MEETING AGENDA

MEETING	**River Systems Advisory Committee**
DATE	December 6, 2017
LOCATION TIME	City Hall Meeting Room 112 4:00 pm – 6:00 pm
CHAIR	Mariette Pushkar

AGENDA ITEMS

ITEM #	DESCRIPTION
1	Welcome: • Roll call and certification of quorum • Introduction of members and city staff • Declaration of pecuniary interest or conflict of interest
2	Agenda 1. Niska Road Bridge Detailed Design a) Information from City staff and project team b) Hearing of Delegation(s) - Laura Murr (see attachments) - Hugh Whiteley c) In Committee Discussion – Motion 2. Natural Heritage Action Plan – Project Update and Engagement Models
3	Adoption of Minutes – June 21, 2017 & September 13, 2017
4	Other Business & Next Meeting
5	Adjournment

CITY OF
Guelph
Making a Difference

November 15, 2015
River System Advisory Committee

Item

Niska Rd Class EA
Report provides a status update regarding the project and shares new/updated information in relation to the design studies that are proceeding currently.

Proposal

The City of Guelph (City) initiated a Class Environmental Assessment (EA) study to investigate opportunities for improvements to Niska Road from the City limits to Downey Road. Segments of the roadway and the bridge over the Speed River are nearing the end of their operational life and require a solution to address their deterioration and increasing maintenance costs. The EA was completed earlier in 2017 following a decision from the MOE.

Location

The study area includes areas adjacent to Niska Rd from the City limit to the intersection of Niska at Downey Rd, including the crossing of the Speed River. The approximate extent of the Study Area is shown on the map included as Attachment 1. Based on the direction from Council and as reflected in the final EA – improvements to the intersection at Downey and Niska are not included in the detail design.

Back ground

- The study area for the Niska Rd EA includes portions of the Hanlon Creek subwatershed, as well as the Speed River subwatershed.
- There are also known natural heritage features and areas within the study area that are part of the City's Natural Heritage System (NHS) as identified within the Official Plan. A map of the known limits of the NHS for the area is included as Attachment 3. These features include:
    - Significant Woodlands;
    - Significant Wetlands (PSW);
    - Significant Valleylands (Speed River Valley);
    - Significant Wildlife Habitat (ecological linkages, deer winter congregation areas & waterfowl over wintering habitat);
    - Surface Water and Fish Habitat;
    - Wildlife Movement Corridors (associated with the ecological linkage)
    - Habitat for locally significant species
- The City's Official Plan recognizes Niska Road as a two-lane collector road which collects vehicle trips from the area and provides for through movement for vehicular travel to/from arterial roadways and expressways. A secondary function is to serve land access and to link the Townships of Puslinch and Guelph-Eramosa.
- The preferred solution from the EA includes:
    - The reconstruction of Niska Road from the City limits to the Downey Road intersection and provision of operational improvements to Niska Road
    - Replacement of the existing Bailey Bridge with a new two lane structure
- RSAC's previous motions regarding the Niska EA are also attached for ease of reference (attachment 2).

Project Update

Additional fields studies were completed through 2017 to collect additional information via an environmental addendum study to address gaps and recommendations for additional field study through the detail design process as recommended by the EA. Updated information (below and attached) is based on the preliminary results of these studies and are being used to advance and inform both the road and bridge design.

This project is being brought back to the committee now to provide a project update and collect some initial thoughts/feedback ahead of a community PIC in December. The full design and revised environmental reports will also be share early in the New Year for further input/ insight.

Geology, Hydrology and Hydrogeology

Between Ptarmigan Drive and Pioneer Trail, surficial geology is mapped as glaciofluvial deposits. Organic deposits and modern alluvium associated with the Speed River and adjacent wetlands are mapped from Pioneer Trail west towards the Niska Road bridge. Bedrock underlying the site is of the Guelph Formation.

Twelve (12) mini-piezometers were installed to monitor shallow groundwater levels. They have been installed in or near surface water bodies or wetlands to assess vertical gradients of groundwater flow. The following criteria were also considered in the location selection:

- At least one (1) monitoring location (well or piezometer) located on lands classified as agricultural and shallow marsh as identified in the Natural Heritage Strategy
- Two (2) single piezometers should be installed in the Speed River, one upstream and one downstream of the Niska Road crossing
- Some piezometers should be installed as nests, with a shallow and deep piezometer installed at a single location. This will allow for the accurate assessment of vertical hydraulic gradients, even if surface water is not present during a monitoring event.
- Piezometers should be installed on both sides (north and south) of the Niska Road Right of Way (ROW) to allow for an assessment of the hydraulic connection underneath Niska Road.
- Piezometers will generally target areas of suspected groundwater discharge. This will include areas near groundwater seeps observed by RJ Burnside.

Water monitoring commenced in the spring of 2017 and the last samples are being collected this month (November). Attachment 4 includes a map of the minipiezometer locations.

Sixteen (16) boreholes were also completed along Niska Rd from Ptarmigan west to the Speed River on May 10 and 11, 2017. Four (4) locations also included water monitoring wells (also shown in attachment 4). Soil and groundwater conditions were observed in the open boreholes throughout the drilling operations.

Preliminary findings:

- Support groundwater movement flowing generally in an east-west direction (generally parallel to the road).
- Confirmed presence of organics (peat) under Niska Rd at boreholes 17-3 & 4 (see attachment 3). Peat was found at a depth of approximately 1.4 m to 2.2 m below the ground surface
- Depth to groundwater becomes increasingly shallow west of Pioneer Trail

as topography drops to the west.

- Depth to water below the existing Niska Road west of Pioneer Trail is 1 to 2.7 m below existing grade. No groundwater was encountered in boreholes 17-10 to 17-16 during drilling.
- The highest recorded surface water elevation in the Speed River was measured at MP-01 on May 15, 2017 with an elevation of 298.4 meters above sea level (masl). This corresponds with several larger storms experienced in late April and early May.
- Groundwater elevations recorded from the mini-piezometers and monitoring wells during the unusually wet months of June, July and August exceed the surface water elevations recorded at the Speed River (consistent with groundwater flow towards the Speed River).
- Nested mini-piezometers MP-04D/S, MP-05D/S and MP-07D/S have consistently shown upward hydraulic gradients in the groundwater.
- The Speed River Wetland Complex receives some water from groundwater discharging into ephemeral and perennial pools or ponds along the base of topographic relief trending north-south immediately east of MP-04D/S, MP-05D/S, and MP-07D/S.

Water Quality Sampling

Water quality sampling has been conducted (spring and fall) at the crossing of Niska Road and the Speed River to support detailed design recommendations for location of a new Storm Water Management outlet.

Samples will also be used for characterizing preexisting conditions, for comparison post construction.

Terrestrial Ecology

Vegetation community and tree inventory updates

Updates to the vegetation (ELC) communities have also been looked at, while refinements to some of the community boundaries, the majority of boundaries and classifications remained consistent. Significant woodland boundaries have also been surveyed. The tree inventory has also been revised – however an update on anticipated removals will be provided in a future report for input, once the road design is further advanced as this will impact the number of anticipated removals. Decline of ash spp. within the road allowance may also increase the number of removals anticipated.

Bats

Following methods from the Guelph MNRF office, a review of candidate roost trees was completed (trees over 25 cm). All trees that have the potential to be maternity roost habitat were identified, as were the 10 “best” trees as required by MNRF bat maternity colony habitat surveys. Three (3) monitoring stations were established one on the North side and one on the South side of the road in the “best” candidate trees, and an additional detector was placed within the wetland on the North side of the road for bat activity comparison (see the map in attachment 6).

A total of 2,310 calls were recorded from Location 1 (in the wetland) compared to 769 at Location 2 (North side of Niska Road) and 884 at Location 3 (South side of Niska Road). Species at Risk (which include all Myotis species and Tricoloured Bat (Perimyotis subflavus), which typically have calls in the 40-45 kHz range) were detected on site. Species of bats with calls in the 16-35 kHz range were most common: primarily Big Brown Bat (Eptesicus fuscus) and

Silver-haired Bat (Lasionycterus noctivagans). To a lesser extent, Hoary Bat (Lasiurus cinereus) and Eastern Red Bat (Lasiurus borealis) were recorded.

Preliminary findings:

- None of the trees along the ROW appear to be being used as maternity roosts.
- There is foraging activity within the valleyland – however the greatest concentration of activity is within wetland areas to the north.
- City team is having further discussions with MNRF staff regarding requirements, steps and timing windows

Birds

Updated bird surveys were also completed. Observations included 44 species, including several that were not previously identified through the EA. Of the birds recorded, two are Species at Risk: Barn Swallow (listed as Threatened Federally and Provincially) and Eastern Wood-pewee (listed as Special Concern Federally and Provincially).

Eleven species recorded are listed as locally rare in the City of Guelph: Great Blue Heron, Green Heron, Black-billed Cuckoo, Red-bellied Woodpecker, Hairy Woodpecker, Northern Flicker, Pileated Woodpecker, Eastern Wood-pewee, Barn Swallow, Brown Creeper, Baltimore Oriole. Four area sensitive birds were recorded, including: Hairy Woodpecker, Pileated Woodpecker, Red-breasted Nuthatch and Brown Creeper.

Preliminary findings:

- Work on breeding findings/analysis is still ongoing (will be in the updated EIS report)
- Vegetation removal and related works will need to be completed outside of bird breeding windows

Amphibians

Five frog species were recorded during amphibian call surveys and observed during wildlife movement surveys in 2017: Spring Peeper, American Toad, Gray Treefrog, Green Frog and Northern Leopard Frog.

Reptiles

Three species of reptiles were observed during field surveys in 2017: Snapping Turtle, DeKay’s Brownsnake and Eastern Gartersnake. Snapping Turtle is listed as a Special Concern Federally and Provincially. Both Snapping Turtle and DeKay’s Brownsnake are listed as locally significant species in Guelph.

Wildlife & Wildlife Movement

Wildlife movement surveys were completed in order to inform the numbers, sizing, and locations of wildlife crossings. Wildlife movement surveys were completed to target reptiles and amphibians, as they are highly vulnerable to road kill. However, all wildlife including other mammals (i.e. deer, raccoon) that were encountered in the ROW was documented.

