	PO	PO	PO	PR		PO		1	
Blue Jay	*Cyanocitta cristata*	PR	PO		PR	PO	PO	PO	PO	PO	PR	2	1	
Brown Creeper	*Certhia americana*					PO	PO	PO	PO					
Canada Goose	*Branta canadensis*		X											
Cedar Waxwing	*Bombycilla cedrorum*			PO		PO		PO	PO		PO		1	
Chipping Sparrow	*Spizella passerina*			PO	PO						PO	1		
Common Grackle	*Quiscalus quiscula*				X		PO				PO		1	
Downy Woodpecker	*Picoides pubescens*		X	PO							PO		1	
Eastern Kingbird	*Tyrannus tyrannus*		PO											
Eastern Meadowlark	*Sturnella magna*			PO										
Eastern Wood-pewee	*Contopus virens*				PO	PO								
Field Sparrow	*Spizella pusilla*			PO	PO									
Gray Catbird	*Dumetella carolinensis*				PO									
Great Crested Flycatcher	*Myiarchus crinitus*		PR		PO	PO	PO	PO		PO				
Hairy Woodpecker	*Picoides villosus*	PO							PO					
Indigo Bunting	*Passerina cyanea*	PO			PO						PO		1	
Killdeer	*Charadrius vociferus*						PO	PO	PO		PO	1		
Northern Cardinal	*Cardinalis cardinalis*		PO	PO	PO		PO		PO	PR				
Northern Flicker	*Colaptes auratus*								PO					
Mourning Dove	*Zenaida macroura*								PO	PO				
Passerine Species		PO		PO		PO								
Red-breasted Nuthatch	*Sitta canadensis*					PR			PO		PO		2	
Red-eyed Vireo	*Vireo olivaceus*				PO		PO			PR	PO	1		
Ring-billed Gull	*Larus delawarensis*										OB	1		
Red-winged Blackbird	*Agelaius phoeniceus*										PO		1	
Savannah Sparrow	*Passerculus sandwichensis*							PO						
Song Sparrow	*Melospiza melodia*	PR	PO	PR	PR	PR	PR	PR	PR	PO	PO	1		
Spotted Sandpiper	*Actitis macularia*							PO						
White-breasted Nuthatch	*Sitta carolinensis*		PO		PR		PR							
Total	**33**	8	11	11	16	11	11	11	12	9	15	**8**	**11**	

Breeding Bird Plot 008	SWMM1-1													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*		PR		PO		PO			PO				Song Sparrow
American Goldfinch	*Spinus tristis*	PR	PO	PR	PR	PO	PO	PR	PR	PO	PO		2	Savannah Sparrow
American Robin	*Turdus migratorius*	PO	PO	PR	PO	PO	PO	PR	PR	PR	PR	1	2	Blue Jay
American Woodcock	*Scolopax minor*							PO						Black-capped Chickadee
Barn Swallow	*Hirundo rustica*								X					Mourning Dove
Belted Kingfisher	*Megaceryle alcyon*					PO			PO	CO				Horned Lark
Black-billed Cuckoo	*Coccyzus erythropthalmus*				PO									American Robin
Black-capped Chickadee	*Poecile atricapillus*		PR	PR	PR	PO	PO		PR	PO	PO	2		Cedar Waxwing
Blue Jay	*Cyanocitta cristata*	PO	PO		PR	PO	PO	PO		PO	PR	1	1	American Woodcock
Brown-headed Cowbird	*Molothrus ater*		PO		PO	PO	PO		PO	PR	PO	1		
Cedar Waxwing	*Bombycilla cedrorum*	PO			PO			PO						
Chipping Sparrow	*Spizella passerina*	PO												
Common Grackle	*Quiscalus quiscula*		PR	X	X		PO			PO	CO	1		
Common Yellowthroat	*Geothylpis trichas*	PO		PO	PO	PO	PO	PO	PO	PO	PR	1	1	
Eastern Kingbird	*Tyrannus tyrannus*									PO				
Eastern Meadowlark	*Sturnella magna*			PR	PO									
Eastern Wood-pewee	*Contopus virens*						PO							
Gray Catbird	*Dumetella carolinensis*	CO	PR		PR		CO	PO			PO	1		
Great Crested Flycatcher	*Myiarchus crinitus*							PO						
Hairy Woodpecker	*Picoides villosus*	PO		PO										
House Wren	*Troglodytes aedon*						PO	PO			PO	2		
Killdeer	*Charadrius vociferus*						PO		PO					
Mallard	*Anas platyrhynchos*		X			X	X		X					
Mourning Dove	*Zenaida macroura*						PO		PO	PO	PR	2		
Northern Cardinal	*Cardinalis cardinalis*	PO		PO	PR		PO	PR	PO	PO	PR	1	2	
Northern Flicker	*Colaptes auratus*						PO		PO					
Northern Waterthrush	*Parkesia noveboracensis*							PO						
Red-eyed Vireo	*Vireo olivaceus*						PO	PO						
Red-winged Blackbird	*Agelaius phoeniceus*	PO	PR	PR	PO		PO	PO	PR					
Ring-billed Gull	*Larus delawarensis*								X		X	1		
Savannah Sparrow	*Passerculus sandwichensis*			PO	PO			PR			PO		2	
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	2	3	
Yellow Warbler	*Setophaga petechia*			PR	PO		PO		PR					
Total	**33**	11	11	12	17	9	20	15	16	13	14	**16**	**13**	

Breeding Bird Plot 009	MASM1-1													
		Breeding Evidence												Incidental Observations
											2015			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*			PO	PO	CO			PO					Tree Swallow
American Goldfinch	*Spinus tristis*				PR	PO	PO		PR		PO		2	Turkey Vulture
American Robin	*Turdus migratorius*			PO	PR	PO	PR	PO	PO	PR				Song Sparrow
Baltimore Oriole	*Icterus galbula*				PR		PO							Wild Turkey (2)
Barn Swallow	*Hirundo rustica*			PR	PO	PO		PO		X	X		2	Savannah Sparrow
Black-capped Chickadee	*Poecile atricapillus*			PO										Black-capped Chickadee
Blue Jay	*Cyanocitta cristata*								X		PO	1		Black-billed Cuckoo
Bobolink	*Dolichonyx oryzivorus*				PO				PR					Bobolink (P)
Canada Goose	*Branta canadensis*		CO											
Cedar Waxwing	*Bombycilla cedrorum*									PO	PR		3	
Chipping Sparrow	*Spizella passerina*						PO							
Common Grackle	*Quiscalus quiscula*				X		PO	PO			PR	2		
Common Yellowthroat	*Geothylpis trichas*		PR	PO	PO	PR	PR	PO	PO	PR	PR	1	1	
Eastern Kingbird	*Tyrannus tyrannus*				PR			PO						
Eastern Meadowlark	*Sturnella magna*				PR		PO	PR	PO					
Eastern Wood-pewee	*Contopus virens*				PO									
European Starling	*Sturnus vulgaris*				PO		PO	PO			PO	2		
House Wren	*Troglodytes aedon*						PO							
Killdeer	*Charadrius vociferus*		PR		PR			PO	PO					
Mallard	*Anas platyrhynchos*		X			X	PO							
Northern Cardinal	*Cardinalis cardinalis*			PO										
Northern Flicker	*Colaptes auratus*						PO							
Red-tailed Hawk	*Buteo jamaicensis*			PO	PO									
Red-winged Blackbird	*Agelaius phoeniceus*		CO	CO	CO	PR	PR	PR	PR	PR	PR	4	3	
Ring-billed Gull	*Larus delawarensis*		X	X										
Rock Pigeon	*Columba livia*							PO						
Savannah Sparrow	*Passerculus sandwichensis*		PR	PO	PO	PR	PO	PR	PR	PO	PO	2		
Song Sparrow	*Melospiza melodia*			PO	PR	PR		PO	PR	PO	PR	1	2	
Tree Swallow	*Tachycineta bicolor*		CO	PO				PO	PO		PO	3	2	
Turkey Vulture	*Cathartes aura*							PO						
Warbling Vireo	*Vireo gilvis*								PO					
Wild Turkey	*Meleagris gallopavo*								PO					
Willow Flycatcher	*Empidonax traillii*				PO			PR	PO	PR	PO		1	
Yellow Warbler	*Setophaga petechia*			PO	PO			PO			PR	1	1	
Total	**34**		8	13	19	9	13	16	15	8	13	**17**	**17**	

Breeding Bird Plot 011	FODR1-1													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*				PO	PO								
American Goldfinch	*Spinus tristis*				X	PO	PO	PR	PR	PR	PO		4	
American Redstart	*Setophaga ruticilla*				PO			PO		PR	PR	1	1	
American Robin	*Turdus migratorius*				PO	PR	PR	PR	PR	PO	PO		1	
Baltimore Oriole	*Icterus galbula*					PO	PO		PR					
Barn Swallow	*Hirundo rustica*					PO			X					
Black-capped Chickadee	*Poecile atricapillus*					PO	PO	PO	PR	PO	PO	2		
Blue Jay	*Cyanocitta cristata*				PO				PO					
Brown-headed Cowbird	*Molothrus ater*									PO				
Cedar Waxwing	*Bombycilla cedrorum*					PO			PO	PO				
Chestnut-sided Warbler	*Setophaga pensylvanica*						PO							
Chipping Sparrow	*Spizella passerina*						PO			PO				
Cliff Swallow	*Petrochelidon pyrrhonota*								X					
Common Grackle	*Quiscalus quiscula*				X			PO	PO					
Common Yellowthoat	*Geothlypis trichas*										PO		1	
Downy Woodpecker	*Picoides pubescens*						PO				PO		1	
Eastern Kingbird	*Tyrannus tyrannus*					PR								
Eastern Meadowlark	*Sturnella magna*				PO				PO					
Eastern Wood-pewee	*Contopus virens*				PO	PO			PO					
European Starling	*Sturnus vulgaris*							PO	CO	PO				
Gray Catbird	*Dumetella carolinensis*				PO	PO	PO	CO	PO	PO	PR	1	2	
Horned Lark	*Eremophila alpestris*								PO					
House Wren	*Troglodytes aedon*				PR	PO								
Killdeer	*Charadrius vociferus*				PO					PO				
Mourning Dove	*Zenaida macroura*					PO	PR		PO					
Northern Cardinal	*Cardinalis cardinalis*				PO			PO		PO				
Northern Flicker	*Colaptes auratus*				PO				PO	PO				
Red-eyed Vireo	*Vireo olivaceus*						PO	PO	PO	PO				
Red-winged Blackbird	*Agelaius phoeniceus*				PO	PO	PO	PO	PR		PR	2	4	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				PO					PO	PO		1	
Savannah Sparrow	*Passerculus sandwichensis*					PR			PO					
Song Sparrow	*Melospiza melodia*				PR	PO	PO		PR	PR	PO		1	
Tree Swallow	*Tachycineta bicolor*						PR				PO		1	
Turkey Vulture	*Cathartes aura*								X					
Warbling Vireo	*Vireo gilvis*				PO	PO	PO	PO		PO			1	
White-breasted Nuthatch	*Sitta carolinensis*							PO						
Yellow Warbler	*Setophaga petechia*						PO	PR	PR	PO				
Total	**37**				17	16	15	13	22	17	11	**6**	**18**	

Breeding Bird Plot 016	SWDM3-2													
		Breeding Evidence												Incidental Observations
											2015			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*						PO		PO					Northern Cardinal >100m (S)
American Goldfinch	*Spinus tristis*						PO	PO		PR	PR	1	1	Savannah Sparrow >100m (S)
American Redstart	*Setophaga ruticilla*						PO							Brown-headed Cowbird
American Robin	*Turdus migratorius*						PR	CO	PR	PO	PR	3	2	Warbling Vireo
Baltimore Oriole	*Icterus galbula*						PO		PO					Horned Lark
Black-capped Chickadee	*Poecile atricapillus*						PO	PR						American Goldfinch
Blue Jay	*Cyanocitta cristata*						PR				PO	1		
Brown-headed Cowbird	*Molothrus ater*						PO		PO					
Cedar Waxwing	*Bombycilla cedrorum*						PO							
Downy Woodpecker	*Picoides pubescens*							PO						
Eastern Wood-pewee	*Contopus virens*							PO						
Hairy Woodpecker	*Picoides villosus*						PO							
Horned Lark	*Eremophila alpestris*								PO					
Indigo Bunting	*#N/A*										PO		1	
Killdeer	*Charadrius vociferus*						PO	PR	PO		PO		1	
Red-eyed Vireo	*Vireo olivaceus*						PO		PO	PO	PO		1	
Red-winged Blackbird	*Agelaius phoeniceus*										PR	4	2	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*									PO				
Savannah Sparrow	*Passerculus sandwichensis*						PO		PO		PO		2	
Song Sparrow	*Melospiza melodia*						PR	PR	PR	PO	PR	3	3	
Tree Swallow	*Tachycineta bicolor*						PO							
Warbling Vireo	*Vireo gilvis*						PR		PR					
Yellow-bellied Sapsucker	*Sphyrapicus varius*						PO							
Yellow Warbler	*Setophaga petechia*								PR					
Total	**24**						17	7	10	5	9	**12**	**13**	

Breeding Bird Plot 019	**MEM**													
		Breeding Evidence												**Incidental Observations**
											2015			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*							PR	PO					Great Blue Heron >100 (H)
American Goldfinch	*Spinus tristis*						PO	PO	PR	PO				Cuckoo sp. (H)
American Robin	*Turdus migratorius*						PO	PO	PR	PO				Yellow-bellied Sapsucker
American Woodcock	*Scolopax minor*								PO					Eastern Wood Pewee
Baltimore Oriole	*Icterus galbula*								PR		CO	1	4	
Bank Swallow	*Riparia riparia*						PO							
Barn Swallow	*Hirundo rustica*						PO	PO	PO	X	CO	2	4	
Blue Jay	*Cyanocitta cristata*							PO	PO	PO	PR	1	1	
Bobolink	*Dolichonyx oryzivorus*							PR						
Brown-headed Cowbird	*Molothrus ater*						PO				PO	2		
Cedar Waxwing	*Bombycilla cedrorum*							PO		PO	PR	2	2	
Common Grackle	*Quiscalus quiscula*						PO	X	PO	PO				
Common Yellowthroat	*Geothylpis trichas*						PR	PO	PR	PO	PO	1		
Eastern Kingbird	*Tyrannus tyrannus*									PO				
Eastern Meadowlark	*Sturnella magna*							PR						
Eastern Wood-pewee	*Contopus virens*						PO		PR	PO				
European Starling	*Sturnus vulgaris*								PO					
Gray Catbird	*Dumetella carolinensis*									PO	PO		1	
Great Blue Heron	*Ardea herodias*										X	1		
Great Crested Flycatcher	*Myiarchus crinitus*								PO	PO				
House Wren	*Troglodytes aedon*								PO					
Indigo Bunting	*Passerina cyanea*							PO		PR				
Northern Cardinal	*Cardinalis cardinalis*								PR					
Northern Flicker	*Colaptes auratus*								PO		PO		2	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*								PO					
Red-bellied Woodpecker	*Melanerpes carolinus*								PO		PO	1		
Red-eyed Vireo	*Vireo olivaceus*										PR	1	1	
Red-winged Blackbird	*Agelaius phoeniceus*						PO	PR	PR	PO	PR	2	1	
Savannah Sparrow	*Passerculus sandwichensis*							PO						
Song Sparrow	*Melospiza melodia*						PR	PR	CO	PR	PR	3	3	
Tree Swallow	*Tachycineta bicolor*							PO	PO		PO	1		
Warbling Vireo	*Vireo gilvis*								PO					
Willow Flycatcher	*Empidonax traillii*									PO				
Wood Thrush	*Hylocichla mustelina*								PO					
Yellow-bellied Sapsucker	*Sphyrapicus varius*										PO	1		
Yellow Warbler	*Setophaga petechia*							PO						
Total	**36**						10	16	22	15	15	**19**	**19**	

Breeding Bird Plot 020	Agricultural Field													
		Breeding Evidence												Incidental Observations
												2015		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	17-Jun	29-Jun	**2015**
American Crow	*Corvus brachyrhynchos*								PO	PO				Eastern Meadowlark
American Goldfinch	*Spinus tristis*						PR	PR	PR		PR	1	4	Barn Swallow
American Robin	*Turdus migratorius*						PO	PO	PR	PO	PO	1		Bobolink
Baltimore Oriole	*Icterus galbula*							PR						American Crow
Barn Swallow	*Hirundo rustica*							X	X	X				Chimney Swift (P)
Black-capped Chickadee	*Poecile atricapillus*							PO	PO					Red-tailed Hawk (H)
Blue Jay	*Cyanocitta cristata*							PO	PR					Red-winged Blackbird (P)
Bobolink	*Dolichonyx oryzivorus*						PO	PO	PR	PR	PR	1	3	Ring-billed Gull
Brown-headed Cowbird	*Molothrus ater*							PO						Eastern Kingbird
Chipping Sparrow	*Spizella passerina*						PR							
Cedar Waxwing	*Bombycilla cedrorum*							PO						
Common Grackle	*Quiscalus quiscula*						PO	PO	PO	PO				
Common Yellowthroat	*Geothylpis trichas*							PR	PO	PR	PO		1	
Downy Woodpecker	*Picoides pubescens*							PO						
Eastern Kingbird	*Tyrannus tyrannus*								PR	PO	PO	1		
Eastern Meadowlark	*Sturnella magna*						PO	PO	PR	PO	PR	3	1	
European Starling	*Sturnus vulgaris*								PO					
Great Crested Flycatcher	*Myiarchus crinitus*							PO						
House Wren	*Troglodytes aedon*						PR	PO		PO				
Indigo Bunting	*Passerina cyanea*							PO						
Killdeer	*Charadrius vociferus*								PO	PO				
Mallard	*Anas platyrhynchos*									X				
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*								X					
Red-tailed Hawk	*Buteo jamaicensis*								PR					
Red-winged Blackbird	*Agelaius phoeniceus*						PR	CO	PR	CO	PO		2	
Ring-billed Gull	*Larus delawarensis*								PO					
Rock Pigeon	*Columba livia*									X				
Savannah Sparrow	*Passerculus sandwichensis*						PR	CO	PR	PR	PR	4	6	
Song Sparrow	*Melospiza melodia*						PO	PR	CO	PO	PR	1	2	
Tree Swallow	*Tachycineta bicolor*							X	X	X	X		3	
Warbling Vireo	*Vireo gilvis*							PO	PO					
Yellow Warbler	*Setophaga petechia*						PO							
Total	**32**						11	21	20	16	10	**12**	**22**	

Incidentals

Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2015	
		Breeding Evidence											
												17-Jun	29-Jun
Alder Flycatcher	*Empidonax alnorum*							PO					
American Crow	*Corvus brachyrhynchos*	PO		PO	PO	PO	PO	PO					
American Goldfinch	*Spinus tristis*	PR	X	PO	PO	PO	PO	PR			PO		
American Robin	*Turdus migratorius*	PO		PO	PO	PR	PO	PR			PO		
Baltimore Oriole	*Icterus galbula*	PR	PR		PO		PO	PO					
Barn Swallow	*Hirundo rustica*			X			PO				PO		
Black-capped Chickadee	*Poecile atricapillus*			PO	PO		PO						
Black-billed Cuckoo	*Coccyzus erythropthalmus*												
Blue Jay	*Cyanocitta cristata*	PO			PO	PO	PO	PO			PO		
Bobolink	*Dolichonyx oryzivorus*	PO		PO		PR	PR	PR			PR	9	
Brown-headed Cowbird	*Molothrus ater*	PO	PO	PO	PO	PR	PO	PR					
Canada Goose	*Branta canadensis*		PR			X		PO					
Cedar Waxwing	*Bombycilla cedrorum*		PR	PO		PO	PO						
Chimney Swift	*Chaetura pelagica*										PR		
Chipping Sparrow	*Spizella passerina*				PO		PO						
Common Grackle	*Quiscalus quiscula*		X	PO			PO	PO					
Common Yellowthroat	*Geothylpis trichas*		PO	PO		PR	PO	PO					
Cuckoo sp.											PO		
Downy Woodpecker	*Picoides pubescens*			PO									
Eastern Bluebird	*Sialia sialis*										PR		
Eastern Kingbird	*Tyrannus tyrannus*	PO	PO			PR					PO		
Eastern Meadowlark	*Sturnella magna*		PO	PO	PO	PR	PO	PO			PO		
Eastern Wood-pewee	*Contopus virens*		PO		PO	PO		PO					
European Starling	*Sturnus vulgaris*	PO		PO	PO		PO	PO					
Field Sparrow	*Spizella pusilla*		PO	PO			PO						
Grasshopper Sparrow	*Ammodramus savannarum*										PO		
Gray Catbird	*Dumetella carolinensis*		PO	PO	PO		PO	PO					
Great Blue Heron	*Ardea herodias*			X			X				OB		
Great Crested Flycatcher	*Myiarchus crinitus*			PO			PO				PO		
Gull sp.								X					
Hairy Woodpecker	*Picoides villosus*						PO	PO					
Horned Lark	*Eremophila alpestris*												
House Sparrow	*Passer domesticus*												
House Wren	*Troglodytes aedon*				PO		PO	PO					
Indigo Bunting	*Passerina cyanea*	PO	PR	PR			PO				PO		
Killdeer	*Charadrius vociferus*						PR	PR			PO		
Mallard	*Anas platyrhynchos*		X		PR	X	X						
Mourning Dove	*Zenaida macroura*			PO	PO	PO		PR					
Nashville Warbler	*Leiothlypis ruficapilla*										PR		
Northern Cardinal	*Cardinalis cardinalis*	PO		PO	PO		PO				PR		
Northern Flicker	*Colaptes auratus*				PO	PR	PO	PO					
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*												
Northern Waterthrush	*Parkesia noveboracensis*					PO							
Pine Warbler	*Setophaga pinus*			PO									
Red-tailed Hawk	*Buteo jamaicensis*	PR		PO	PO		PR	PO			PO		
Red-winged Blackbird	*Agelaius phoeniceus*	PO		PO	CO	PR	PO	CO			PR		
Ring-billed Gull	*Larus delawarensis*						X	X					
Rock Pigeon	*Columba livia*					X							
Ruffed Grouse	*Bonasa umbellus*						PO						
Savannah Sparrow	*Passerculus sandwichensis*		PO	PO	PO	PR	PO	PO			PO		
Song Sparrow	*Melospiza melodia*	PO	PO	PO	PO	PR	PO	PO					
Spotted Sandpiper	*Actitis macularia*						PO	PO					
Tree Swallow	*Tachycineta bicolor*	PR			CO	PO	PO	PO					
Turkey Vulture	*Cathartes aura*			X		X		X			OB		
Vesper Sparrow	*Pooecetes gramineus*				PO								
Warbling Vireo	*Vireo gilvis*					PO	PO						
Wild Turkey	*Meleagris gallopavo*							PO					
Willow Flycatcher	*Empidonax traillii*					PO							

Incidentals													
		Breeding Evidence											
												2015	
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	17-Jun	29-Jun
Winter Wren	*Troglodytes hiemalis*					PO	PO						
White-breasted Nuthatch	*Sitta carolinensis*	PO					PO						
Wood Thrush	*Hylocichla mustelina*			PO									
Yellow Warbler	*Setophaga petechia*			PO	PO	PR	PO						
Total	**53**	18	17	29	25	28	39	31	1	1	22		

APPENDIX VI

Bird Species Observed in the Study Area 2006 - 2015

Appendix VI. Bird Species Observed in the Study Area

						NRSI									
Common Name	**Scientific Name**	**SRANK**	**COSEWIC**	**SARO**	**Local Status**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
HERONS & BITTERNS															
Great Blue Heron	*Ardea herodias*	S4B			**			X			X				X
Green Heron	*Butorides virescens*	S4B			**									(X)	
GEESE															
Canada Goose	*Branta canadensis*	S5					PR			X	*	(PO)	*	(PO)	
DUCKS															
Wood Duck	*Aix sponsa*	S5							X	*			*		
Mallard	*Anas platyrhynchos*	S5				PO	PR		X	X	PO		PR	PO	PO
Bufflehead	*Bucephala albeola*	S4								*					
Hooded Merganser	*Lophodytes cucullatus*	S5B, S5N											*		
VULTURES															
Turkey Vulture	*Cathartes aura*	S5B			√	PO	X	X	X	X	X	PO	X	(X)	X
HAWKS, KITES & EAGLES															
Northern Harrier	*Circus cyaneus*	S4B	NAR	NAR	√*					*					
Cooper's Hawk	*Accipiter cooperii*	S4	NAR	NAR	√*					*					
Red-tailed Hawk	*Buteo jamaicensis*	S5	NAR	NAR		PO	CO	PO	CO	PO	PR	(PO)	PR	(PO)	PO
CARACARAS & FALCONS															
American Kestrel	*Falco sparverius*	S4			√*				X		*				
PARTRIDGES, GROUSE & TURKEY															
Ruffed Grouse	*Bonasa umbellus*	S4									(PO)				
Wild Turkey	*Meleagris gallopavo*	S5								*	*		PO		PO
PLOVERS															
Killdeer	*Charadrius vociferus*	S5B, S5N				PO	CO		PO		PO	PR	PO	PO	PO
Solitary Sandpiper	*Tringa solitaria*	S4B												(PR)	
SANDPIPERS & PHALAROPES															
Spotted Sandpiper	*Actitis macularia*	S5								*	(PO)	PO	*		PO
American Woodcock	*Scolopax minor*	S4B					PO	PO	PR		*	PO	PO	(PR)	PO
GULLS															
Ring-billed Gull	*Larus delawarensis*	S5B, S4N					X	X		*	X	X	PO		X
Herring Gull	*Larus argentatus*	S5B, S5N			**					*					
DOVES															
Rock Pigeon	*Columba livia*	SNA					X			X		PO		PO	
Mourning Dove	*Zenaida macroura*	S5					PO	PO	PO	PO	PR	PR	PO	PO	PR
CUCKOOS															
Yellow-billed Cuckoo	*Coccyzus americanus*	S4B			√	PO									
Black-billed Cuckoo	*Coccyzus erythropthalmus*	S5B			√*								X	PR	PO
SWIFTS															
Chimney Swift	*Chaetura pelagica*	S4B, S4N	T	THR	√	PO									PR
TYPICAL OWLS															
Barred Owl	*Strix varia*	S5			√									(X)	

Common Name	Scientific Name	SRANK	COSEWIC	SARO	Local Status	NRSI									
						2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
KINGFISHERS															
Belted Kingfisher	*Megaceryle alcyon*	S4B			√					PO			PO	CO	
WOODPECKERS															
Red-bellied Woodpecker	*Melanerpes carolinus*	S4			√								PO		PO
Yellow-bellied Sapsucker	*Sphyrapicus varius*	S5B			√*					*	PO		*		PO
Downy Woodpecker	*Picoides pubescens*	S5				PO	X	PO		CO	PO	PO	PO	PO	PR
Hairy Woodpecker	*Picoides villosus*	S5			√*	PO	X	PO	PO		PO	PO	PR		
Northern Flicker	*Colaptes auratus*	S4B			√*	PR	CO		PO	PO	PO	PO	PO	PO	PO
Pileated Woodpecker	*Dryocopus pileatus*	S5			√*					*			*		
FLYCATCHERS															
Flycatcher spp						PO		X							
Eastern Wood-pewee	*Contopus virens*	S4B	SC	SC		PO	PO	PR	PO	PR	PO	PR	PR	PR	PO
Alder Flycatcher	*Empidonax alnorum*	S5B									PR	PO			
Willow Flycatcher	*Empidonax traillii*	S5B			√				PO	PR		PR	PR	PR	PR
Least Flycatcher	*Empidonax minimus*	S4B			√	PO		PO							
Eastern Phoebe	*Sayornis phoebe*	S5B					PO			*				(PO)	PO
Great Crested Flycatcher	*Myiarchus crinitus*	S4B				PO	PR	PO	PO	PR	PR	PO	PO	PR	PR
Eastern Kingbird	*Tyrannus tyrannus*	S4B			√*	PO	PO		PR	PR	PO	PO	PR	PO	PO
LARKS															
Horned Lark	*Eremophila alpestris*	S5B								*			PO		PO
SWALLOWS															
Tree Swallow	*Tachycineta bicolor*	S4B				PO	CO	PO	PO	PO	PR	PO	PO	X	PO
Bank Swallow	*Riparia riparia*	S4B			√*[1]						PR			PO	PO
Barn Swallow	*Hirundo rustica*	S4B	T	THR		PO	PR	PR		PO	(PO)	PO	PO	X	CO
Cliff Swallow	*Petrochelidon pyrrhonota*	S4B			**[2]								X		
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	S4B							PR			PO	PO		
CROWS & JAYS															
Blue Jay	*Cyanocitta cristata*	S5				PR	CO	PR	PR	PO	PR	PR	PR	PR	PR
American Crow	*Corvus brachyrhynchos*	S5B				PR	CO	PO	PR	CO	PO	PR	PO	PO	X
CHICKADEES															
Common Redpoll	*Carduelis flammea*	S4B											*		
Black-capped Chickadee	*Poecile atricapillus*	S5				PR	PR	PR	PO	PO	PO	CO	PR	PR	PR
NUTHATCHES															
Red-breasted Nuthatch	*Sitta canadensis*	S5			√*					PR	*	PO	PO		PO
White-breasted Nuthatch	*Sitta carolinensis*	S5				PO	PO		PO		PR	PO			
CREEPERS															
Brown Creeper	*Certhia americana*	S5B			√*				PO	PO	PO	PO	PO		
WRENS															
House Wren	*Troglodytes aedon*	S5B				PO	PR	PR	PO	PO	PR	PR	PR	PR	PR
Winter Wren	*Troglodytes hiemalis*	S5B			√*					PO	(X)				
KINGLETS															
Golden-crowned Kinglet	*Regulus satrapa*	S5B											*		
Ruby-crowned Kinglet	*Regulus calendula*	S4B			√					*			*		