Preliminary findings:

- There is species dispersal between habitats and are crossing Niska Rd
- Looking at up to three wildlife culverts from the River/new bridge abutments up to Pioneer Trail.
- Design for culverts will need to accommodate smaller species

(amphibians/reptiles) and incorporate funnel fencing and integration into the road bed with openings to provide sir circulation and ambient temperature.
- Construction mitigation being looked at in terms of timing windows, keeping wildlife out of construction areas and providing temporary crossings during construction.
- Signage for deer is also being looked at, as is reducing vehicle speeds (through traffic calming) to reduce risks of deer/car collisions.

Road Design

Road design is underway; a current draft version of the design is attached to this report. Improvements to Niska Road will include:

- 2 vehicular lanes, sidewalks & traffic calming measures
- A single multi-use path on the north side of Niska Rd from Ptarmigan to the Speed River to minimize the overall road footprint while providing connections out of the City and to the trails west of the Speed River.
- Raising the height of the roadway profile, particularly in the low-lying area on approach to the bridge on the east bank.
- Removal of organics and/or reinforcement of the road subgrade in areas where organics are present.
- Construction dewatering during road and storm drain excavation in the area from the Speed River up to approximately Pioneer Trail. Mitigation plans for dewatering are being prepared.
- The base of infrastructure (road base and storm drains) are likely to be within the depth range of the high seasonal water table. As road and storm drain alignment is generally parallel to groundwater flow this alignment should minimize the potential for intercepting groundwater long term.
- Road and storm drain design are going to incorporate measures to mitigate the potential for backfill materials to preferentially drain the shallow water table between Pioneer Trail and the Speed River.
- Stormwater treatment will include quantity control within the road profile as well as OGS for quality treatment.
- Retaining walls also being incorporated to minimize encroachment into adjacent natural features.
- Road design will incorporate up to 3 wildlife crossings; and side slope design will also need to accommodate funnel fencing.
- Wildlife signage to also be incorporated.

Bridge Design

Bridge design is also proceeding a general description of the bridge design along with a summary of the ongoing studies and preliminary results/constraints is provided below:

- The Bridge design will include:
    - A wider span of up to 40m – the existing span is roughly 24m (between abutments)
    - New abutments that would support the new bridge
    - Raising the height of bridge profile so that the new deck is higher than the existing condition
    - Incorporating sidewalks/viewing areas on both sides of the bridge
    - Incorporating visual design elements based on input from the Heritage Impact Assessment (HIA)

- In terms of the HIA - Heritage Guelph is involved in reviewing this report and providing input on the recommendations this will feed into both the discussions around abutments as well as the overall bridge design.
- The HIA notes the abutments are historically significant and as such should be preserved. From a cultural heritage perspective it is preferred to keep the abutments in situ for preservation. However the HIA also presents an alternative conservation approach to relocate, one, or both, abutments/wing walls elsewhere in the vicinity of the bridge as commemorative monuments.
- The existing abutments have been flagged in reports as being undermined and have a potential for failure.
- The existing abutments are confining the river and have supported the creation of pools above and below the bridge over time.
- The abutments are stable enough that if the Bailey Bridge is removed they are not expected to immediately fall into the river, however they will continue to be further undermined overtime and may still fail in the future.
- The existing crossing provides deficient freeboard and clearance compared to current Provincial Standards;
- The proposed bridge will still create significant backwater affect upstream due to changes in elevation and cross section. Removal of the existing abutments (to the riverbed) would assist in reducing or alleviating this condition and get it closer to meeting Provincial Standards. It would also assist in reducing/minimizing the increase in backwater/flood related impacts upstream.
- A storm outfall is also required in the vicinity of the abutments.
- Environmental considerations for the bridge design are largely focused on the impacts associated with retention/removal of the existing abutments, backwatering, channel confinement, fish habitat and river geomorphology.
- A geomorphologist has been retained to provide additional input on potential impacts/benefits to reducing channel confinement and in relation to the pool formations above and below the bridge – should the abutments need to be removed.

Comments With respect to the information provided above, staff also offer the following comments:

1. A SWM solution should be proposed that recognizes that the Speed River is a cold/cool water managed community. This should include additional water quality treatment beyond only oil/grit separators to support an enhanced level of water quality treatment prior to out letting to the river in order to address water quality impacts. This warrants further exploration through detail design, recognizing the tight space constraints due to the adjacent NHS.
2. Invasive species management should be incorporated into the update removal plans as they are developed.
3. Compensation plantings (from vegetation removal) should be used to help minimize edge impacts and promote foraging habitat for key species including locally significant birds.
4. At least 3 wildlife crossing structures should be integrated into the road design based on the road length and possible spacing of structures and following current road ecology guidelines.

5. Bridge and road construction plans should include/ identify staging areas and include provisions to minimize encroachments into riparian habitats and adjacent natural heritage features (sediment and erosion controls, tree protection fencing, landscaping and restoration plans, etc.) to the greatest extent possible and mitigate potential negative impacts.
6. The City should explore opportunities to improve or enhance fish habitat as part of a detailed mitigation plan – in the event in water work is required for abutment removal. This should include opportunities for shoreline enhancement.

Suggested Motion

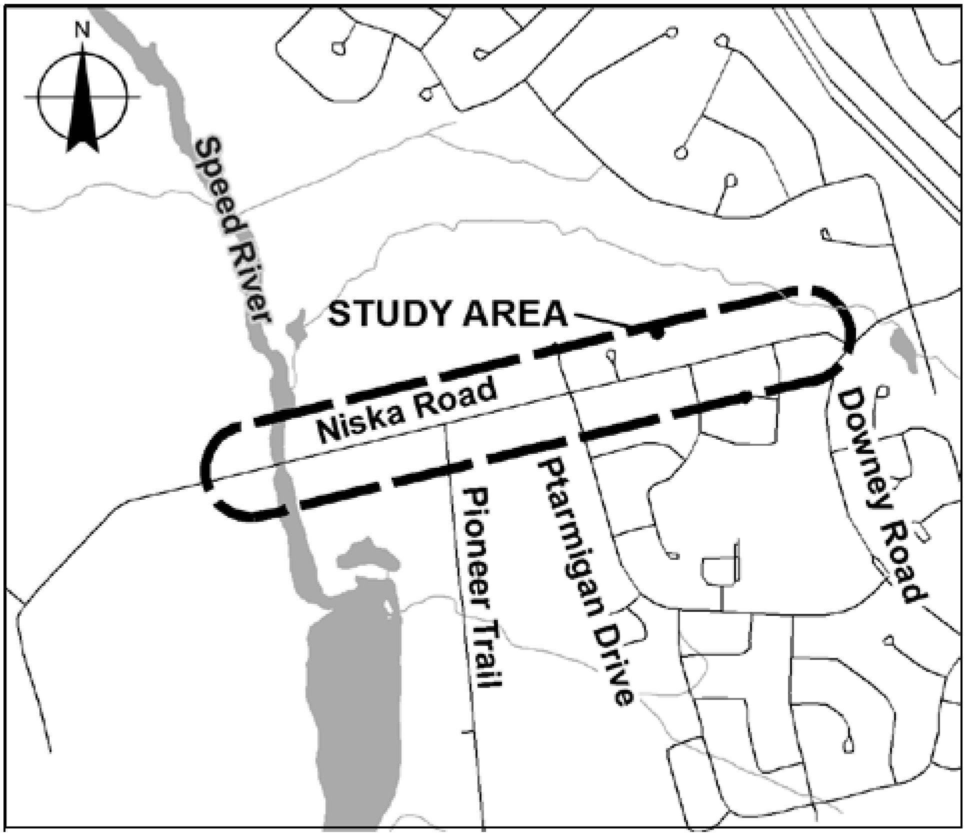
Staff recommends that the River System Advisory Committee provide the following as it relates to the Niska Rd EA:

THAT the River System Advisory Committee support the following in relation to the preliminary alternative design options:

- **Consideration of abutment removal subject to the protection and enhancement of fish habitat including shoreline stabilization and water quality improvements;**
- **A SWM strategy that incorporates additional SWM water quality measures beyond incorporation of OGS;**
- **Minimization of encroachment into the adjacent natural areas from the road and bridge footprints; and,**
- **Preparation of a wildlife construction protocol, dewatering plan, sediment and erosion control plan and a phasing/ staging plan;**

THAT the River System Advisory Committee be provided an opportunity to review the environmental addendum and supporting reports and provide further input into the advancement of the detailed design phase of the Niska Rd project.

Attachment 1- Study Area Map



Attachment 2 – RSAC Motion Oct 8, 2015 Re: Niska Rd EA

Moved by Ian McCormick and seconded by Ryan VanEngen,

"That as part of the preparation of the Environmental Study Report, the EA documents, including the draft Natural Environment Report and Evaluation of Alternative Tables be revised to incorporate the following:

- Characterization and an impact assessment on the hydrological and groundwater functions of the river valley, including seepages and existing ditch flows and potential thermal impacts;
- That the implications both negative and positive of water and sediment runoff for each of the road alternatives on the adjacent natural areas be evaluated;
- Updates to appropriately incorporate the City's Natural Heritage System policies;
- Consideration of fragmentation impacts resulting from tree removal, as well as invasive species as it relates to Significant Woodlands and Wetlands;
- Clarification regarding the potential significance of the ELC Savannah Community including the presence of indicator species and any related available SRANK information;
- Consideration of impacts as it relates to the Monarch Butterfly and it's habitat;
- That impacts to ecological functions also be considered in relation to changes/impacts regarding flood elevations;
- Consideration of timing windows for breeding birds to avoid impacts to bird species and fisheries be included;
- A stormwater management approach that provides for an enhanced level of water quality treatment that is appropriate for the Speed River as a cold/cool water managed stream;
- An analysis regarding the need for more than one wildlife passage for reptiles and small mammals be provided;
- An analysis regarding large mammal/ vehicle strikes and the potential benefits of traffic calming/ speed reduction and increased or alternative methods for signage."

Motion Carried
-Unanimous-

Moved by Nicola Lower and seconded by Jeremy Shute

"That the River System Advisory Committee support the following in relation to the preliminary alternative design options:

- A bridge design that respects the views from and of the bridge and provides for recreational access to the river (i.e. canoe launch). Including consideration for height restrictions.
- A cross section that provides for a balance that provides for pedestrian and cyclist access, and incorporates traffic calming measures to ensure safe access and address traffic volumes and provide for recreational use, while reducing the amount of encroachment into the natural heritage system to the greatest extent.
- A signalized intersection that avoids further encroachment natural heritage system.