Common Name	Scientific Name	SRANK	COSEWIC	SARO	Local Status	NRSI 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
THRUSHES															
Swainson's Thrush	*Catharus ustulatus*	S4B			√					*					
Hermit Thrush	*Catharus guttatus*	S5B			√					*					
Wood Thrush	*Hylocichla mustelina*	S4B	T		√*		CO	PO		*			PO		
Eastern Bluebird	*Sialia sialis*	S5B													PR
American Robin	*Turdus migratorius*	S5B				PR	CO	PR	PR	CO	PR	CO	PR	PR	PR
MIMIDS															
Gray Catbird	*Dumetella carolinensis*	S4B				PR	PR	PO	PO	PO	CO	CO	PO	PO	PR
Brown Thrasher	*Toxostoma rufum*	S4B			√					*					
WAXWINGS															
Cedar Waxwing	*Bombycilla cedrorum*	S5B				PO	PR	PO	PO	PR	PR	PO	PR	PR	PR
STARLINGS															
European Starling	*Sturnus vulgaris*	SNA				PO	X	PO	PO	X	PR	PO		PO	PO
VIREOS															
Warbling Vireo	*Vireo gilvis*	S5B								PR	PR	PR	PR	PO	PO
Red-eyed Vireo	*Vireo olivaceus*	S5B				PR	PO	PO	PO	PR	PO	PO	PR	PR	PR
WOOD WARBLERS															
Warbler spp.						PO									
Tennessee Warbler	*Oreothlypis peregrina*	S5B			√	PO				X					
Nashville Warbler	*Oreothlypis ruficapilla*	S5B								*					PR
Yellow Warbler	*Setophaga petechia*	S5B					X	PR	PR	PR	PR	PR	PR	PR	PR
Chestnut-sided Warbler	*Setophaga pensylvanica*	S5B				PO					PO				
Yellow-rumped Warbler	*Setophaga coronata*	S5B								*					
Black-throated Green Warbler	*Setophaga virens*	S5B			√					*					
Pine Warbler	*Setophaga pinus*	S5B			√*			PR		PO		PO			
American Redstart	*Setophaga ruticilla*	S5B			√*					PO	PO	PO		PR	PR
Ovenbird	*Seiurus aurocapillus*	S4B			√*		PO			*					
Northern Waterthrush	*Parkesia noveboracensis*	S5B								PR	PO	PR	PR	PR	PR
Common Yellowthroat	*Geothlypis trichas*	S5B				PR	PR	PR	PO	PR	PR	PR	CO	PR	PR
CARDINALS & ALLIES															
Northern Cardinal	*Cardinalis cardinalis*	S5				PO	PR	PO	PO	PO	PR	PR	PR	PR	PR
Scarlet Tanager	*Piranga olivacea*	S4B			√	PO						PO			
SUMMER FINCHES															
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	S4B			√*				PO	PR	PR			PR	PO
Indigo Bunting	*Passerina cyanea*	S4B				PO	PR	PR		PO	(PO)	PR		PR	PO
SPARROWS															
Grasshopper Sparrow	*Ammodramus savannarum*	S4B			√								PO	(PO)	PO
American Tree Sparrow	*Spizella arborea*	S4B								*					
Chipping Sparrow	*Spizella passerina*	S5B				PO	PO	PR	PO	X	PR		PR	PO	PO
Field Sparrow	*Spizella pusilla*	S4B			√*		PO	PO		X	PO				PO
Vesper Sparrow	*Pooecetes gramineus*	S4B			√*				PO						
Savannah Sparrow	*Passerculus sandwichensis*	S4B			√*		PR	PO	PO	PR	PR	PR	PR	PR	PR
Song Sparrow	*Melospiza melodia*	S5B				PR	CO	PR	PO	PR	PR	PR	CO	PR	PR
Swamp Sparrow	*Melospiza georgiana*	S5B				PO						PR			PO
White-throated Sparrow	*Zonotrichia albicollis*	S5B								*					
Dark-eyed Junco	*Junco hyemalis*	S5B			√		X			*			*		

						NRSI									
Common Name	**Scientific Name**	**SRANK**	**COSEWIC**	**SARO**	**Local Status**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
BLACKBIRDS															
Bobolink	*Dolichonyx oryzivorus*	S4B	T	THR	√*	PO	PO	PO	PO	PR	PO	PR	PR	PR	PR
Red-winged Blackbird	*Agelaius phoeniceus*	S4				PR	CO	CO	CO	PR	CO	CO	PR	CO	PR
Eastern Meadowlark	*Sturnella magna*	S4B	T	THR	√*		PO	PR	PO	PR	PO	PR	PR	PO	PR
Rusty Blackbird	*Euphagus carolinus*	S4B	SC	NAR						*					
Common Grackle	*Quiscalus quiscula*	S5B				PO	PR	PO	X	PO	PO	PO	PO	PO	CO
Brown-headed Cowbird	*Molothrus ater*	S4B				PO	PR	PR	PO	PR	PO	PR	PR	PR	PO
ORIOLES															
Baltimore Oriole	*Icterus galbula*	S4B			√*	PO	PR	PO	PO	PO	PR	PR	PR	PR	CO
WINTER FINCHES															
House Finch	*Carpodacus mexicanus*	SNA						CO							
Pine Siskin	*Spinus pinus*	S4B							PO						
American Goldfinch	*Spinus tristis*	S5B				PR	CO	PR	PR	PO	PR	PR	PR	PR	PR
OLD WORLD SPARROWS															
House Sparrow	*Passer domesticus*	SNA								*			*		
					Total	**42**	**46**	**41**	**43**	**74**	**57**	**51**	**61**	**51**	**58**

Legend
* Incidental birds recorded during other surveys
(breeding evidence) Species and breeding evidence recorded outside of point count

SRANK
S1 Critically Imperiled
S2 Imperiled
S3 Vulnerable
S4 Apparently Secure
S5 Secure
? Rank Uncertain
S#S# Range Rank —Numeric range rank (e.g., S2S3) used to indicate any range of uncertainty about the status of the species

B Breeding
SZ Not of practical conservation concern
SE Exotic
SAN Non-breeding accidental
SZN Non-breeding migrants/vagrants

COSEWIC, SARO Codes
E, END Endangered
T, THR Threatened
SC Special Concern
NAR Not at Risk

Local Status (Wellington) (Dougan 2009)
√ Significant and rare
√* Significant but not rare
** Only habitats that support or have recently supported active nests should be considered signficant
[1] Only significant in nesting colonies of >100
[2] Only significant in nesting colonies >8

Breeding Evidence Codes
X Observed
PO Possible breeder
PR Probable breeder
CO Confirmed breeder

APPENDIX VII

Amphibian Species Observed by Plot 2006 - 2015

Appendix VII. Amphibian Species Observed by Plot 2006 - 2015

Station #1

	2006	2007			2008			2009			2010			2011			2012			2013			2014			2015		
	Calling	Calling			Calling			Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	June 22	April 29	May 16	June 5	April 24	May 15	June 4	April 23	May 11	June 2	April 24	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 17	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad	Nothing Heard			Nothing Heard			Nothing Heard		Nothing Heard				Nothing Heard	1 (1)			Nothing Heard	Nothing Heard	Nothing Heard							2(2)	Nothing Heard	
Northern Spring Peeper		3	1 (4)		3	1 (5)		1 (4)			1 (7)	2 (7)		3	1 (10)					3	2 (6)		3	1 (4)		2(2)		
Tetraploid Gray Treefrog										1 (1)						1 (1)					2 (3)	2(10)			3			2(9)
Western Chorus Frog																												
Northern Leopard Frog																												
Pickerel Frog																												
Green Frog																												
Mink Frog																												
Bullfrog																												
Wood Frog		1 (7)						1 (1)						2 (10)						2 (3)			1 (1)					
Beaufort Wind Scale	0	5	0	1	0	0	3	1	0	2	1	2	2	3	3	1	1	3	2	1	0	1	4	1	1	1	1	1
%Cloud Cover	98	98	100	25	65	100	100	10	5	15	5	100	100	20	100	5	100	35	100	70	10	100	20	100	0	0	15	0
Air temp. (^{o}C)	21	13	10	10	7	9	16	2	3	12	10	10	18	15	13	12	12	16	12	6	15	13	5	15	17.5	12	-	18
Water temp. (^{o}C)	19.9	8.0	10.1	10.3	N/A	N/A	11.8	3.4	6.2	10.5		7.7		13	12	11.6	N/A	N/A	N/A	5.6	11.2	13.7	5	10.3	12.8	9.1	N/A	N/A
Water pH	7.2	7.4	7.1	7.2	N/A	N/A	8.2	9.1	8.6	9.4		6.5		N/A	7.6	7.5	N/A	N/A	N/A	7.4	7.3	8.2	7.4	7.4	8	7.8	N/A	N/A
Precipitation?	None	Light rain	Very light rain	None	None	None	None	None	None	None	None	Light rain	None	None	Moderate Rain	None	None	None	None	None	None	Rain	None	None	None	None	None	None

Station #10	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad		Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	2(3)	Nothing Heard	2(2)
Northern Spring Peeper					1 (2)					1 (1)	1 (1)										
Tetraploid Gray Treefrog																					2(8)
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog	1 (2)						1 (2)														
Beaufort Wind Scale	0	0	2	0	2	0	3	4	3	1	3	2	1	0	1	3	1	0	1	1	1
%Cloud Cover	20	10	15	5	100	100	90	100	5	100	40	100	60	10	100	35	100	90	10	15	0
Air temp. (^{o}C)		3	12	4	10	24	14.5	13.8	12	13	16	12	5	13	17	5	15	17	12	12.5	18
Water temp. (^{o}C)	8.5	10.7	14.1	12.1	9.3	19	12	13.1	16.5	14.3	17	N/A	9.3	18.9	N/A	8.4	17.9	15	13.2	N/A	N/A
Water pH	8.8	8.6	9.5	7.8	7	7.4	N/A	8	8.1	7.6	8.2	N/A	7.9	7.9	N/A	N/A	8	7.7	7.8	N/A	N/A
Precipitation?	None	None	None	None	Light rain	None	None	Moderate Rain	None	None	None	None	None	None	Rain	None	None	None	None	None	None

Station #11

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad		Nothing Heard	Nothing Heard			Nothing Heard			Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard		Nothing Heard	Nothing Heard	3	Nothing Heard	2(2)
Northern Spring Peeper	1 (1)			1 (1)	2 (5)		1 (4)	1 (4)		2 (5)			1 (1)	1 (1)		1 (1)					
Tetraploid Gray Treefrog																					2(7)
Western Chorus Frog																					
Northern Leopard Frog	1 (1)																				
Pickerel Frog				1 (1)																	
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog	1 (1)																				
Beaufort Wind Scale	0	0	2	0	2	0	3	4	1	1	3	2	1	0	1	3	1	0	0	1	1
%Cloud Cover	20	10	25	5	100	100	40	100	5	100	40	100	60	10	100	40	100	90	0	15	0
Air temp. (^oC)	3	3	12	4	10	24	14.5	13	12	13	16	12	5	13	17	6	16	17	11	12.9	18
Water temp. (^oC)	6.6	n/a	n/a	6	9.5		12	12	14.3	14.5	16.7	N/A	8.2	18.6	N/A	6.5	18.1	16	12	12.5	N/A
Water pH	7.8	n/a	n/a	8.1	7.8		N/A	7.1	8.0	7.8	8	N/A	7.9	7.8	N/A	7.9	7.7	7.6	7.4	7.81	N/A
Precipitation?	None	None	None	None	Light rain	None	None	Moderate Rain	None	None	None	None	None	None	Rain	None	None	None	None	None	None

Station #12

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad						Nothing Heard			Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard							2(2)	Nothing Heard	
Northern Spring Peeper	3	1 (3)		1 (6)	3		3	3					3	3		2 (6)	1 (1)				
Tetraploid Gray Treefrog															1(1)		1 (3)	1 (2)			2(8)
Western Chorus Frog																					
Northern Leopard Frog	1 (2)																				
Pickerel Frog																					
Green Frog			1 (2)																		
Mink Frog																					
Bullfrog																					
Wood Frog	1 (2)						1 (2)						1 (1)								
Beaufort Wind Scale	0	0	2	2	2	0	4	4	2	1	3	2	2	0	1	3	1	1	2	1	1
%Cloud Cover	20	10	15	30	100		50	100	0	100	15	100	70	10	100	10	100	0	0	15	0
Air temp. (^{o}C)	2	3	10	5	10		14.5	13.5	10	10.5	16	12	7	12	17	5	15	17.5	12	12	18
Water temp. (^{o}C)	6.9	11.5	14.6	11.1	10.4	19.8	N/A	N/A	10	N/A	N/A	N/A	9.7	12.3	N/A	N/A	13.4	N/A	N/A	N/A	N/A
Water pH	8	9.2	9.9	7.8	6.8	8	N/A	N/A	8.4	N/A	N/A	N/A	7.4	7.5	N/A	N/A	7.5	N/A	N/A	N/A	N/A
Precipitation?	None	None	None	None	Light rain	None	None	Moderate Rain	None	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

Station #13

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper																					
Tetraploid Gray Treefrog															1(1)						
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog																					
Beaufort Wind Scale	0	0	0	1	1	0	1	2	1	2	0	1	0	1	3	3	1	0	2	3	1
%Cloud Cover	30	10	50	10	100	100	30	100	0	90	0	100	60	5	100	5	0	90	90	5	10
Air temp. (^{o}C)	3	5	14	5	8	24	14	13	12	10	17	15	6	13	14	7	21	17	10	14	18
Water temp. (^{o}C)	6.2	8	11.3	6.6	8	14.5	11	N/A	12	N/A	N/A	N/A	N/A	N/A	N/A	5.9	N/A	N/A	N/A	N/A	N/A
Water pH	8	8.8	9.9	7.8	7.9	7.2	N/A	N/A	8.2	N/A	N/A	N/A	N/A	N/A	N/A	7.6	N/A	N/A	N/A	N/A	N/A
Precipitation?	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Rain	None	None	None	None	None	None

Station #14

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad	Nothing Heard	Nothing Heard	1 (1)	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	
Northern Spring Peeper										2 (2)							2 (6)				
Tetraploid Gray Treefrog																					1(2)
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog																					
Beaufort Wind Scale	0	0	0	0		0	1	N/A	1	1	0	2	0	1	2	3	1	0	2	2	1
%Cloud Cover	20	10	50	5	100	100	30	100	0	90	0	100	50	5	100	5	0	90	90	5	10
Air temp. (°C)	2	5	14	5		24	15	13	12	11	17	12	7	13	14	7	18	17	10	13	18
Water temp. (°C)	6.6	8.8	n/a	7.1	7	13.7	N/A	N/A	12	N/A	N/A	N/A	N/A	N/A	N/A	6.9	N/A	N/A	N/A	N/A	N/A
Water pH	8	8.5	n/a	8.1	8	7.4	N/A	N/A	8.5	N/A	N/A	N/A	N/A	N/A	N/A	7.8	N/A	N/A	N/A	N/A	N/A
Precipitation?	None	None	None	None	None	None	None	None	None	None	None	Light rain	None	None	Rain	None	None	None	None	None	None

Station #15

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard					Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard		Nothing Heard			Nothing Heard	Nothing Heard
Northern Spring Peeper					1(3)		3	2 (4)		3			1 (1)	1(1)		2 (4)			2(4)		
Tetraploid Gray Treefrog						2 (3)															
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																		1 (5)			
Mink Frog																					
Bullfrog																					
Wood Frog													1 (1)			1 (1)			2(5)		
Beaufort Wind Scale	0	0	0	0	2	0	3	2	0	1	0	1	0	0	1	3	0	0	2	1	1
%Cloud Cover	20	10	50	5	100	100	40	100	0	100	0	100	50	10	100	5	0	90	90	5	10
Air temp. (°C)	2	5	14	5	10	24	15	13	14	12	16	12	7	16	17	7	18	17	10	-	18
Water temp. (°C)	5.7	8.3	10.4		8.9	17.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.2	17.3	N/A	N/A	N/A	N/A
Water pH	8	9	9.8		7.2	6.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.9	7.9	N/A	N/A	N/A	N/A
Precipitation?	None	None	None	None	Light rain	None	None	Hard Rain	None	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

Station #16

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard	*2 (2)*	Nothing Heard	2 (3)						Nothing Heard		Nothing Heard	2(2)
Northern Spring Peeper	3			1 (3)			2 (4)	3					2 (3)	3		1 (1)	1 (1)				
Tetraploid Gray Treefrog												2 (6)			2(7)						2(11)
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog							2 (8)						3						2(5)		
Beaufort Wind Scale	0	0	0	1	1	0	2	2	1	2	0	1	0	1	1	3	1	0	3	3	2
%Cloud Cover	30	10	50		100	100	10	100	0	100	0	100	80	15	100	5	0	90	100	5	10
Air temp. (^oC)	4	7	16	8	8	24	14	13.5	13	11	20	16	6	14	14	7.5	20	18	12	14	20
Water temp. (^oC)	7.5	8.8	13.7	11.2	7.5		14	13.7	11.2	N/A	N/A	N/A	9.4	17.8	N/A	6.1	17.7	N/A	11.6	N/A	N/A
Water pH	8.1	9.1	9.5	7.5	7.9		N/A	8.1	8.4	N/A	N/A	N/A	7.9	8.4	N/A	7.5	7.6	N/A	7.5	N/A	N/A
Precipitation?	None	None	None	None	None	None	None	Hard Rain	None	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