And providing that the preferred options minimize the overall amount of encroachment into adjacent natural heritage features and provide opportunities for edge enhancement.

And that the protection of the viewscape be incorporated into a preferred road and bridge design."

Motion Carried
-Unanimous-

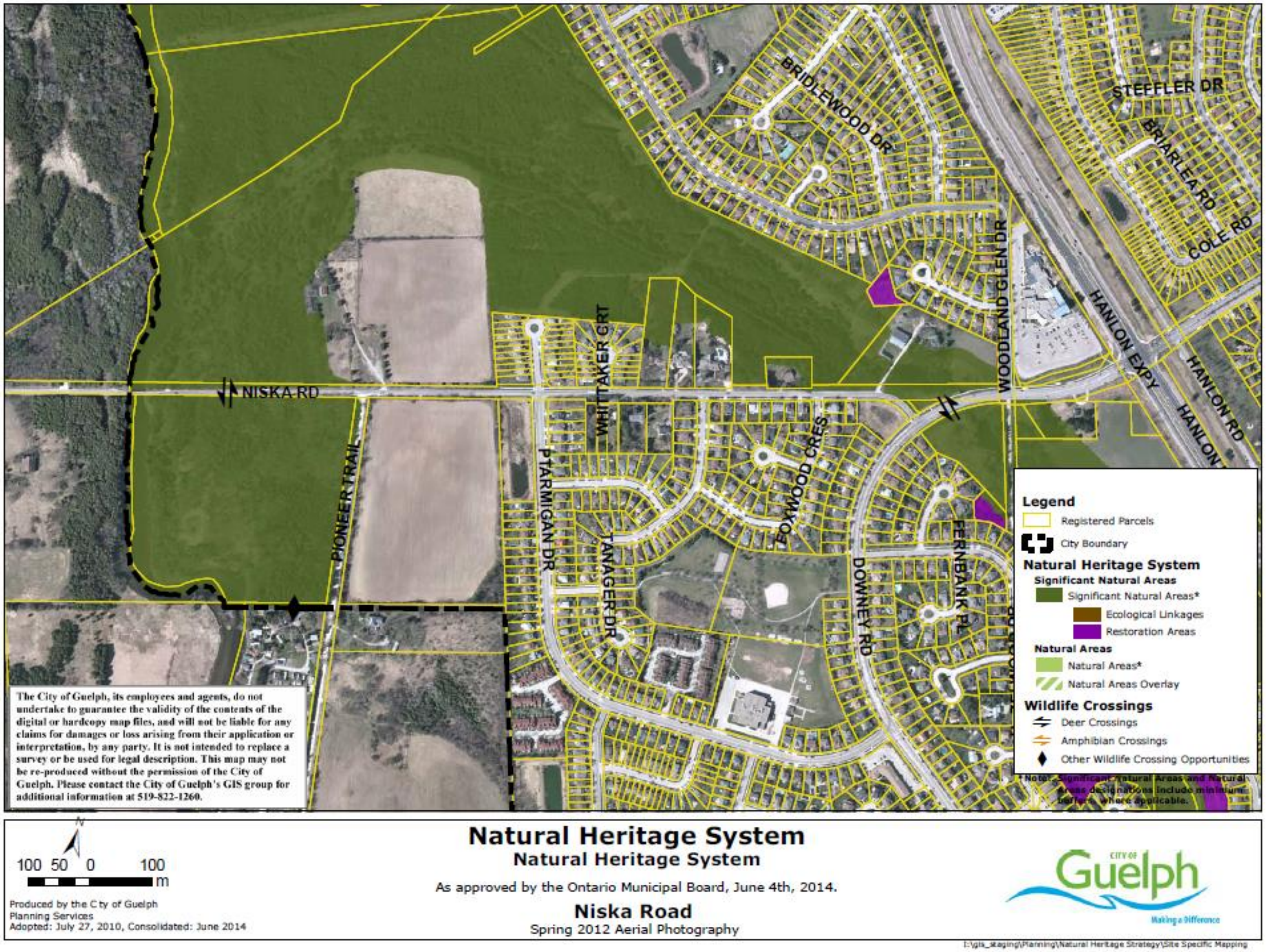
Moved by Jeremy Shute and seconded by Ryan VanEngen

"That the River System Advisory Committee be provided an opportunity to participate in the detailed design phase of the Niska Rd project and,

That the following be incorporated into the project through the detailed design phase:
- A bat habitat assessment for the presence of maternity roosts;
- A detailed tree preservation and landscape and compensation plan including details regarding the management of invasive species to be completed as part of the project;
- An environmental management plan to include: wildlife construction protocol, dewatering plan, sediment and erosion control plan and a phasing/ staging plan, wildlife timing windows;
- At least one wildlife passage for reptiles and small mammals be provided within the roadway between Pioneer Trail and the Speed River. The wildlife passage design should be based on current road ecology science and design parameters;
- A review of alternative deer/wildlife movement signage options/designs and incorporation of wildlife signage into the detailed design."

Motion Carried
-Unanimous-

Attachment 3 – Natural Heritage System



*Note: Significant Natural Areas and Natural Areas designations include minimum buffers, where applicable.

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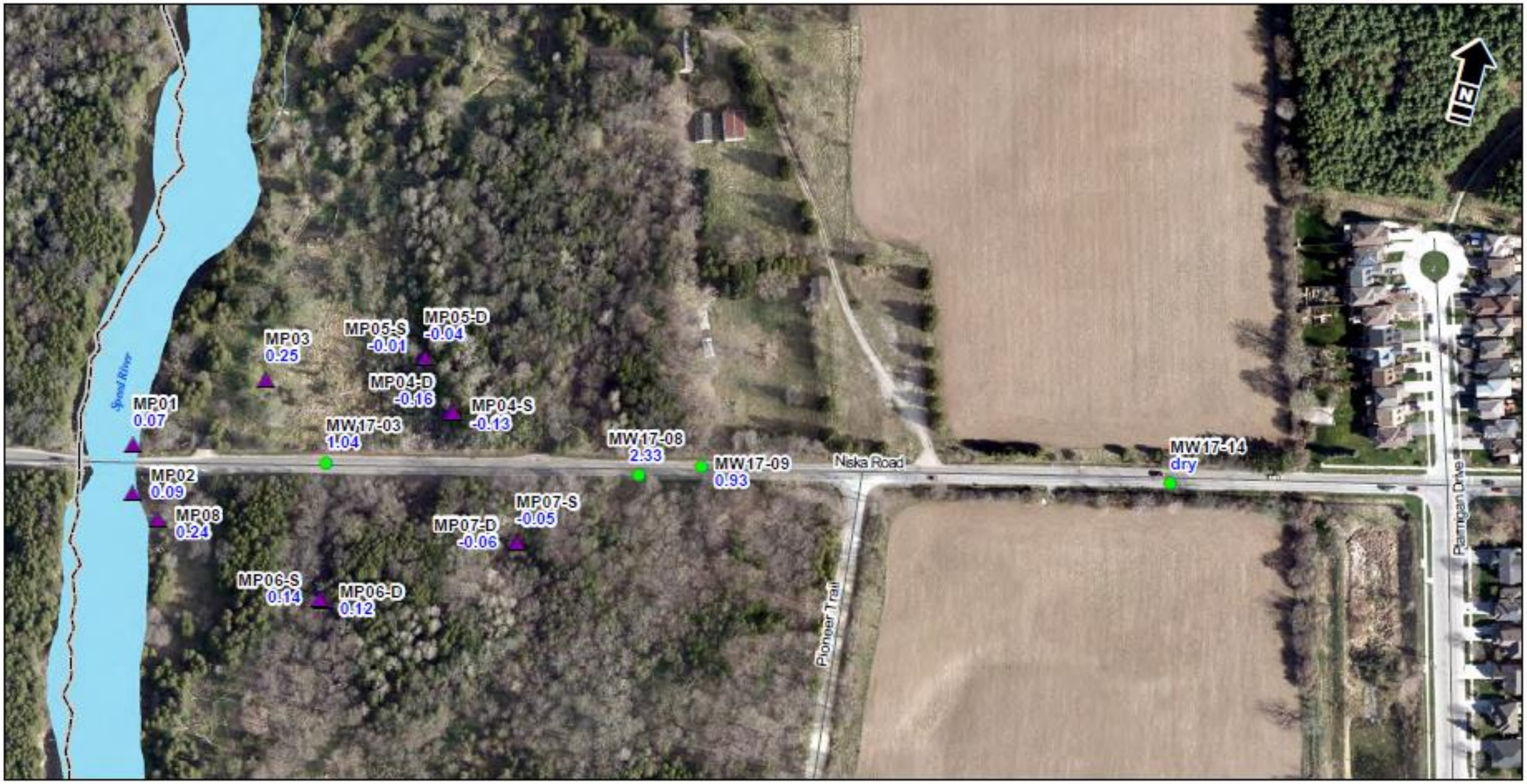
Natural Heritage System
Natural Heritage System
As approved by the Ontario Municipal Board, June 4th, 2014.
Niska Road
Spring 2012 Aerial Photography