Station #17

	2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 23	May 11	June 2	April 24	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad		No Datasheet	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper																	1 (2)				
Tetraploid Gray Treefrog																	1 (2)				
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog	1 (2)						1 (5)														
Beaufort Wind Scale	0		2	0	2	0	3	3	1	1	3	2	0	0	1	4	1	1	2	1	1
%Cloud Cover	10		25	10	100	100	20	100	10	100	40	100	0	10	100	30	100	0	0	15	0
Air temp. (°C)			12	12	10	18	15	13.2	12	11	16	12	6	16	17	6	22	20	11	13.5	18
Water temp. (°C)	6.3		n/a	15	8		12	12.5	N/A	N/A	N/A	N/A	8.5	16	N/A	6.2	18.6	N/A	N/A	N/A	N/A
Water pH	8.2		n/a	7.9	6.9		N/A	8.1	N/A	N/A	N/A	N/A	7.8	7.7	N/A	7.4	8	N/A	N/A	N/A	N/A
Precipitation?	None		None	None	Rain	None	None	Heavy Rain	None	None	None	Light rain	None	None	Rain	None	None	None	None	None	None

Station #18	2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad			Nothing Heard	3	Nothing Heard		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper		3				1 (1)									
Tetraploid Gray Treefrog									2(2)			1 (1)			
Western Chorus Frog															
Northern Leopard Frog															
Pickerel Frog															
Green Frog															
Mink Frog															
Bullfrog															
Wood Frog	1 (1)														
Beaufort Wind Scale	1	2	2	1	0	1	1	1	2	3	1	0	2	1	3
%Cloud Cover	10	100	0	100	0	100	80	15	100	5	0	90	90	5	10
Air temp. (^oC)	14	14	13	11	20	15	6	16	14	7.5	20	18	12	14	20
Water temp. (^oC)	12	N/A	10	N/A	N/A	N/A	N/A	N/A	N/A	5.5	N/A	N/A	8.9	N/A	N/A
Water pH	N/A	N/A	8	N/A	N/A	N/A	N/A	N/A	N/A	7.6	N/A	N/A	7.9	N/A	N/A
Precipitation?	None	Hard Rain	None	None	None	None	None	None	Rain	None	None	None	None	None	None

Station #2	2006			2007			2008			2009			2010			2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling			Calling			Calling			Calling			Calling			Calling		
COMMON NAME			June 22	April 29	May 16	June 5	April 24	May 15	June 4	April 23	May 11	June 2	April 24	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad			Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	
Northern Spring Peeper							1 (2)							1 (4)																
Tetraploid Gray Treefrog																										1 (3)				2(3)
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																														
Mink Frog																														
Bullfrog																														
Wood Frog																														
Beaufort Wind Scale			2	4	2	1	1	0	4	1	0	2	0	2	0	3	3	0	1	0	2	1	0		3	1	1	0	1	1
%Cloud Cover			98	98	100	25	65	100	100	20	10	25	10	100		20	100	5	100	35	100	0	10		20	100	0	0	15	0
Air temp. (^oC)			23	12	10	10	7	11	17	2	4	12	13	10	18	15	12.5	12	13	16	12	5.5	13		8	22	20	14	12	18
Water temp. (^oC)				10.0	12.1	11.7	7	7.8	13.2	5.2	6.3	8.5	8.6	6.9	11.3	9	8.7	8.1	N/A	N/A	N/A	3.6	N/A		5	9.2	13	N/A	9.1	N/A
Water pH				7.6	7.5	7.3	N/A	7.9	8.3	8.4	8.5	9.8	7.6	6.7	8.5	N/A	7.9	7.6	N/A	N/A	N/A	7.9	N/A		7.7	7.7	8.3	N/A	7.48	N/A
Precipitation?			None	None	None	None	None	None	None	None	None	None	None	Light rain	None	None	Moderate Rain	None	None	None	Light rain	None	None		None	None	None	None	None	None

Station #4

COMMON NAME	2006 Calling	2007 Calling			2008 Calling			2009 Calling			2010 Calling			2011 Calling			2012 Calling			2013 Calling			2014 Calling			2015 Calling		
	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		1 (1)	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	2 (2)	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper					3				1 (2)								1 (1)											
Tetraploid Gray Treefrog																												
Western Chorus Frog																												
Northern Leopard Frog																								1 (1)				
Pickerel Frog																												
Green Frog																									1 (2)			
Mink Frog																												
Bullfrog																												
Wood Frog														1 (1)														
Beaufort Wind Scale	1	3	2	1	1	1	1	1	0	1	0	2	0	3	2	0	1	0	1	0	0	2	3	1	0	3	1	2
%Cloud Cover	80	20	100	20	65	5	100	40	40	50	5	100	100	40	100	5	100	0	100	60	15	100	5	0	90	90	5	10
Air temp. (°C)	20	14	10	9	12	17	16	5	8	16	5	8	24	15	14	12	12	22	15	7	15	14	7.5	20	19	12	13	18
Water temp. (°C)		11.4	11.5	11.2	9	10.5	14.5	7.1	9.1	11.8	6.2	6		10	N/A	8.1	N/A	N/A	N/A	4.8	N/A	14.7	5.5	18.8	10.4	7.8	N/A	N/A
Water pH		7.6	7.7	7.6	N/A	7.8	8.3	8.2	9.3	9	7.8	7.6		N/A	N/A	7.6	N/A	N/A	N/A	8.1	N/A	8.4	7.2	8	8.2	7.3	N/A	N/A
Precipitation?	None	None	None	None	None	None	None	None	None	None	None	Rain	None	None	Rain	None	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

Station #6	2006	2007			2008			2009			2010		
	Calling	Calling			Calling			Calling			Calling		
COMMON NAME	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 22	May 13	June 3
American Toad	Nothing Heard	1(4)		Nothing Heard					Nothing Heard				Nothing Heard
Northern Spring Peeper		3	2(3)		1 (2)	1(1)	1(2)	3			3	2 (5)	
Tetraploid Gray Treefrog							3			1 (1)			
Western Chorus Frog		1(1)											
Northern Leopard Frog													
Pickerel Frog													
Green Frog							1(2)			1 (1)			
Mink Frog													
Bullfrog													
Wood Frog													
Beaufort Wind Scale	1	3	2	1	1	0	3	0	0	0	1	1	0
%Cloud Cover	2	40	100	20	65	100	100	30	10	50	10	100	100
Air temp. (^oC)	18	12	9	9	11	13	16	2	5	15	8	8	24
Water temp. (^oC)	23.6	14.4	14.1	15.3	N/A	13.8	16.3	8.9	7.7	16.7	13.3	9	19.1
Water pH	7.8	7.8	7.8	7.6	N/A	8.0	8.5	8.1	8.7	9.8	7.9	8.5	7.2
Precipitation?	None	None	None	None	None	None	None	None	None	None	None	None	None

Station #6	2011			2012			2013			2014			2015		
	Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad	1 (6)		Nothing Heard	Nothing Heard	Nothing Heard				Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard	1(1)
Northern Spring Peeper	3	3				1 (1)	2 (4)	1 (2)					2(4)		
Tetraploid Gray Treefrog												1 (2)			2(4)
Western Chorus Frog															
Northern Leopard Frog															
Pickerel Frog															
Green Frog															
Mink Frog															
Bullfrog															
Wood Frog	1 (2)						3						1(1)		
Beaufort Wind Scale	1	3	1	2	0	2	1	1	1	3	1	0	2	3	2
%Cloud Cover	40	100	0	100	0	100	70	5	100	5	0	90	0	5	10
Air temp. (^oC)	14	13.5	12	11	19	15	6	13	14	7.5	20	17	11	14	20
Water temp. (^oC)	13.5	N/A	10	N/A	N/A	N/A	10.5	N/A	N/A	6.7	N/A	N/A	N/A	N/A	N/A
Water pH	N/A	N/A	8.3	N/A	N/A	N/A	7.4	N/A	N/A	8.1	N/A	N/A	N/A	N/A	N/A
Precipitation?	None	Rain	None	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

Station #7	2006	2007			2008			2009		
	Calling	Calling			Calling			Calling		
COMMON NAME	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper						1(1)				
Tetraploid Gray Treefrog										
Western Chorus Frog										
Northern Leopard Frog										
Pickerel Frog										
Green Frog										
Mink Frog										
Bullfrog										
Wood Frog										
Beaufort Wind Scale	1	3	2	1	1	0	2	0	0	0
%Cloud Cover	75	15	100	20	65	50	100	30	10	50
Air temp. (^oC)	18	13	10	7	11	13	16	4	7	15
Water temp. (^oC)	11.4	9.3	10.5	10.4	N/A	10.9	10.8	5.9	n/a	12
Water pH	8.2	7.7	7.7	7.6	N/A	8.2	8.4	8	n/a	9.7
Precipitation?	None	None	None	None	None	None	None	None	None	None

Station #7	2010			2011			2012		
	Calling			Calling			Calling		
COMMON NAME	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper									
Tetraploid Gray Treefrog									
Western Chorus Frog									
Northern Leopard Frog									
Pickerel Frog									
Green Frog									
Mink Frog									
Bullfrog									
Wood Frog									
Beaufort Wind Scale	1	1	0	1	1	2	1	0	2
%Cloud Cover	0	100	100	10	100	0	100	0	100
Air temp. (^oC)	8	8	24	13	14	13	12	20	15
Water temp. (^oC)	8.6	6		8	9.5	11.6	7.6	N/A	N/A
Water pH	7.6	7.9		N/A	8	8.4	7.8	N/A	N/A
Precipitation?	None	None	None	None	Rain	None	Light rain	None	None

Station #7	2013			2014			2015		
	Calling			Calling			Calling		
COMMON NAME	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16
American Toad	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	
Northern Spring Peeper									
Tetraploid Gray Treefrog			2 (6)						2(3)
Western Chorus Frog									
Northern Leopard Frog									
Pickerel Frog									
Green Frog									
Mink Frog									
Bullfrog									
Wood Frog									
Beaufort Wind Scale	1	0	2	3	1	0	2	1	3
%Cloud Cover	80	15	100	5	0	90	100	5	10
Air temp. (^oC)	7	14	14	7.5	20	18	12	13	18
Water temp. (^oC)	5.3	7.7	N/A	5.4	8.5	11.9	6	12.3	N/A
Water pH	8.1	8.6	N/A	7.3	7.8	7.8	7.8	8.9	N/A
Precipitation?	None	None	Rain	None	None	None	None	None	None

Station #8

COMMON NAME	2006 Calling June 22	2007 Calling April 29	2007 May 16	2007 June 6	2008 Calling April 24	2008 May 15	2008 June 4	2009 Calling April 23	2009 May 11	2009 June 2	2010 Calling April 22	2010 May 13	2010 June 3	2011 Calling April 27	2011 May 18	2011 June 2
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper																
Tetraploid Gray Treefrog																
Western Chorus Frog																
Northern Leopard Frog																
Pickerel Frog																
Green Frog																
Mink Frog																
Bullfrog																
Wood Frog																
Beaufort Wind Scale	1	2	2	1	1	0	1	0	0	1	1	2	0	2	2	1
%Cloud Cover	80	15	100	20	65	50	100	30	30	50	0	100	100	40	100	0
Air temp. (^oC)	18.5	13	10	9	11	14	16	3	7	16	8	8	24	14	13	13
Water temp. (^oC)	14.5	11.5	11.4	11	10	12.1	13	7.6	8.9	12.4	9.4	7	13.6	12	12	13
Water pH	8	7.7	7.8	7.8	N/A	8.2	8.5	8.1	9.4	9.4	7.6		7.1	N/A	8.4	8.4
Precipitation?	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Rain	None

COMMON NAME	2012 Calling April 19	2012 May 15	2012 June 4	2013 Calling April 16	2013 May 9	2013 June 10	2014 Calling April 29	2014 May 21	2014 June 9	2015 Calling Apr 20	2015 May 21	2015 June 16
American Toad	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper												
Tetraploid Gray Treefrog		1 (1)										
Western Chorus Frog												
Northern Leopard Frog												
Pickerel Frog												
Green Frog												
Mink Frog												
Bullfrog												
Wood Frog												
Beaufort Wind Scale	1	1	2	0	0	1	3	1	0	3	1	2
%Cloud Cover	100	5	100	80	15	100	35	100	90	100	5	10
Air temp. (^oC)	12	22	15	7	14	14	5	15	17	12	13	18
Water temp. (^oC)	12.9	N/A	N/A	7	14.6	14	N/A	N/A	N/A	8.3	12.3	N/A
Water pH	8.4	N/A	N/A	8.4	8.4	8.5	N/A	N/A	N/A	7.4	8.9	N/A
Precipitation?	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

Station #9

	2007			2008			2009			2010			2011		
	Calling			Calling			Calling			Calling			Calling		
COMMON NAME	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 24	May 13	June 3	April 27	May 18	June 2
American Toad				Nothing Heard		3					Nothing Heard	Nothing Heard	1 (1)		
Northern Spring Peeper	2(10)	1(2)			1(3)		1 (7)	1 (4)		1 (1)			1 (2)	1 (4)	
Tetraploid Gray Treefrog						1 (1)			1 (2)						
Western Chorus Frog															
Northern Leopard Frog							1 (1)								
Pickerel Frog															
Green Frog			1(1)												
Mink Frog															
Bullfrog															
Wood Frog	1(2)						1 (4)						1 (2)		
Beaufort Wind Scale	5	2	1	1	0	1	0	0	2	0	2	0	3	3	2
%Cloud Cover	70	100	20	65	50	100	10	20	25	5	100	100	20	100	5
Air temp. (^oC)	13	10	9	11	14	16	2	6	14	1	10	18	15	9.4	11
Water temp. (^oC)	12.5	12.2	13.7	10	12.1	13	5.4	7.7	14.3	8.5			N/A	N/A	12.9
Water pH	7.7	7.5	7.3	N/A	8.2	8.5	8.2	8.7	9.6	8			N/A	N/A	6.6
Precipitation?	None	None	None	None	None	None	None	None	None	None	Rain	None	None	Heavy Rain	None

	2012			2013			2014			2015		
	Calling			Calling			Calling			Calling		
COMMON NAME	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16
American Toad	Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard			Nothing Heard		Nothing Heard	
Northern Spring Peeper				1 (2)	2 (5)		3	1 (5)		3		
Tetraploid Gray Treefrog												2(5)
Western Chorus Frog												
Northern Leopard Frog												
Pickerel Frog												
Green Frog												
Mink Frog												
Bullfrog												
Wood Frog										2(3)		
Beaufort Wind Scale	1	3	2	1	0	1	4	1	1	3	1	1
%Cloud Cover	100	40	100	80	10	100	35	100	0	0	15	0
Air temp. (^oC)	12	16	12	5	16	17	5	22	18	11	12.6	18
Water temp. (^oC)	N/A	N/A	N/A	6.3	14.5	N/A	5.2	17.6	N/A	13	N/A	N/A
Water pH	N/A	N/A	N/A	7.5	7.6	N/A	7.4	7.6	N/A	7.1	N/A	N/A
Precipitation?	Light rain	None	None	None	None	Rain	None	None	None	None	None	None

LEGEND		
X individual seen, but not calling		
# (_) call intensity and estimated number of individuals		
Call Level Codes		
1 Calls can be counted; not simultaneous		
2 Some simultaneous calls; yet distinguishable		
3 Calls not distinguishable individually; overlapping		
NA: (Not Applicable) denotes lack of water or not recorded		
Beaufort Wind Scale #	**KPH**	**Description**
0	0-2	Calm; smoke rises vertically
1	3 to 5	Light air movement; smoke drifts
2	6 to 11	Slight Breeze; felt on face, leaves rustle
3	12 to 19	Gentle breeze; leaves and small twigs in constant
4*	20-30	Moderate breeze; small branches are moving, raises
5*	31-39	Fresh breeze; small trees in leaf begin to sway, crested
6*	40-50	Strong breeze, large branches in motion
	*	Unacceptable wind strengths for amphibian surveys