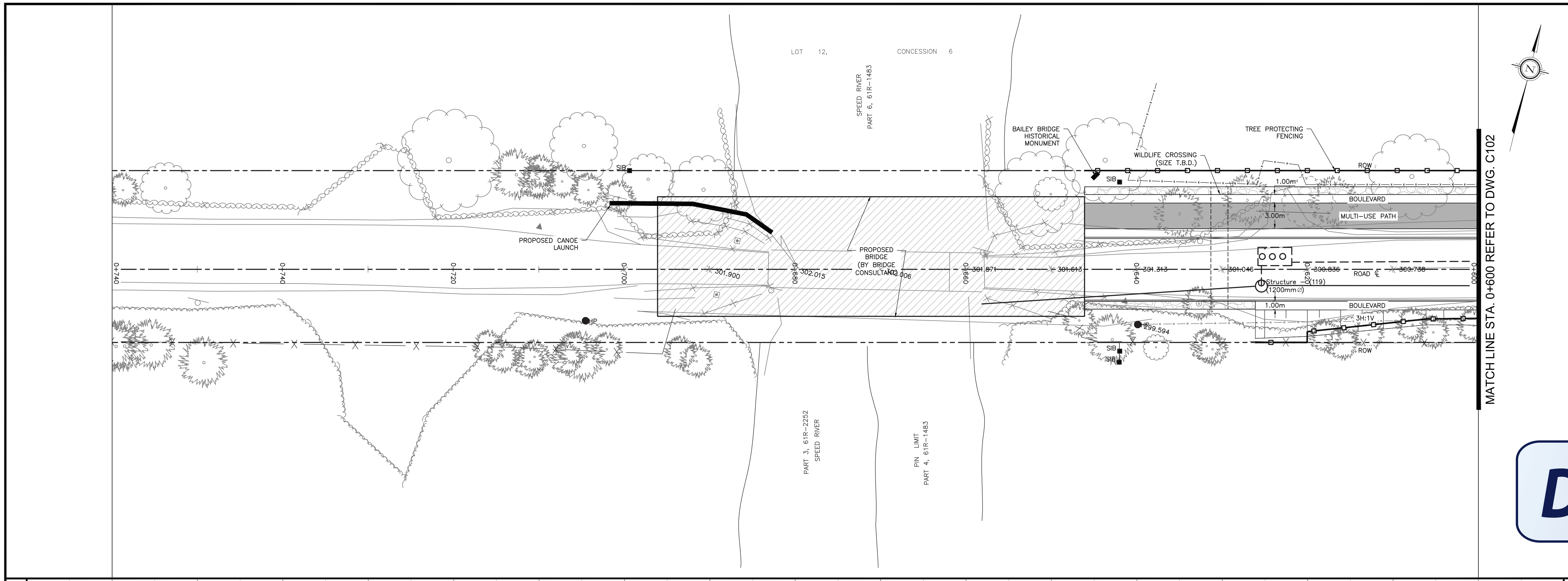
Produced by the City of Guelph
Planning Services
Adopted: July 27, 2010, Consolidated: June 2014

I:\gis_staging\Planning\Natural Heritage Strategy\Site Specific Mapping

Attachment 4 – Locations of monitoring wells and minipiezometer locations



Attachment 5 – Bat monitoring station locations



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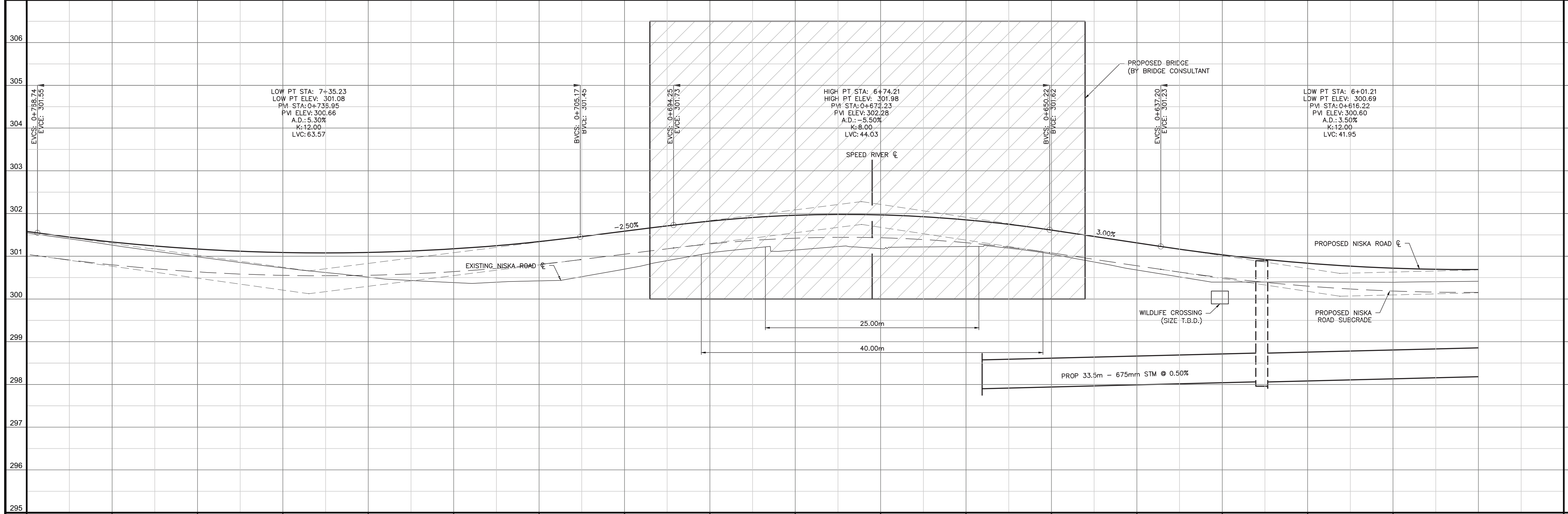

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PROP. GRADE	301.58	301.33	301.17	301.09	301.09	301.18	301.34	301.58	301.82	301.96	301.97	301.85	301.61	301.31	301.03	300.84	300.72
NORTH STORM SEWER																	
SOUTH STORM SEWER												297.90	PROP. 33.50m - 675mm Ø Reinforced Concrete STM SEWER 0.50%		298.07 298.06		
CHAINAGE	0+770	0+760	0+750	0+740	0+730	0+720	0+710	0+700	0+690	0+680	0+670	0+660	0+650	0+640	0+630	0+620	0+610

EXISTING CENTRELINE
PROPOSED GRADE
NORTH STORM SEWER
SOUTH STORM SEWER
CHAINAGE

THE POSITION OF POLES, LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES, AND SHALL ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

No.	DATE	DESCRIPTION	BY:	CH'KD.
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ISSUES/REVISIONS

CITY OF Guelph

ENGINEERING SERVICES

NISKA ROAD
FROM PTARMIGAN DRIVE TO
TO 900m WEST

PLAN & PROFILE
STA. 0+600 TO 0+760

SCALES:
HOR: 1 : 250 VER: 1 : 50

DATE DRAWN:
JULY 2017

DRAWN BY: CF
CHECKED BY:

CONSULTANT DRAWING No.
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CITY CONTRACT No.
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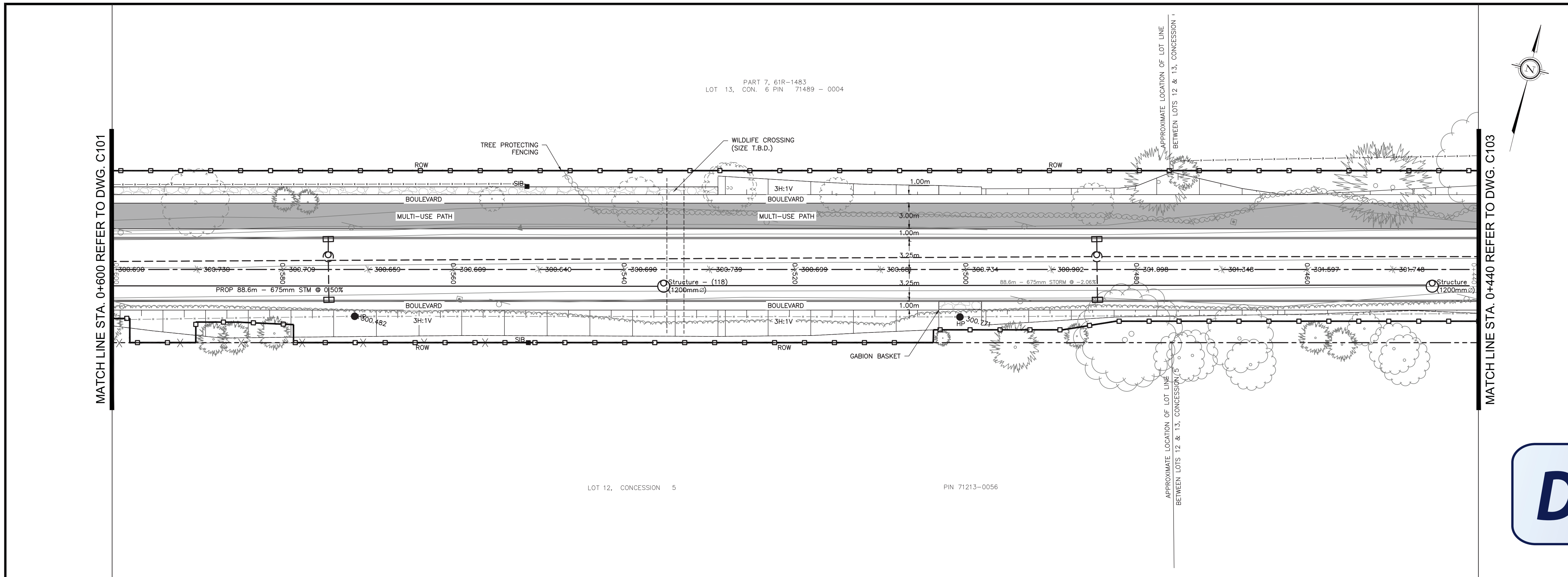