APPENDIX VIII
Herpetofaunal Species Observed in the Subject Property

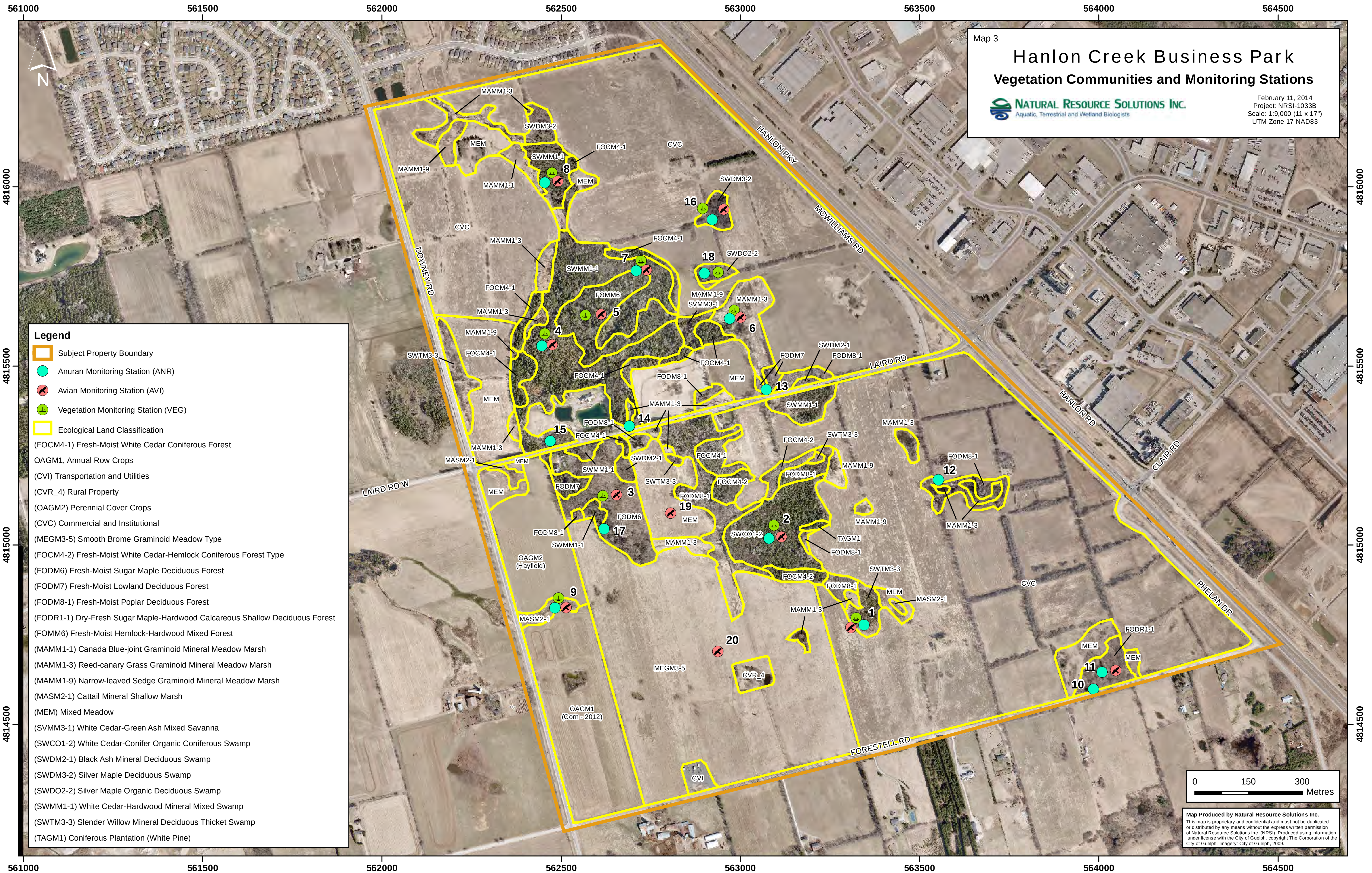
Appendix VIII. Herptofauna Species Observed in the Study Area

Common Name	Scientific Name	SRANK	COSEWIC	SARO	NRSI										
					1998-2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Turtles															
Common Snapping Turtle	*Chelydra serpentina serpentina*	S5	SC		√										
Midland Painted Turtle	*Chrysemys picta marginata*	S5								√	√				
Snakes															
Eastern Milksnake	*Lampropeltis t. triangulum*	S3	SC	SC											
Eastern Gartersnake	*Thamnophis sirtalis sirtalis*	S5			√					√	√		√		
Northern Brownsnake	*Storeria dekayi dekayi*	S5	NAR	NAR						√					
Northern Red-belied Snake	*Storeria occipitomaculata occipitomaculata*	S5								√					
Salamanders															
Jefferson/Blue-spotted Salamdander Polyploids	*Ambystoma jeffersonianum-laterale polyploids*	S2									√				
Eastern Red-backed Salamander	*Plethodon cinereus*	S5			√				√						
Toads and Frogs															
American Toad	*Anaxyrus americanus*	S5								√	√	√	√	√	√
Tetraploid Gray Treefrog	*Hyla versicolor*	S5			√	√	√	√	√	√	√	√	√	√	√
Western Chorus Frog*	*Pseudacris triseriata* pop.2	S3	T	NAR	√	√									
Northern Spring Peeper	*Pseudarcris crucifer crucifer*	S5					√	√	√	√	√	√	√	√	√
Bullfrog	*Lithobates catesbeianus*	S4			√	√	√	√	√	√					
Green Frog	*Rana clamitans melanota*	S5								√		√	√	√	√
Pickerel Frog	*Lithobates palustris*	S4	NAR	NAR	√	√	√	√	√	√					
Northern Leopard Frog	*Lithobates pipiens*	S5	NAR	NAR						√	√		√	√	
Mink Frog	*Lithobates septentrionalis*	S5			√	√			√	√					
Wood Frog	*Lithobates sylvatica*	S5			√		√	√	√	√	√	√	√	√	√

*Great Lakes/ St. Lawrence - Canadian Shield Pop.

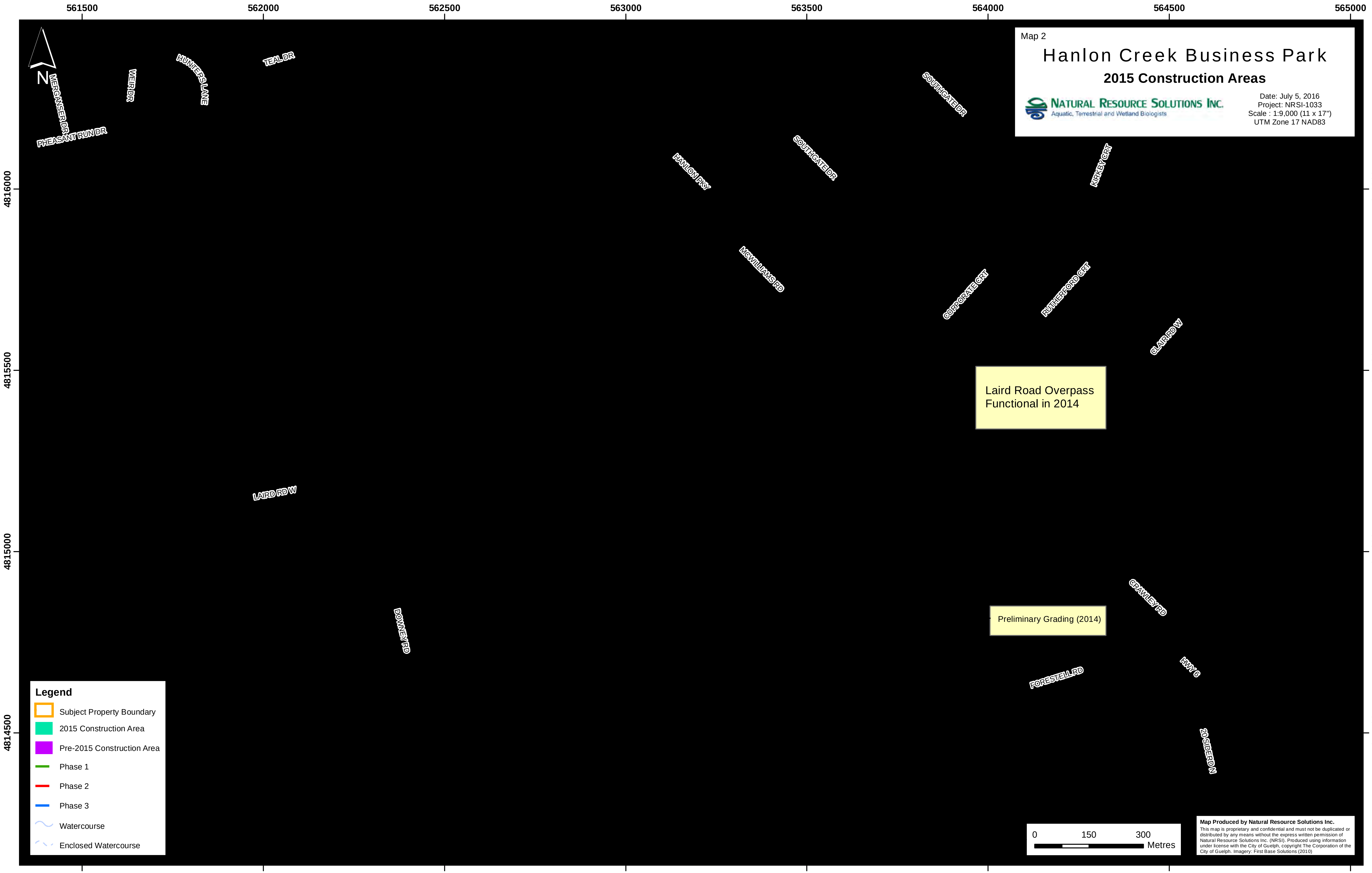
Legend	
SRANK	
S2 Imperiled	S4 Apparently Secure
S3 Vulnerable	S5 Secure
COSEWIC, SARO	
NAR Not at Risk	SC Special Concern
T/THR Threatened	
NRSI	
√ Observed	

MAPS



Path: X:\0682_HanlonTerrestrialandAquaticMonitoring\NRSI_1006_Fig3_ELC_MonitoringStations_9K_2014_02_11_MAW.mxd

Path: X:\0682_HanlonTerrestrialandAquaticMonitoring\NRSI_1033_Fig1_StudyArea_9K_2014_02_11_MAW.mxd



Path: X:\0682_HanlonTerrestrialandAquaticMonitoring\NRSI_1033_Map2_2015ConstructionAreas_9K_2016_07_05_JAS.mxd

MEETING MINUTES

Meeting Date: July 30, 2015
Location: Teleconference
Chair: Nicole Weber (AECOM)
Recorder: Andrew Schiedel (NRSI)

Present: Nicole Weber (Water Resources Engineer, AECOM)
Andrew Schiedel (Aquatic Biologist, NRSI)
Prachi Patel (Environmental Planner, City of Guelph)
John Palmer (GRCA)
Tony Zammit (GRCA)

Purpose: To discuss stream temperatures greater than 24°C from July 26 to 29, 2015

Nicole provided some project background since Prachi was new to the project.

- The Rapid Assessment and Action Protocol (RAAP) was put in place to respond to stream temperatures that exceed 24°C, and turbidity above 10 NTU.
- A meeting or teleconference must occur to determine the reasons for any exceedances, and develop mitigation options as warranted.
- Four telemetry loggers provide temperature and turbidity information on an hourly basis.
- Alerts are sent when temperature exceeds 24°C or turbidity exceeds 10 NTU. The turbidity data is very noisy for reasons such as detritus in the stream, so the data is reviewed weekly rather than responding to each notification.
- There is substantial monitoring of surface water on the site, including 8 temperature loggers in each stormwater management pond, additional stream loggers without telemetry, and periodic water quality sampling.
- The four telemetry loggers on the stream are at stations 3, 6, 11 and 14.
- Station 6 was observed to be above 24°C on July 27. Station 14 first exceeded 24°C on July 29.

Nicole provided background on Stormwater Management Pond 4.

- The pond continuously discharges due to incoming groundwater.
- The pond outlet weir was raised about two years ago to limit the groundwater flow-through; however, the continuous discharge has continued. One problem is reduced storage volume due to the higher minimum (between-storm) water level.
- The continuous discharge occurred in 2014, but air temperatures stayed cooler in the summer of 2014 and Station 6 (immediately downstream of the Pond 4 outlet) never exceeded 24°C. Station 14 exceeded 24°C in 2014, but this was probably not related to the SWM Pond 4 discharge.
    - Station 14 often experiences elevated stream temperatures due to exposure to solar inputs, and groundwater infiltration conditions (as opposed to the discharge that occurs farther upstream on the site).

- Plantings were installed at SWM pond 4, within the pond and over the cooling trench, as an attempt to mitigate temperatures in the pond and cooling trench.
- **Action: Andrew to ask Tara Brenton (NRSI) about the status of the plantings in 2015.**

Prachi requested a site visit to help familiarize her with the project.

- **Action: All attendees to provide Nicole with availability for mornings and afternoons from August 4 to 7.**
- **Action: Andrew to take photographs of the vegetation in SWM Pond 4 and cooling trench.**
- **Action: Nicole to review the SWM pond logger data, and provide plotted data from the SWM pond(s).**

AECOM
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Kitchener, ON, Canada N2P 0A4 519.650.3424 fax
www.aecom.com

Memorandum

To	Prachi Patel, Kime Toole, Michelle Thalen, John Palmer, Tony Zammit, Andrew Scheidel, Tara Breton, Bill Banks	Page	1
CC	Peter Cartwright, Adrienne Sones, Ray Tufgar		
Subject	Hanlon Creek Business Park 2015 Monitoring – Temperature Exceedance		
From	Andrew Minielly H.B.Es, Nicole Weber, P.Eng.		
Date	August 27, 2015	Project Number	60265453

1. Introduction

Water temperature and baseflow monitoring in the Hanlon Creek Business Park has been ongoing since 2003. Construction of Phase 1 & 2 of the Hanlon Creek Business Park was completed in 2011 with development continuing throughout 2015. In addition to the Hanlon creek tributary running through the business park, 3 wet stormwater management ponds were constructed alongside the creek. Ponds 1 and 2 began functioning as stormwater management facilities in 2011 while Pond 4 was brought online in 2012. Post construction monitoring of the 3 on-site SWM facilities and the Hanlon creek tributary began in 2012.

A temperature target of 24°C was established for the receiving stream for fisheries protection. The upper reaches of Tributary A are groundwater fed. Historically, the groundwater input to Tributary A has kept the water temperature in the upstream reach relatively low with a Cool water thermal classification. Since the start of monitoring there have been occasional exceedances of the 24C maximum. 2012 saw the highest number of exceedance events in the upper reaches of tributary A to date. This was due to higher than average temperatures and warm water being continually discharged from Pond 4 into the tributary system. Fewer exceedance events have been recorded during the following years as a result of cooler summer temperatures even though pond 4 still experiences continuous discharge.

As part of the monitoring protocol, any temperature exceedances of 24°C trigger a Rapid Assessment and Action Protocol (RAAP). This involves a discussion between staff from the City of Guelph, Grand River Conservation Authority (GRCA) and the consulting team (AECOM and/or NRSI). The intent of this discussion is to identify the reasons for the exceedance and determine if remedial actions are required.