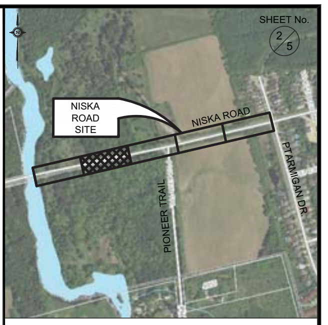

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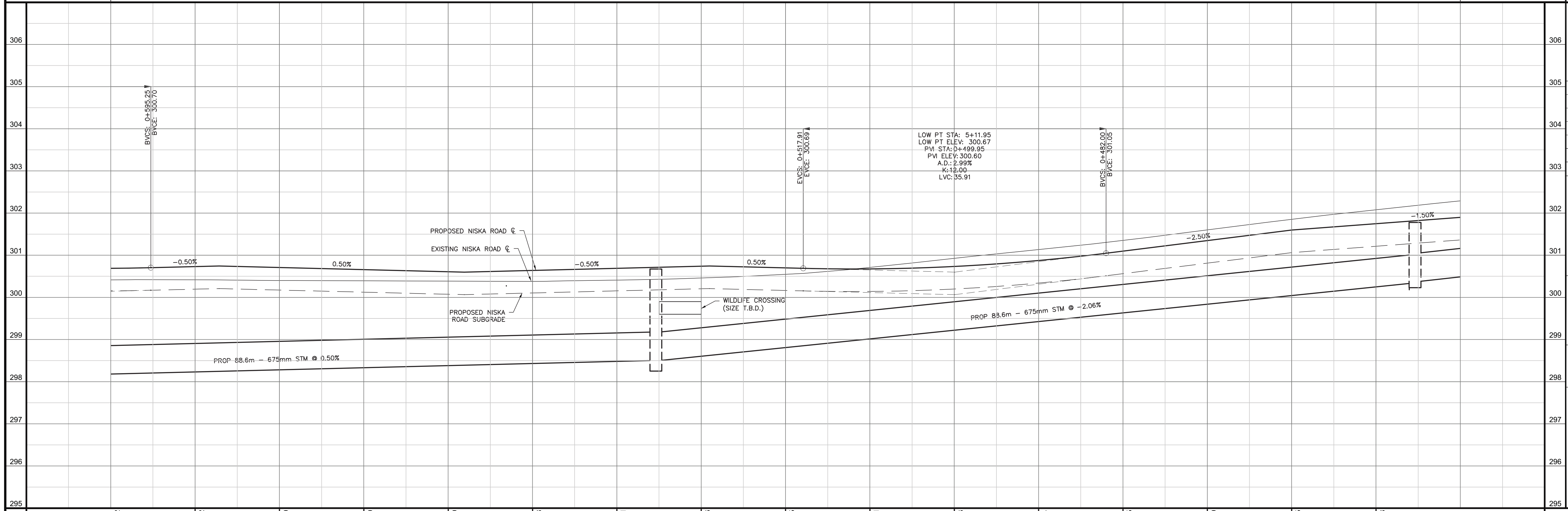

	0+600	0+590	0+580	0+570	0+560	0+550	0+540	0+530	0+520	0+510	0+500	0+490	0+480	0+470	0+460	0+450	
EXISTING CENTRE-LINE	300.42	300.42	300.40	300.39	300.39	300.38	300.41	300.46	300.55	300.71	300.93	301.14	301.35	301.60	301.85	302.08	EXISTING CENTRELINE
PROP. GRADE	300.69	300.73	300.71	300.66	300.61	300.64	300.69	300.74	300.70	300.68	300.73	300.88	301.10	301.35	301.60	301.75	PROPOSED GRADE
NORTH STORM SEWER																	NORTH STORM SEWER
SOUTH STORM SEWER			PROP. 88.65m - 675mm Ø Reinforced Concrete STM SEWER 0.50%				298.50 298.51				PROP. 88.62m - 675mm Ø Reinforced Concrete STM SEWER -2.06%					300.33 300.38	SOUTH STORM SEWER
CHAINAGE	0+600	0+590	0+580	0+570	0+560	0+550	0+540	0+530	0+520	0+510	0+500	0+490	0+480	0+470	0+460	0+450	CHAINAGE

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HOR: 1 : 250 VER: 1 : 50

DATE DRAWN:
JULY 2017

DRAWN BY:
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CONSULTANT DRAWING No.
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CITY CONTRACT No.
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CITY REFERENCE No.
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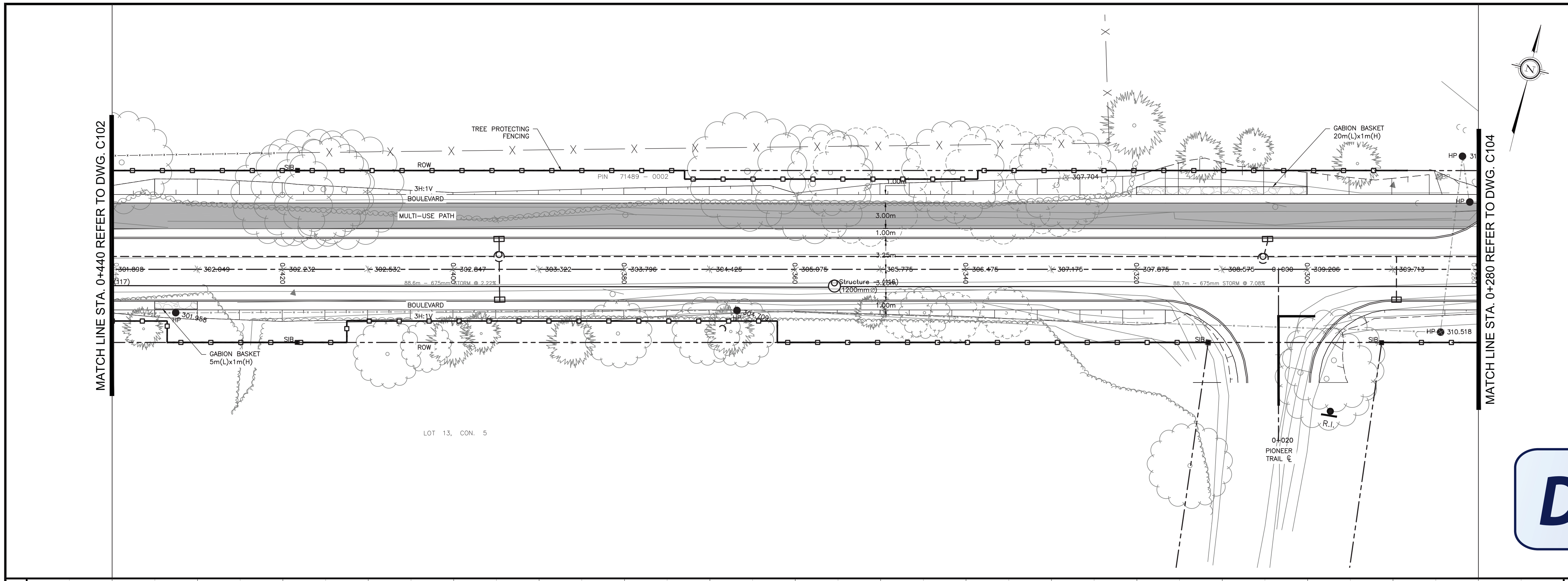

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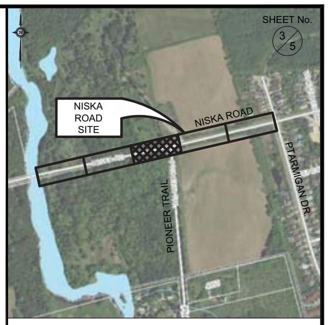

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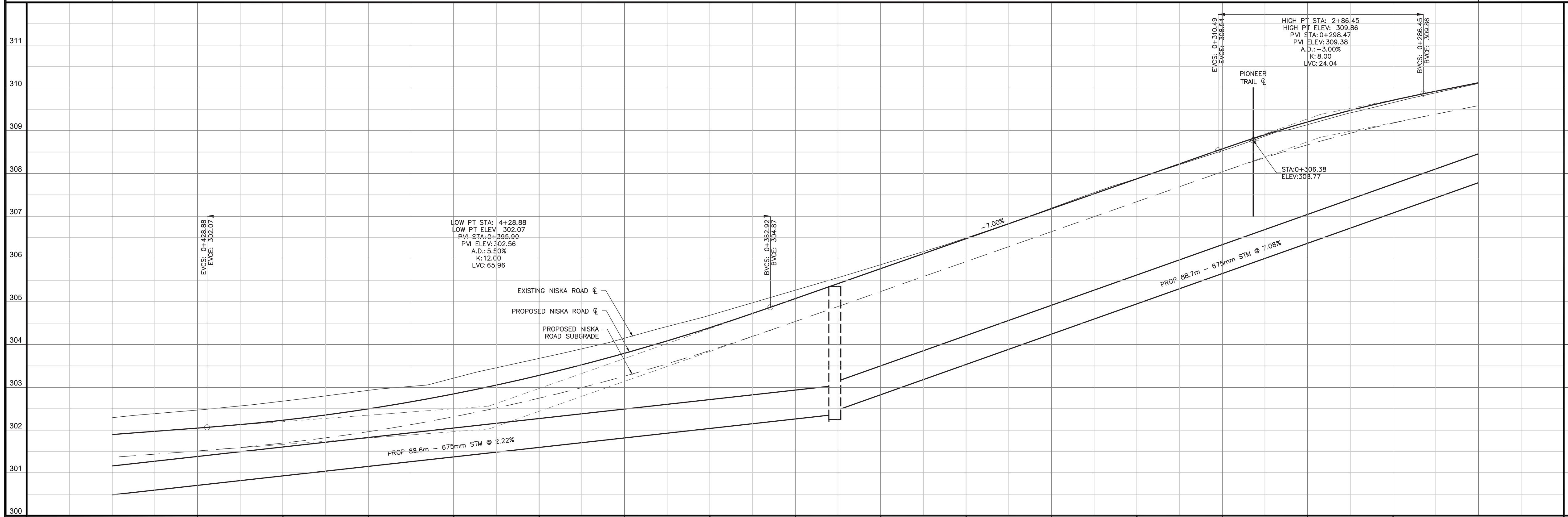


EXISTING CENTRE-LINE	302.29	302.47	302.68	302.93	303.22	303.68	304.15	304.69	305.27		305.87	306.49	307.19	307.88	308.53	309.14	309.66	EXISTING CENTRELINE
PROP. GRADE	301.90	302.05	302.23	302.50	302.85	303.28	303.80	304.40	305.07		305.77	306.47	307.17	307.87	308.57	309.21	309.71	PROPOSED GRADE
NORTH STORM SEWER																		NORTH STORM SEWER
SOUTH STORM SEWER	PROP. 88.62m - 675mm Ø Reinforced Concrete STM SEWER 2.22%									302.35 302.50	PROP. 88.71m - 675mm Ø Reinforced Concrete STM SEWER 7.08%							SOUTH STORM SEWER
CHAINAGE	0+440	0+430	0+420	0+410	0+400	0+390	0+380	0+370	0+360		0+350	0+340	0+330	0+320	0+310	0+300	0+290	CHAINAGE

THE POSITION OF POLES, LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES, AND SHALL ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