Recently, creek surface water temperatures have started to rise, with some stations recording temperatures above 24°C. Surface water temperatures at station HC-A(06) first exceeded the 24°C mark on July 26th and continued to do so each day after around mid-day until July 30th . Temperatures at HC-A(14) also exceeded the 24°C mark on July 28th and 29th. However, the reach between HC-

A(13) and HC-A(14) is considered a losing reach and has historically experienced warmer temperatures at this point in the year.

The temperature exceedances at HC-A(06) triggered a RAAP meeting to try and determine the cause of the warming and determine ways to mitigate the higher temperatures. Upstream temperature and flow conditions with an emphasis on the conditions of Pond 4 due to its contribution to warming in the past have been examined and outlined in this memo. The following schematic (Figure 1) represents the water temperatures at a single point in time (July 26, 2015 14:00) as it moves though the system. This provides a representative example of the warming and cooling that is typically occurring at Pond 4 and the adjacent creek.

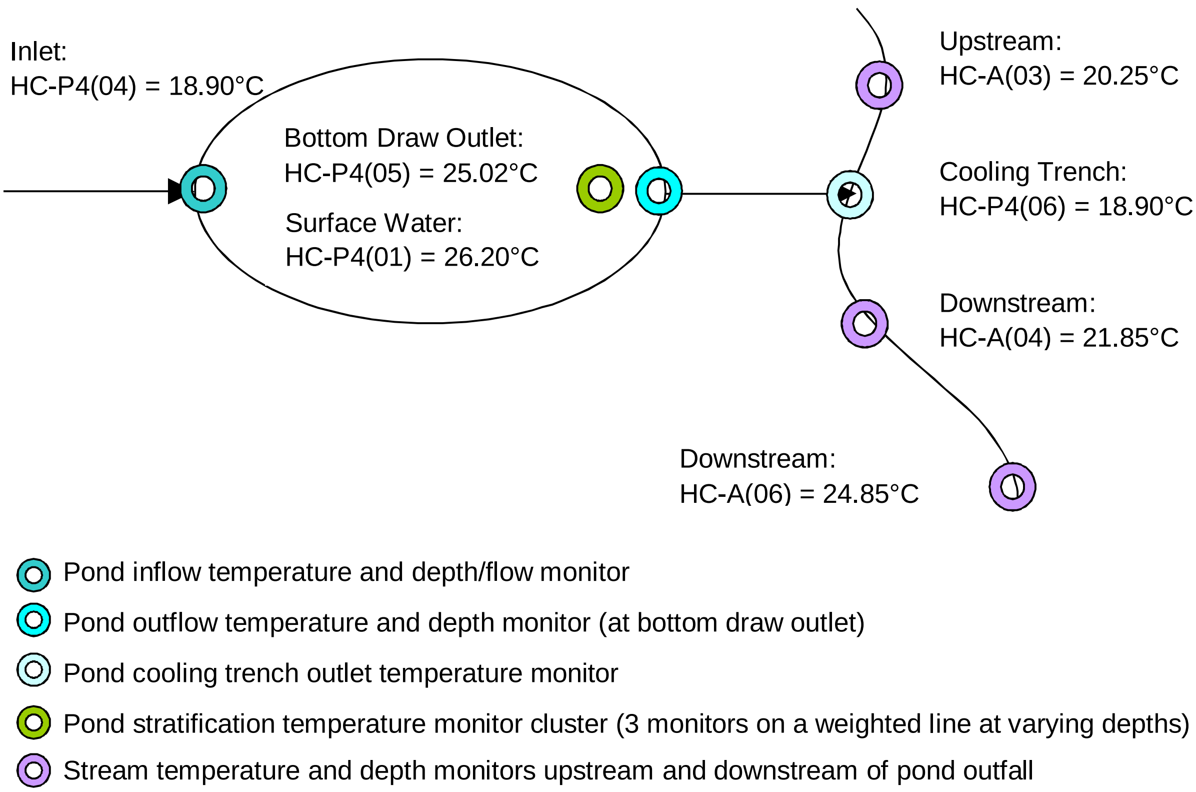

Figure 1: Point Temperature Conditions at Pond 4

2. Background

2.1 Meteorological Conditions

Temperatures recorded over the course of the 2015 monitoring season thus far appear to be in line with average temperature conditions for the area. However, recorded precipitation values have been below average with the exception of the month of June. According to the Kitchener/Waterloo airport precipitation data, July only received 0.6mm of rain with a data gap including July 6th and 7th. Rain gauges located within 22 km of the Kitchener rain gauge recorded a heavy rain event on the 7th. The Elora RCS rain gauge recorded 35.4 mm of rain wile the Roseville rain gauge located south west of

Kitchener recorded 26 mm of rain. Accounting for the missing rain event still places precipitation totals for July well bellow the average. Prolonged dry periods led to lower flows in Hanlon creek tributary A. Climate data for 2015 is highlighted in Table 1 and Table 2.

Table 1: Monthly Average Air Temperatures for the City of Guelph

	Daily Average (°C)					Average Daily Maximum (°C)				
	May	**Jun**	**Jul**	**Aug**	**Sep**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Climate Normals	12.30	16.90	19.70	18.60	14.10	18.5	23.3	25.9	24.5	19.8
2010			20.31	19.75	14.09			26.39	26.12	19.61
2011	12.73	16.70	21.35	19.25	15.24	17.66	22.70	28.59	25.80	20.86
2012	14.48	17.62	22.00	19.30	--	21.97	24.17	30.10	26.50	--
2013	13.5	16.9	19.9	18.0	18	20.4	22.3	25.3	24.5	24.5
2014	12.3	17.8	17.6	17.6	14.1	18.6	24.6	23.6	23.7	20.5
2015	15.1	16.0	18.7			22.7	22.0	25.6		

Table 2: Total monthly precipitation

	Units	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Canadian Climate Normals (1971-2000) Guelph Arboretum	mm	56.4	50.8	72.1	78.3	79.9	76	88.5	95.9	92.1	69.2	86.3	77.7	**923.3**
Observed Guelph Turf Grass Institute 2014	mm	25.8	28.3	14.0	88.9	20.0	46.7	154.3	65.1	179.0	64.7	29.2	17.6	**860.6**
Kitchener Waterloo 2015	mm	21.5	7.5	4.6	73.7	66.1	124.3	0.6						

2.2 Instream Conditions

Water temperatures above 24°C were observed on site at HC-A(06) for several hours a day from July 26 to July 30. Both HC-A(06) and HC-A(14) experienced warm water conditions above 24°C on July 28th and 29th. Temperature conditions for both the in-stream sites and SWM pond 4 are highlighted in Figure 2 and Figure 3 below. Flow conditions for stations HC-A(03),(04),(06) and the Pond 4 outlet are displayed in Figure 4.

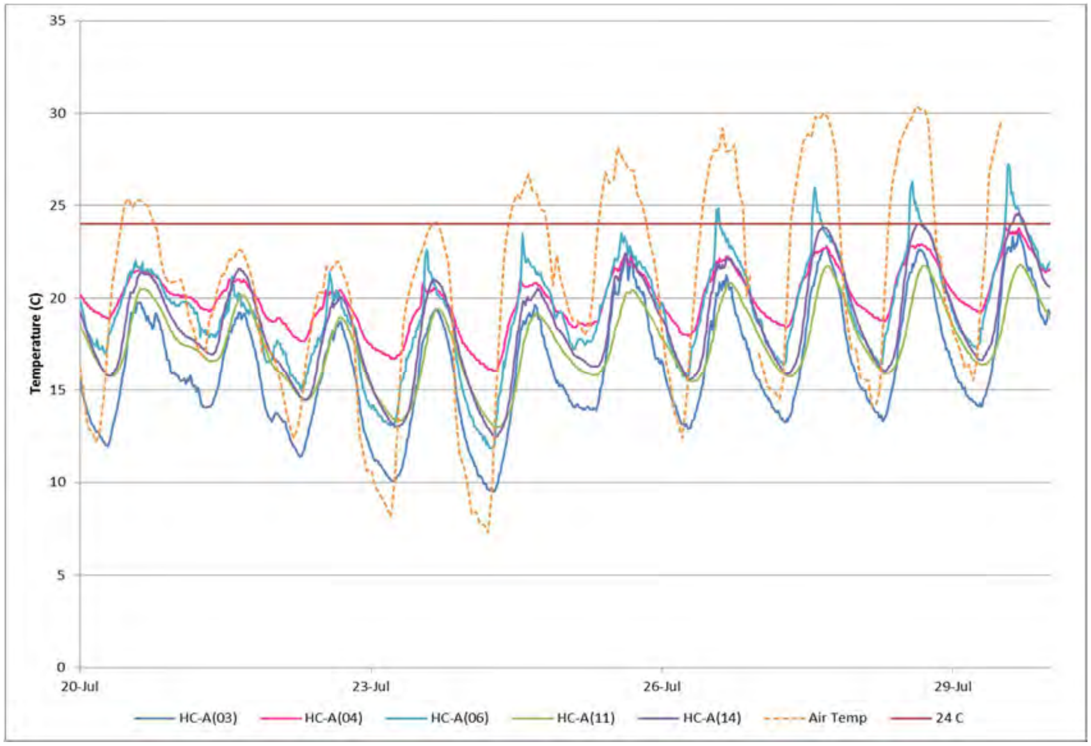

Figure 3 - Surface water and air temperature conditions (July 20 – July 30 2015)

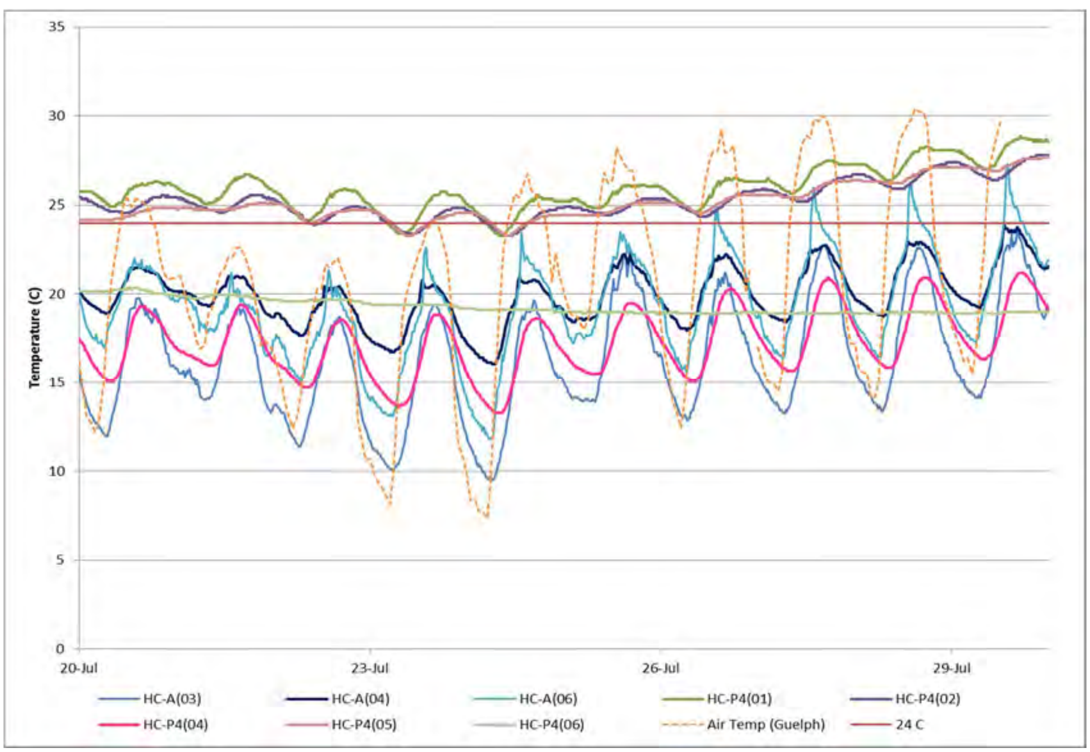

Figure 2 – Pond and creek surface water and air conditions (July 20 – July 30 2015)

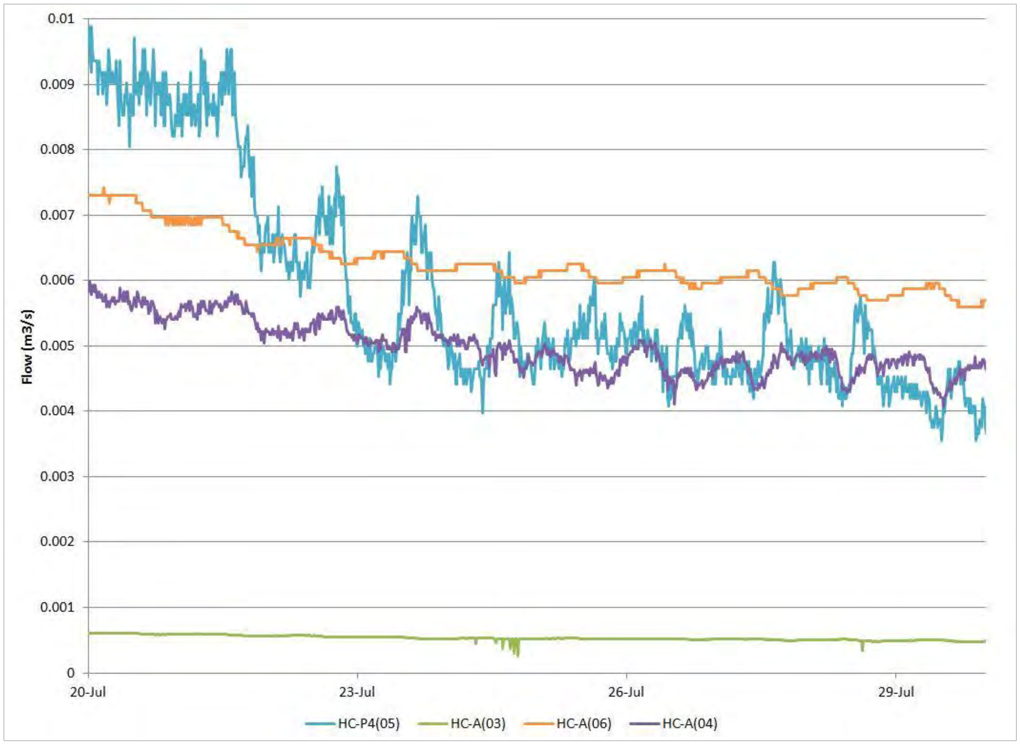

Figure 4 - Pond and creek flow conditions (July 20 - July 30 2015)

The following observations have been made regarding temperature and flow conditions:

- Temperature exceedances have been observed at stations HC-A(06) and HC-A(14).
- Temperatures above 24C were also recorded at pond 4 stations 01, 02 and 05 (Outlet).
- The cooling trench appears to be functioning properly as temperatures at the cooling trench trend downward while the pond outlet and receiving stream temperatures increase.
- All stations where data was gathered appear to be experiencing warming due to increasing air temperatures.
- Pond 4 continues to discharge water even after extended periods of dry conditions.
- Temperature exceedances at station HC-A(06) do not appear to be a direct result of the continuous discharge at pond 4, rather a combination of warm air temperatures, solar heating through exposed areas and low flow conditions. Vegetation directly downstream of HC-A(04) consist of low shrubs and tall grasses with only a small amount of overhanging tree canopy cover.

3. Groundwater Conditions

After reviewing groundwater temperatures (collected by Banks Groundwater Engineering) from the monitoring wells near Pond 4, it is clear that temperatures have experienced little variation from last years recorded values. As of August 1st, the shallow monitoring well (MW 119A) recorded water temperatures of approximately 13°C, which was the same value recorded on August 1st of 2013. It is suspected that, groundwater is entering the pond along the east side of the pond, water is also re-entering the groundwater system on the west side, as groundwater is moving toward Tributary A. Ground water temperatures monitored close to the pond 4 inlet (MW131) also experienced little fluctuation from 2014 to 2015. Additionally, piezometers located directly downstream from HC-A(014) (PZ-13D and PZ-14D) saw minor change in temperatures as seen in Figure 5. Note that temperatures upgradient at MW131 are lower than at MW1119A and this may be a result of the pond heating the water. Water temperatures at the piezometers are not substantially different from each other and are at about the same temperatures as MW119A. The piezometers are more exposed to surface conditions including air temperatures and solar heating. It is expected that by reducing the open water surface area with vegetation and plantings that this will aid in reducing water temperatures and potential groundwater warming.

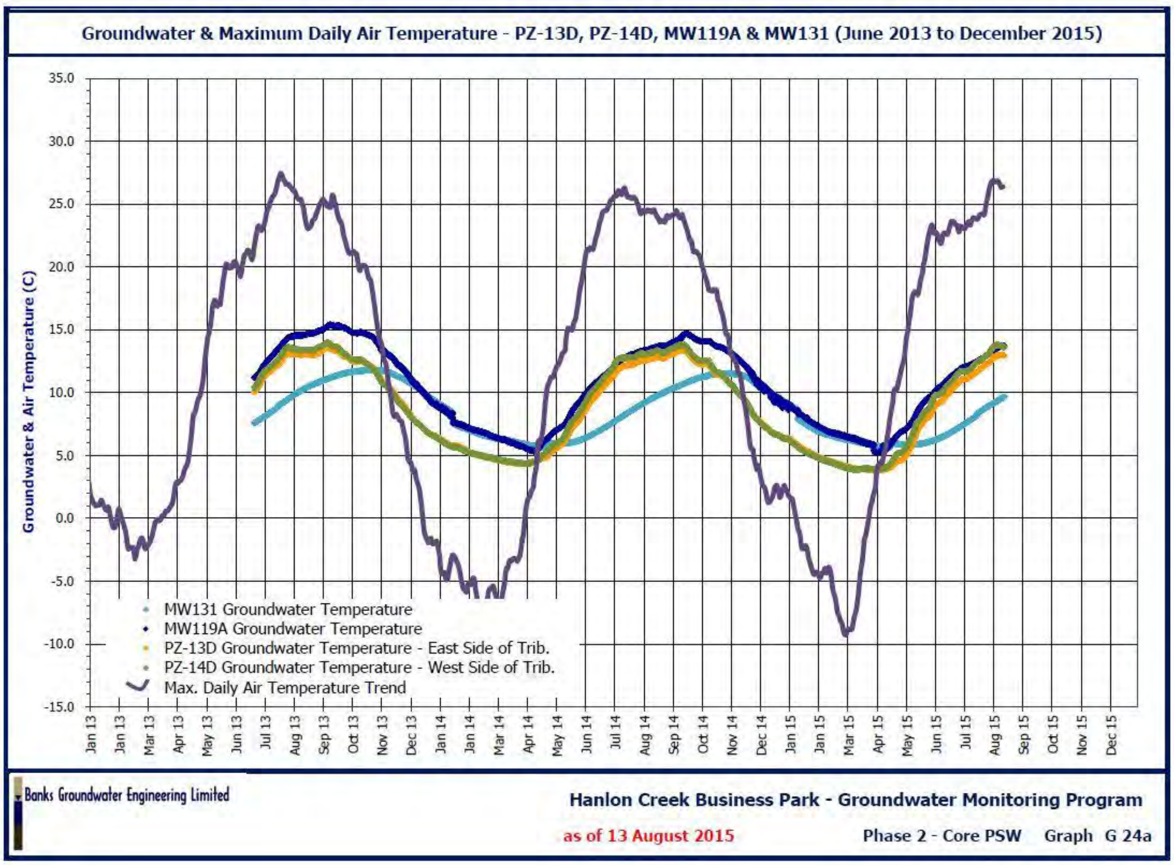

Figure 5 - Groundwater temperature (January 2013 - August 2015)

4. Mitigation Measures

Due to the temperature exceedances experienced in the headwaters of the creek and the constant discharge from Pond 4, the RAAP team decided that it was necessary to implement mitigation measures to reduce the temperature impacts of Pond 4 between rain events. Mitigation measures will work to reduce the temperature of exiting water from Pond 4 and reduce the amount of pond discharge. These measures are expected to help lower upstream surface water temperatures in the creek. The following mitigation measures were recommended to be investigated and to be implemented if found appropriate.

1. Install drainage tile along the south side of the Pond 4 trail from the pond's inlet to the pond's outlet. The drainage tile will be installed at the ponds permanent pool elevation in order to intercept incoming groundwater before it reaches the pond. The ground water will instead be directed towards the cooling trench to help enhance the trenches cooling properties. The tile drain would run approximately 360m in length.
2. Potentially install floating islands in the pond, if necessary to provide further shading and reduce heat gain. However, discussions on site identified that although monitoring has shown these islands have a positive impact on water quality, little to no temperature reductions have been realized.
3. Increase the vegetative cover at the cooling trench outlet to provide additional shading. Review the possibility of moving rock to install live stakes in "bank" areas of the cooling trench.
4. Redirect the cooling trench outlet to the Hanlon creek tributary in order to reduce the undercutting that is occurring on the opposite bank and/or use bioengineering at the cooling trench outlet to protect the banks and provide additional shading.

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Minutes of Meeting

Date of Meeting	September 8, 2015	Start Time	2:30	Project Number	60265453
Project Name	Hanlon Business Park Monitoring				
Location	Conference Call				
Regarding	Temperature exceedances at HC-A-03 and HC-A-06				
Attendees	Prachi Patel (City of Guelph), Bill Banks (Bank Groundwater), Andrew Schiedel (NRSI), Adrienne Sones (AECOM)				
Distribution	Attendees, John Palmer (GRCA), Tony Zammit (GRCA), Prasoon Adhikari (City of Guelph), Tara Brenton (NRSI), Andrew Minielly (AECOM)				
Minutes Prepared By	Adrienne Sones P.Eng.				

PLEASE NOTE: If this report does not agree with your records of the meeting, or if there are any omissions, please advise, otherwise we will assume the contents to be correct.

	Action
• Introductions • As Nicole had mentioned in an e-mail to the project team, she has moved on from AECOM and Adrienne Sones has taken her place at project manager. Adrienne has previous experience with this project, having worked with Nicole from 2008 to 2010 in data collection and reporting for the HCBP.	n/a
• Temperatures exceeded 24°C on September 7, 2015 at site HC-A-03 from 12:45 to 17:15 and at site HC-A-06 at 14:15.	n/a
• HC-A-03 is located upstream of Pond 4 and is currently the most upstream monitoring station. Temperatures at HC-A-03 are not thought to be impacted by discharge from Pond 4. • It was noted that previous exceedances have not occurred at HC-A-03. • It was discussed that the temperature exceedance at HC-A-03 was not likely due to impacts from upstream development. • AECOM staff who were onsite last week identified that the exceedance at HC-A-03 was likely due to low water levels. The temperature gauge could have been out of the water. AECOM will confirm will a site visit today.	n/a n/a n/a AECOM
• The City of Guelph is considering alternatives to mitigate impacts of Pond 4 to the Hanlon Creek system as summarized in AECOM's memo issued on August 28, 2015. • The City will also consider implementation of LID practises in the catchment in their review of alternatives.	n/a n/a

• *Following the conference call AECOM staff onsite observed HC-A-03 to be very dry. The temperature sensor was siting just above the water level, confirming the temperature exceedance at HC-A-03 was likely due to low water levels. The temperature sensor was moved on September 8, 2015 so that is was in the water in efforts to reduce future temperature triggers at this location.*  **Photograph 1 – HCBP HC-A-03 monitoring station on September 8, 2015**	Info.

Subject: Fwd: RE: FW: Above limit cleared on "HC-A(06)"
From: Andrew Schiedel <aschiedel@nrsi.on.ca>
Date: 4/19/2016 11:46 AM
To: Steve Burgin <sburgin@nrsi.on.ca>

Andrew E. Schiedel,
Aquatic Biologist
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-------- Forwarded Message --------
Subject:RE: FW: Above limit cleared on "HC-A(06)"
Date: Thu, 30 Jul 2015 17:52:06 +0000
From: Weber, Nicole <Nicole.Weber@aecom.com>
To: Prachi.Patel@guelph.ca <Prachi.Patel@guelph.ca>, jpalmer@grandriver.ca <jpalmer@grandriver.ca>, aschiedel@nrsi.on.ca <aschiedel@nrsi.on.ca>
CC: Michelle.Thalen@guelph.ca <Michelle.Thalen@guelph.ca>, Kime.Toole@guelph.ca <Kime.Toole@guelph.ca>

Let's have a quick call this afternoon at 2:30 and then maybe a site visit early next week once I have the Pond temperature data assessed in more detail.

Regards.
Nicole

From: Prachi.Patel@guelph.ca [mailto:Prachi.Patel@guelph.ca]
Sent: Thursday, July 30, 2015 1:45 PM
To: jpalmer@grandriver.ca; aschiedel@nrsi.on.ca
Cc: Weber, Nicole; Michelle.Thalen@guelph.ca; Kime.Toole@guelph.ca
Subject: RE: FW: Above limit cleared on "HC-A(06)"

Hi Andrew,

Thanks for the brief background. I'd have preferred our City Engineering Staff to attend the conference call as well as they have better history of the file and associated site plan applications that has moved forward so forth. Both City Engineering Staff on this file are off this week, and acknowledging the urgency of this issue to be addressed, I'm as such available both today and tomorrow. I prefer tomorrow morning (9-10:30) or afternoon (2-3pm) as this will give me some time to catch up with the file and monitoring reports so far.

Let me know if this works. Meanwhile I suggest exploring answers to following questions to aid in discussion during the call:

- How much area is currently stripped & currently devoid of erosion control?
- Are erosion control measures in place, installed properly and effective through the construction areas?
- Are the existing settling controls in place through the construction area installed properly and effective?
- Is there need for additional settling controls through the construction areas?
- Are all sediment control measures and silt fencing installed properly and effective?

A site visit may be helpful to better understand the site conditions. We can discuss this during the call.

Michelle Thalen one of the City Engineering Staff on this file will be returning back to the office on August 4. So we should also have further discussion with City Engineering staff's input to this issue.

Regards,

Prachi Patel, B.Sc (Botany), PG Certification (Ecosystem Restoration)
Environmental Planner
Infrastructure, Development and Enterprise
City of Guelph

T 519-822-1260 x 2563
E prachi.patel@guelph.ca

From: John Palmer [mailto:jpalmer@grandriver.ca]
Sent: July 30, 2015 12:16 PM
To: Andrew Schiedel; Prachi Patel
Cc: Nicole Weber
Subject: RE: FW: Above limit cleared on "HC-A(06)"

I am available this afternoon and tomorrow.
Regards,
John

From: Andrew Schiedel [mailto:aschiedel@nrsi.on.ca]
Sent: July-30-15 11:49 AM
To: prachi.patel@guelph.ca
Cc: Nicole Weber; John Palmer
Subject: Fwd: FW: Above limit cleared on "HC-A(06)"

Hello Prachi,

I am involved with the Hanlon Creek Business Park development. As part of the monitoring for that project, we have a Rapid Assessment and Action Protocol (RAAP) for stream temperature exceedances and high turbidity results. The RAAP group includes representatives from the City, GRCA and the consulting team. Nicole Weber leads the surface water monitoring, and I lead the biological monitoring and the consolidated monitoring reports. The two of us typically represent the consulting team in the RAAP group. Bill Banks is the hydrogeologist doing groundwater monitoring, and he is involved as needed. John Palmer represents the GRCA.

The email below from Nicole indicates a surface water temperature exceedance, so we need to have a phone call about this. Nicole will suggest a time for the call. Can you or someone else attend the call on behalf of the City?

Thank you,
Andrew

-------- Original Message --------
Subject:FW: Above limit cleared on "HC-A(06)"
Date: Thu, 30 Jul 2015 14:30:10 +0000
From: Weber, Nicole <Nicole.Weber@aecom.com>
To: John Palmer (jpalmer@grandriver.ca) <jpalmer@grandriver.ca>, Andrew Schiedel (aschiedel@nrsi.on.ca) <aschiedel@nrsi.on.ca>

Hello.

We have had hot weather over the last few days and Stations 6 and 14 have gone over 24 degrees C. Station 6 is downstream of Pond 4 so I am having my team go out to download the temperature and flow data from Pond 4 so we can look at that as an influencing factor.

Can we hold off on a call until we get that information back?

Andrew, can you please forward this information to whoever is taking care of this at the City in Adele's absence?

Regards.

Nicole S. Weber, M.Sc., PhD, P.Eng.
Senior Project Manager, Water Resources, Water
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Nicole.Weber@aecom.com

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Subject: Fwd: RE: Hanlon Stations 3, 6 and Pond 4 site visit
From: Andrew Schiedel <aschiedel@nrsi.on.ca>
Date: 4/19/2016 11:48 AM
To: Steve Burgin <sburgin@nrsi.on.ca>

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-------- Forwarded Message --------
Subject: RE: Hanlon Stations 3, 6 and Pond 4 site visit
Date: Fri, 28 Aug 2015 20:10:49 +0000
From: Weber, Nicole <Nicole.Weber@aecom.com>
To: John Palmer (jpalmer@grandriver.ca) <jpalmer@grandriver.ca>, Prachi.Patel@guelph.ca <Prachi.Patel@guelph.ca>, Kime.Toole@guelph.ca <Kime.Toole@guelph.ca>, Michelle.Thalen@guelph.ca <Michelle.Thalen@guelph.ca>, tzammit@grandriver.ca <tzammit@grandriver.ca>, Andrew Schiedel (aschiedel@nrsi.on.ca) <aschiedel@nrsi.on.ca>, Tara Brenton <tbrenton@nrsi.on.ca>, Bill Banks <Bill.Banks@banksgroundwater.ca>, Minielly, Andrew <Andrew.Minielly@aecom.com>
CC: Prasoon.Adhikari@guelph.ca <Prasoon.Adhikari@guelph.ca>, Sones, Adrienne <Adrienne.Sones@aecom.com>, Tufgar, Ray <Ray.Tufgar@aecom.com>, Peter.Cartwright@guelph.ca <Peter.Cartwright@guelph.ca>

Hello all.

Please see attached memo summarizing results and discussions related to the temperature exceedance in Hanlon Creek Tributary A in July 2015.

Please note that I have accepted a position outside of AECOM. My last day is September 4, 2015. Adrienne Sones (cc'd) will be taking on managing the surface water monitoring program for HCBP with support from Andrew Minielly and the rest of the water resources team. Ray Tufgar will continue to have input and oversight of the project as well.

Kind regards to all.

Nicole S. Weber, M.Sc., PhD, P.Eng.
Senior Project Manager, Water Resources, Water
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-----Original Appointment-----
From: Weber, Nicole
Sent: Thursday, August 06, 2015 2:07 PM
To: Weber, Nicole; John Palmer (jpalmer@grandriver.ca); Prachi.Patel@guelph.ca; Kime.Toole@guelph.ca; Michelle.Thalen@guelph.ca; tzammit@grandriver.ca; Andrew Schiedel (aschiedel@nrsi.on.ca); Tara Brenton <tbrenton@nrsi.on.ca>; Bill Banks ; Minielly, Andrew
Cc: Prasoon.Adhikari@guelph.ca
Subject: Hanlon Stations 3, 6 and Pond 4 site visit
When: Thursday, August 13, 2015 9:00 AM-11:30 AM (UTC-05:00) Eastern Time (US & Canada).
Where: Meet at Pond 4 outlet

Nicole to provide updated analysis of temperature exceedances in advance of site visit.

Attachments:

MEMO-2015-08-27-TemperatureExceedances2015-v1-60265453.pdf	27 bytes

Subject: Fwd: RE: Hanlon Stations 3, 6 and Pond 4 site visit
From: Andrew Schiedel <aschiedel@nrsi.on.ca>
Date: 4/19/2016 11:48 AM
To: Steve Burgin <sburgin@nrsi.on.ca>

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(e) aschiedel@nrsi.on.ca
www.nrsi.on.ca

-------- Forwarded Message --------
Subject: RE: Hanlon Stations 3, 6 and Pond 4 site visit
Date: Wed, 19 Aug 2015 13:28:36 +0000
From: John Palmer <jpalmer@grandriver.ca>
To: Weber, Nicole <Nicole.Weber@aecom.com>, Prachi.Patel@guelph.ca <Prachi.Patel@guelph.ca>, Kime.Toole@guelph.ca <Kime.Toole@guelph.ca>, Michelle.Thalen@guelph.ca <Michelle.Thalen@guelph.ca>, Tony Zammit <tzammit@grandriver.ca>, Andrew Schiedel (aschiedel@nrsi.on.ca) <aschiedel@nrsi.on.ca>, Tara Brenton <tbrenton@nrsi.on.ca>, Bill Banks <Bill.Banks@banksgroundwater.ca>, Minielly, Andrew <Andrew.Minielly@aecom.com>
CC: Prasoon.Adhikari@guelph.ca <Prasoon.Adhikari@guelph.ca>

Greetings all,

This is just an observation of interest. During the weekend I was swimming in the kettle lake at Pinehurst and at one point found myself among some water lilies. On standing to check the water depth I found it to be over my shoulders which makes one wonder why there has be such little uptake of the water lilies planted in the shallow areas of Pond 4.

Something to think about.
Best regards,
John

Subject: Fwd: RE: Hanlon Stations 3, 6 and Pond 4 site visit
From: Andrew Schiedel <aschiedel@nrsi.on.ca>
Date: 4/19/2016 11:48 AM
To: Steve Burgin <sburgin@nrsi.on.ca>

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-------- Forwarded Message --------
Subject:RE: Hanlon Stations 3, 6 and Pond 4 site visit
Date: Wed, 12 Aug 2015 21:54:12 +0000
From: Weber, Nicole <Nicole.Weber@aecom.com>
To: John Palmer (jpalmer@grandriver.ca) <jpalmer@grandriver.ca>, Prachi.Patel@guelph.ca <Prachi.Patel@guelph.ca>, Kime.Toole@guelph.ca <Kime.Toole@guelph.ca>, Michelle.Thalen@guelph.ca <Michelle.Thalen@guelph.ca>, tzammit@grandriver.ca <tzammit@grandriver.ca>, Andrew Schiedel (aschiedel@nrsi.on.ca) <aschiedel@nrsi.on.ca>, Tara Brenton <tbrenton@nrsi.on.ca>, Bill Banks <Bill.Banks@banksgroundwater.ca>, Minielly, Andrew <Andrew.Minielly@aecom.com>
CC: Prasoon.Adhikari@guelph.ca <Prasoon.Adhikari@guelph.ca>

Hello all.

Please see attached figures showing the temperatures and flows at the affected station and at Pond 4 for the dates where temperature exceedances were observed for discussion tomorrow. Given the late email, I will bring printed copies of the graphs.

Regards.

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-----Original Appointment-----
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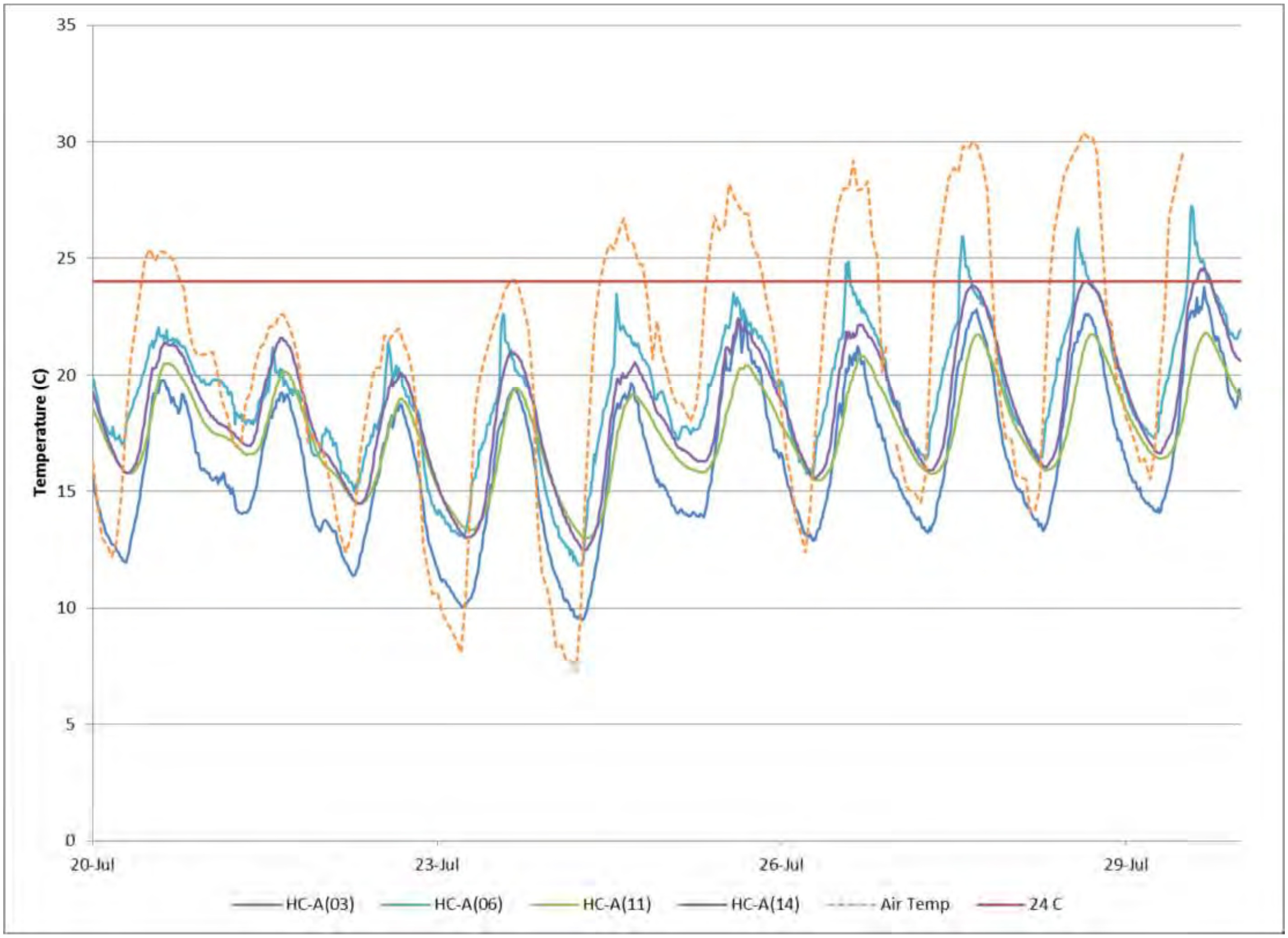
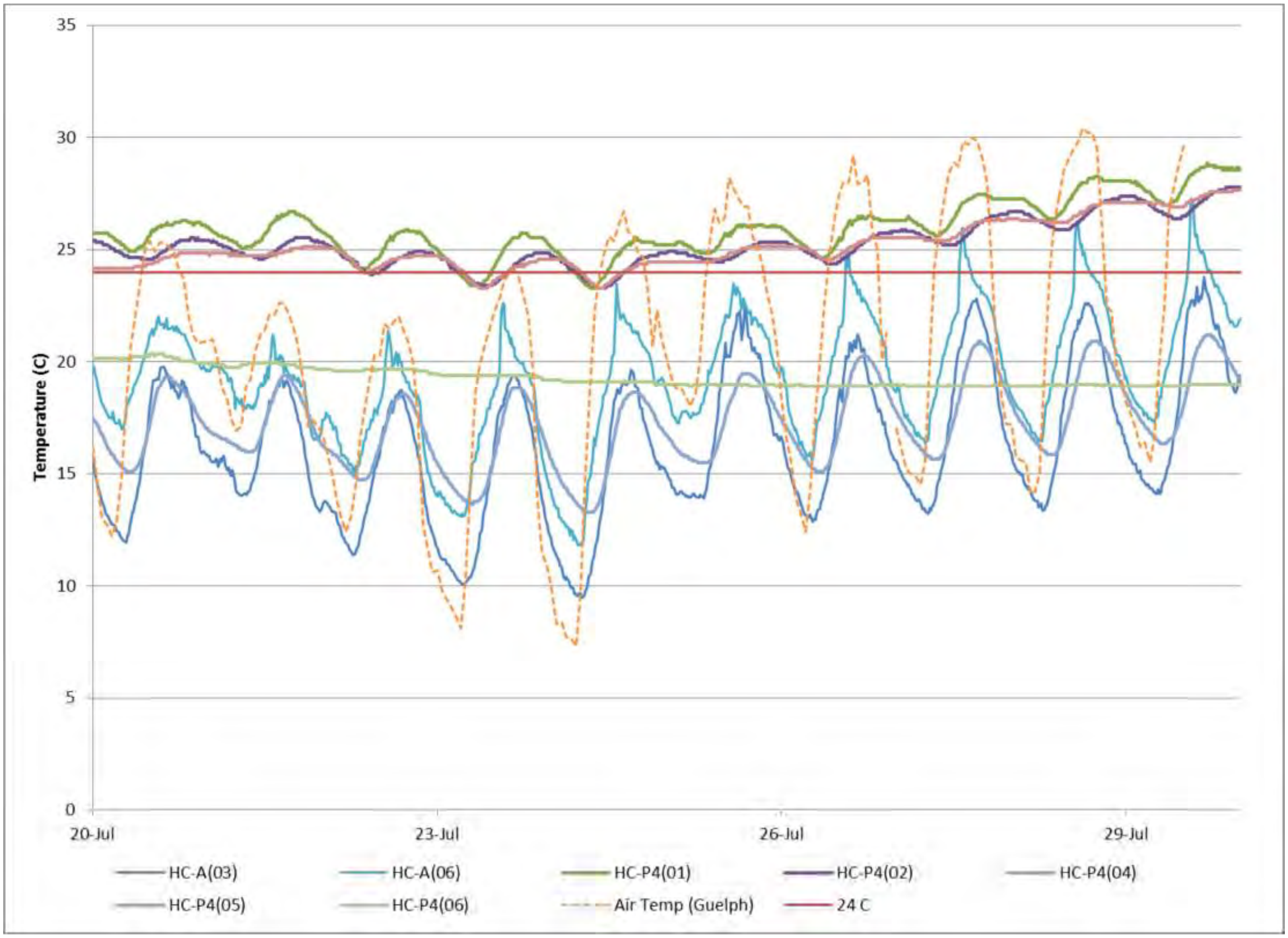
Sent: Thursday, August 06, 2015 2:07 PM
To: Weber, Nicole; John Palmer (jpalmer@grandriver.ca); Prachi.Patel@guelph.ca; Kime.Toole@guelph.ca; Michelle.Thalen@guelph.ca; tzammit@grandriver.ca; Andrew Schiedel (aschiedel@nrsi.on.ca); Tara Brenton <tbrenton@nrsi.on.ca>; Bill Banks ; Minielly, Andrew
Cc: Prasoon.Adhikari@guelph.ca
Subject: Hanlon Stations 3, 6 and Pond 4 site visit
When: Thursday, August 13, 2015 9:00 AM-11:30 AM (UTC-05:00) Eastern Time (US & Canada).
Where: Meet at Pond 4 outlet

Nicole to provide updated analysis of temperature exceedances in advance of site visit.

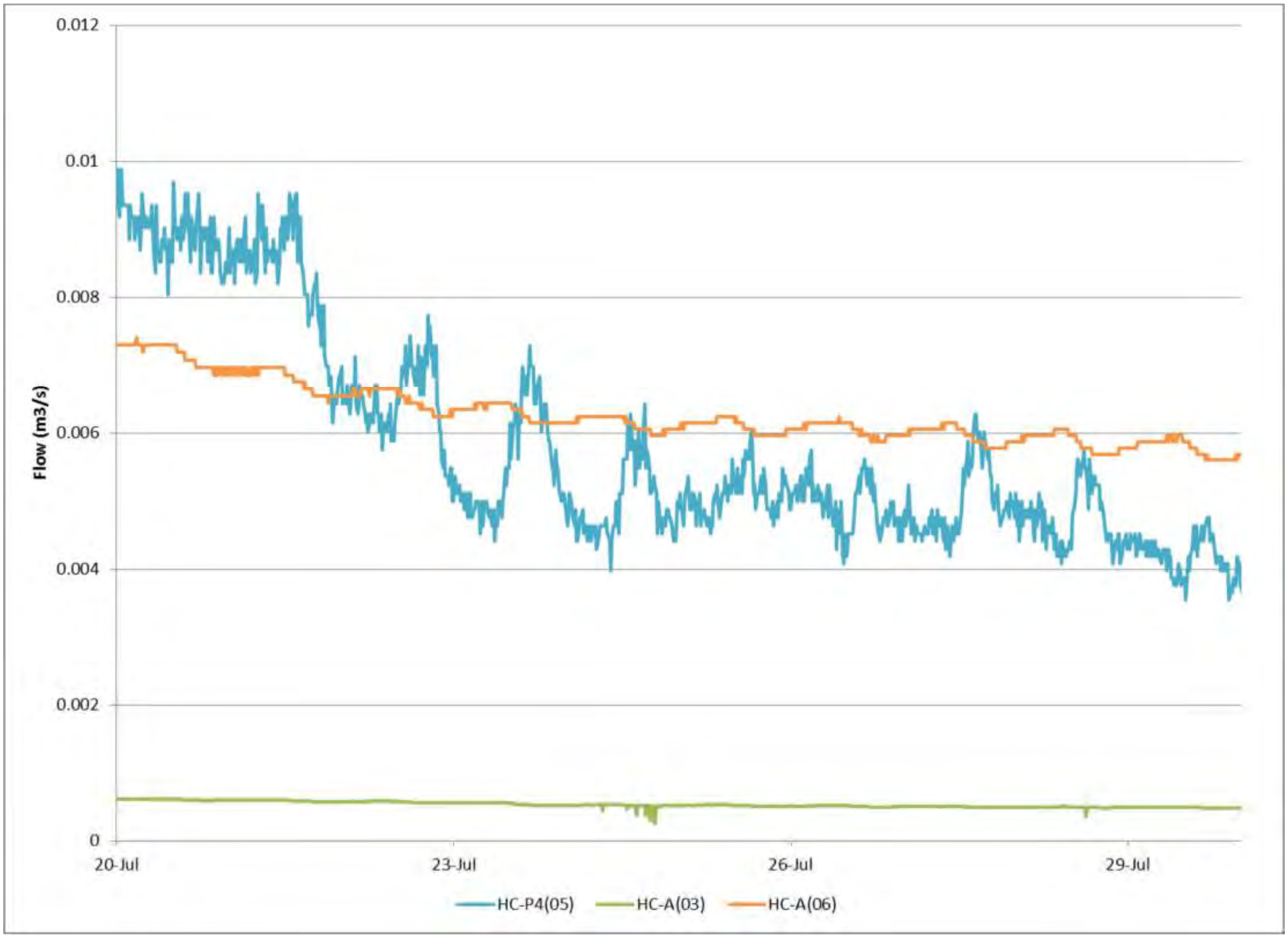
Overall Temperature Jul20 to Jul30 2015.png



Pond 4 Temperature Jul20 to Jul30 2015.png



Flows Jul20 to Jul30 2015.png



Attachments:

Overall Temperature Jul20 to Jul30 2015.png	145 KB
Pond 4 Temperature Jul20 to Jul30 2015.png	138 KB
Flows Jul20 to Jul30 2015.png	58.5 KB