No.	DATE	DESCRIPTION	BY:	CH'KD.
0				

ISSUES/REVISIONS

CITY OF Guelph

ENGINEERING SERVICES

NISKA ROAD
FROM PTARMIGAN DRIVE TO
TO 900m WEST

PLAN & PROFILE
STA. 0+280 TO 0+440

SCALES:
HOR: 1 : 250 VER: 1 : 50

DATE DRAWN:
JULY 2017

DRAWN BY:
CF

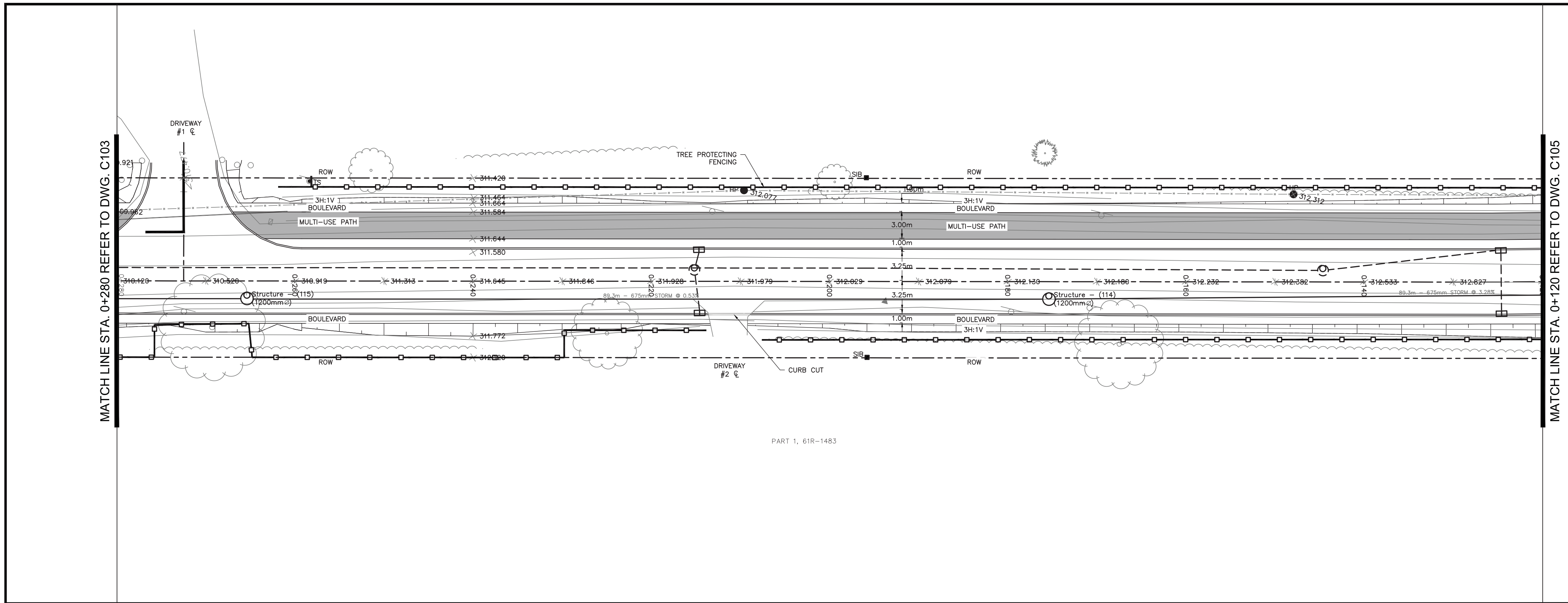
CHECKED BY:

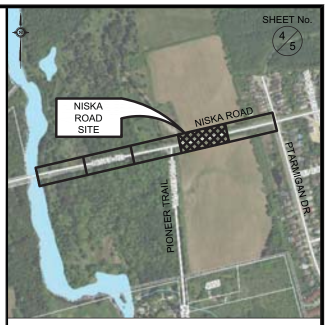
CONSULTANT DRAWING No.
C103

CITY CONTRACT No.
-

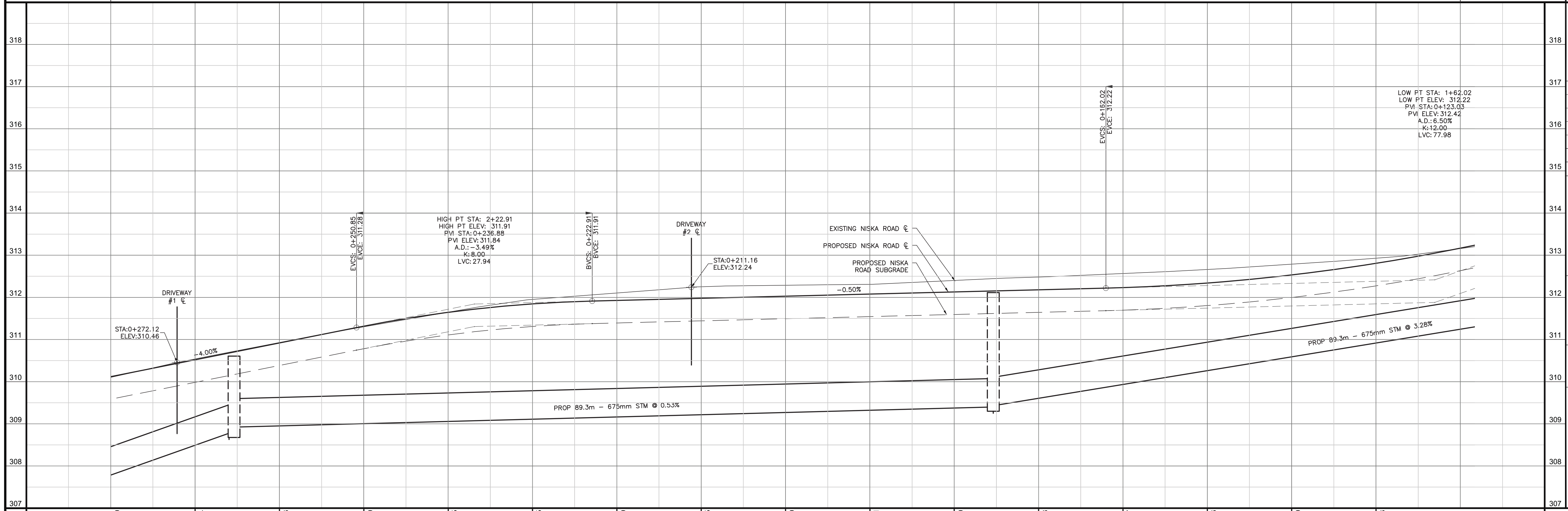
CITY REFERENCE No.
-

REV.
0





KEY PLAN Scale : NOT TO SCALE



EXISTING CENTRE-LINE	310.10	310.54	310.93	311.30	311.65	311.95	312.10	312.25	312.29	312.31	312.40	312.48	312.57	312.66	312.79	312.93	EXISTING CENTRELINE
PROP. GRADE	310.12	310.52	310.92	311.32	311.64	311.85	311.93	311.98	312.03	312.08	312.13	312.18	312.23	312.34	312.53	312.81	PROPOSED GRADE
NORTH STORM SEWER																	NORTH STORM SEWER
SOUTH STORM SEWER		308.78 308.93					PROP. 89.31m - 675mm Ø Reinforced Concrete STM SEWER 0.53%				309.40 309.43				PROP. 89.30m - 675mm Ø Reinforced Concrete STM SEWER 3.28%		SOUTH STORM SEWER
CHAINAGE	0+280	0+270	0+260	0+250	0+240	0+230	0+220	0+210	0+200	0+190	0+180	0+170	0+160	0+150	0+140	0+130	CHAINAGE

THE POSITION OF POLES, LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES, AND SHALL ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

No.	DATE	DESCRIPTION	BY:	CH'KD.
0				

ISSUES/REVISIONS

CITY OF Guelph

ENGINEERING SERVICES

NISKA ROAD
FROM PTARMIGAN DRIVE TO
TO 900m WEST

PLAN & PROFILE
STA. 0+120 TO 0+280

SCALES:
HOR: 1 : 250 VER: 1 : 50

DATE DRAWN:
JULY 2017

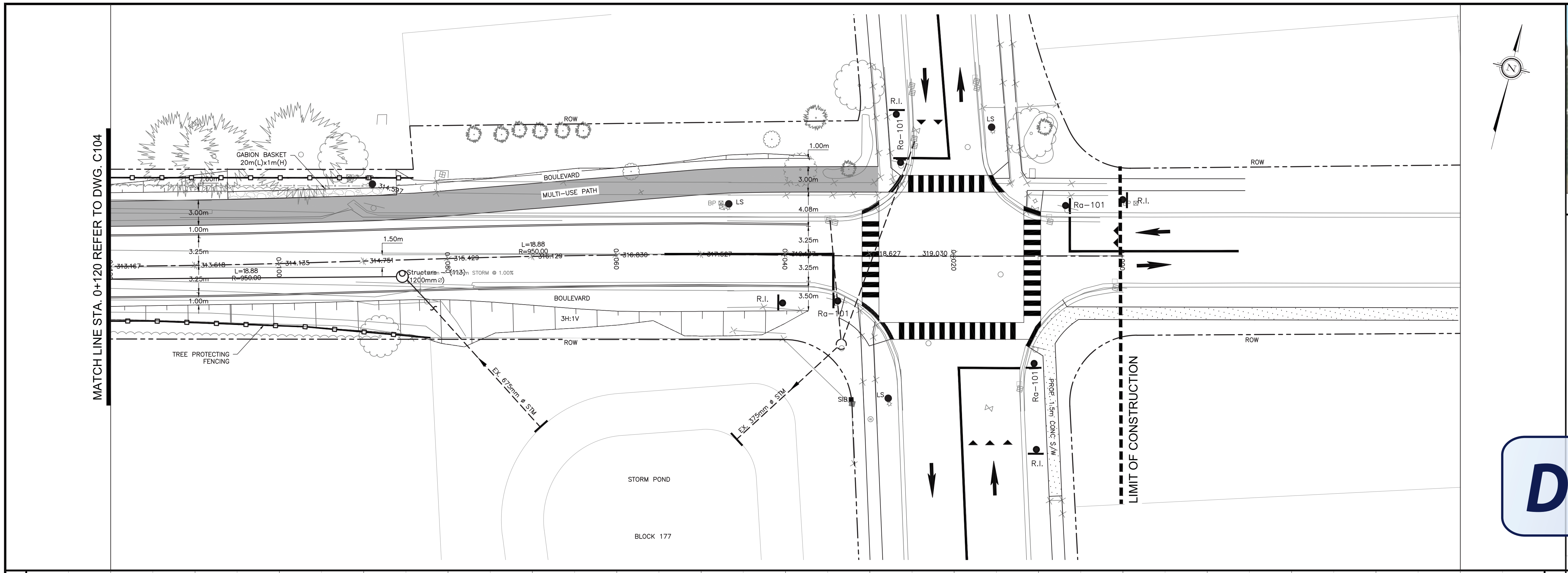
DRAWN BY: CF
CHECKED BY:

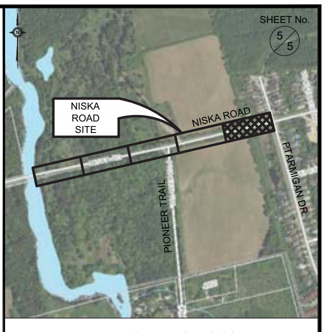
CONSULTANT DRAWING No.
C104

CITY CONTRACT No.
-

CITY REFERENCE No.
-

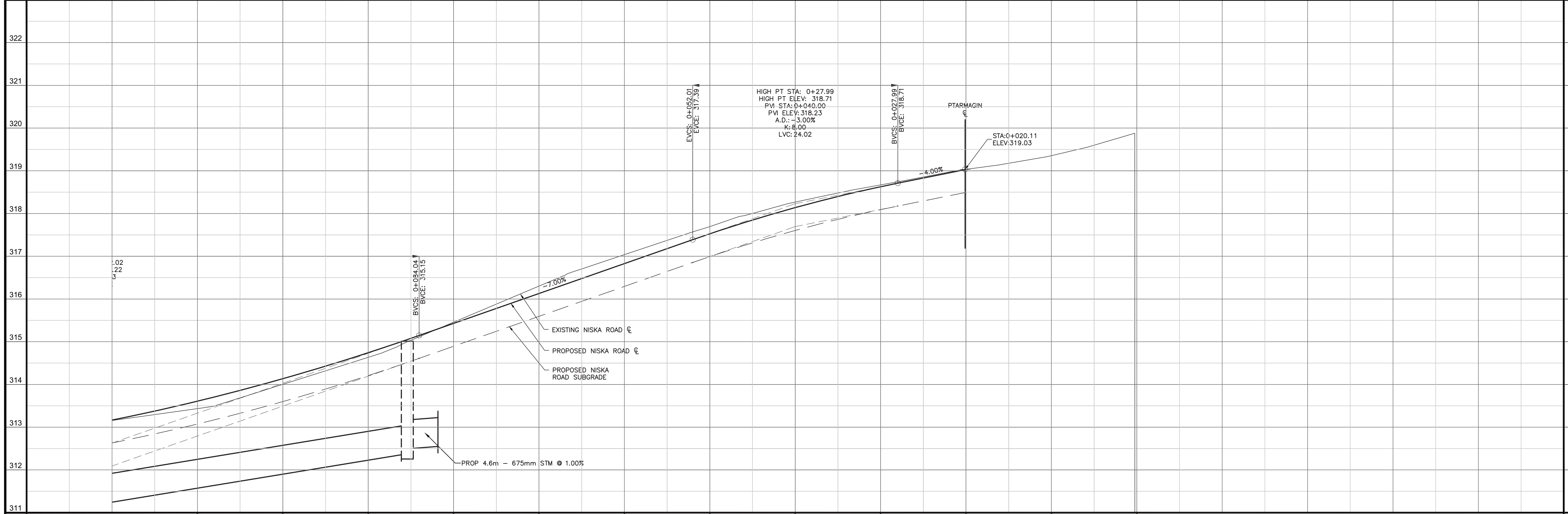
REV.
0





KEY PLAN Scale : NOT TO SCALE

DRAFT



EXISTING CENTRE-LINE	313.16	313.44	314.00	314.64	315.46	316.30	317.04	317.69	318.27	318.67	319.04	319.35	0.00
PROP. GRADE	313.17	313.61	314.13	314.74	315.43	316.13	316.83	317.53	318.14	318.63	319.03		
NORTH STORM SEWER													
SOUTH STORM SEWER				312.36	PROP. 4.61m - 675mm Ø Reinforced Concrete STM SEWER 1.00% 312.55 312.50								
CHAINAGE	0+120	0+110	0+100	0+090	0+080	0+070	0+060	0+050	0+040	0+030	0+020	0+010	0+000

THE POSITION OF POLES, LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES, AND SHALL ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

No.	DATE	DESCRIPTION	BY:	CH'KD.
0				

ISSUES/REVISIONS

CITY OF Guelph

ENGINEERING SERVICES

NISKA ROAD
FROM PTARMIGAN DRIVE TO
TO 900m WEST

PLAN & PROFILE
STA. 0+000 TO 0+120

EXISTING CENTRELINE
PROPOSED GRADE
NORTH STORM SEWER
SOUTH STORM SEWER
CHAINAGE

SCALES:
HOR: 1 : 250 VER: 1 : 50

DATE DRAWN:
JULY 2017

DRAWN BY:
CF

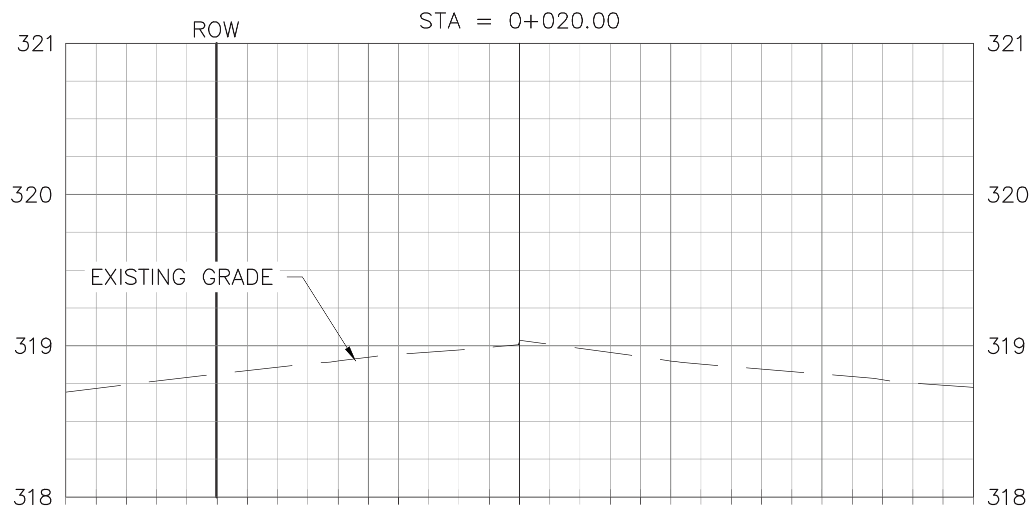
CHECKED BY:

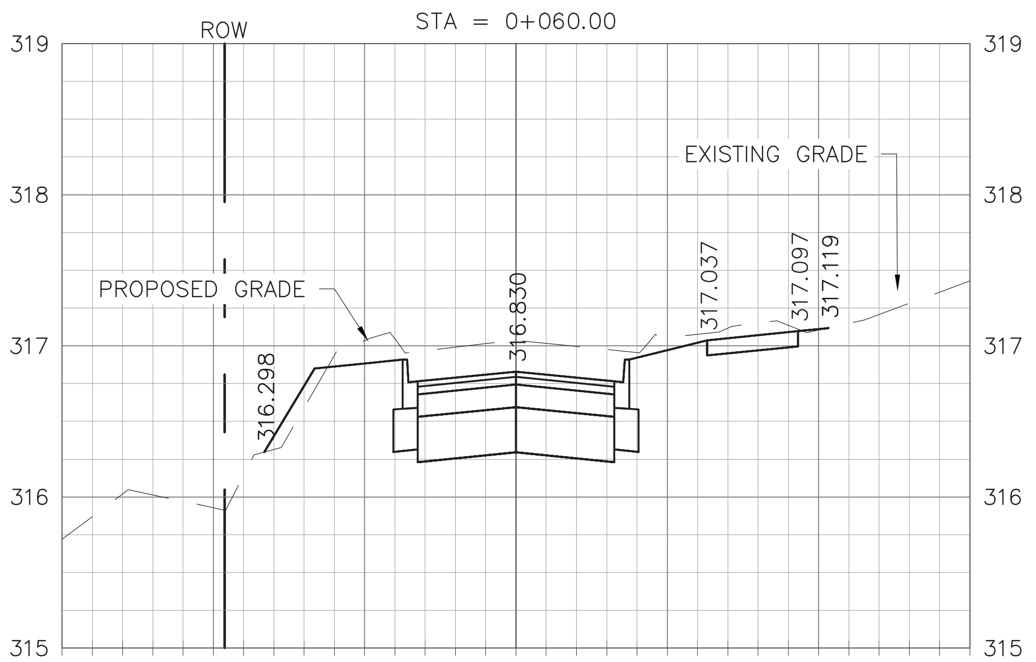
CONSULTANT DRAWING No.
C105

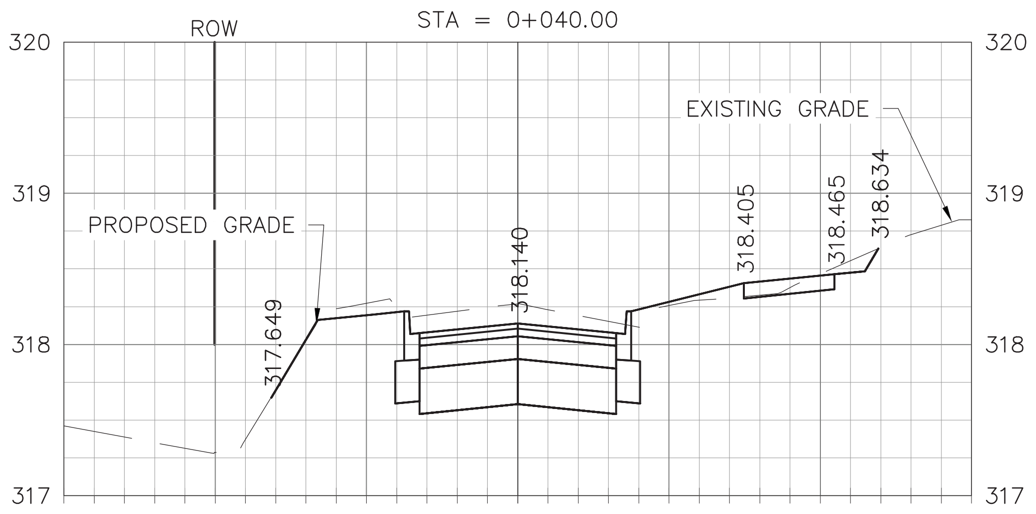
CITY CONTRACT No.
-

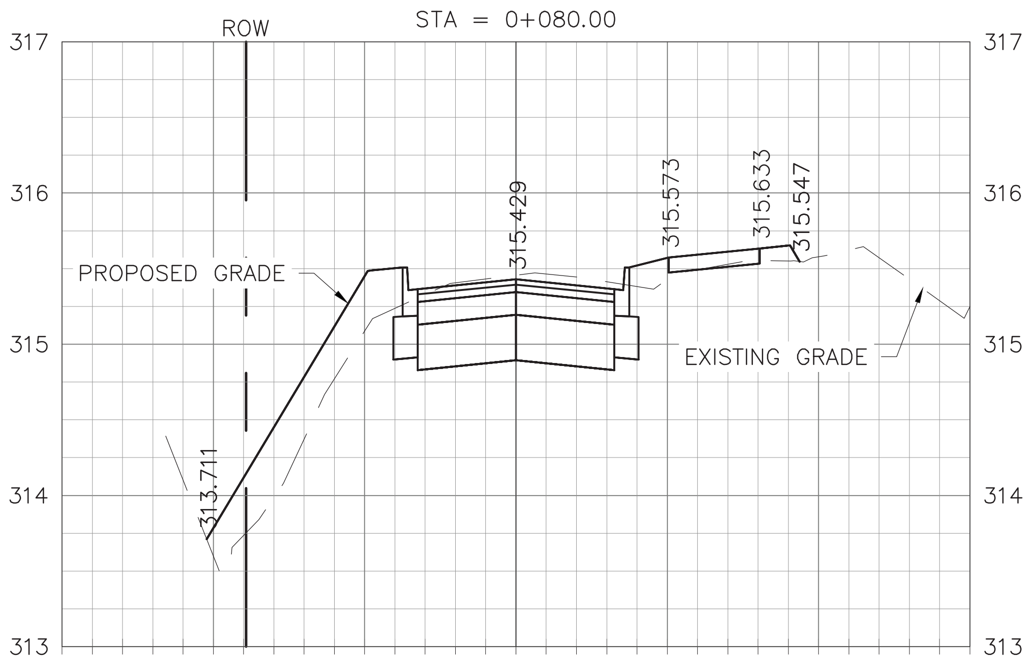
CITY REFERENCE No.
-

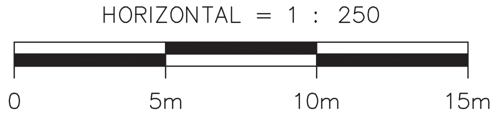
REV.
0

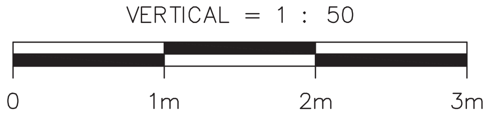












Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

NISKA ROAD

SAMPLE LINE CROSS-SECTIONS 0+020 TO 0+080

Drawn	Checked	Date		Figure No.
C.F.	A.V.	JULY 2017		**F-01**
Scale		Project No.		
HOR: 1:250 VER: 1:50		-		

File: T:\Pete\City of Guelph\173704 Niska Road Design\NISKA - Plan & Profiles (2016).dwg Date Plotted: November 2, 2017 - 11:03 AM

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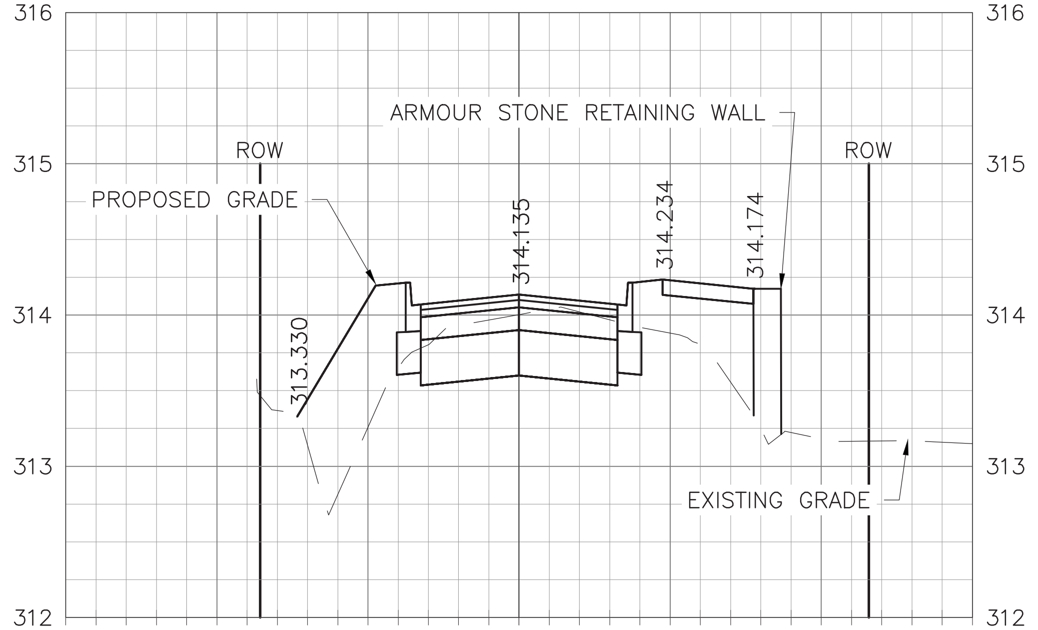

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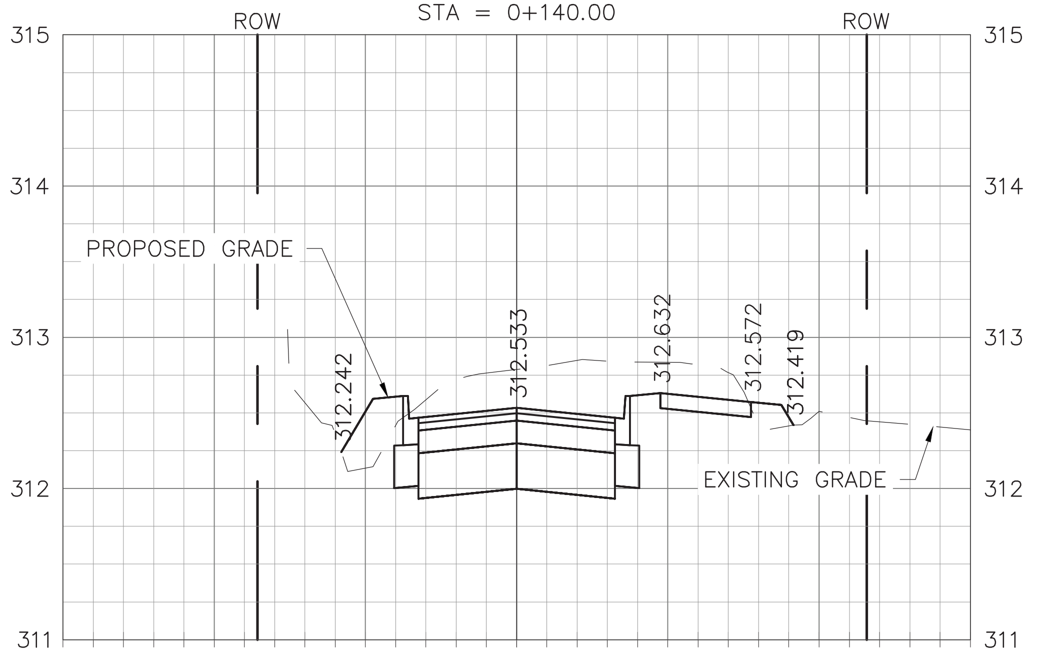

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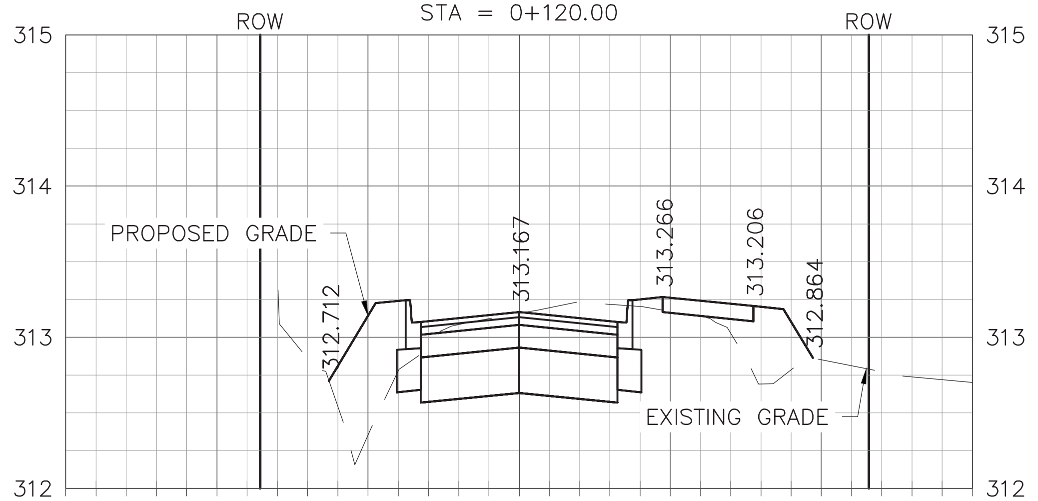

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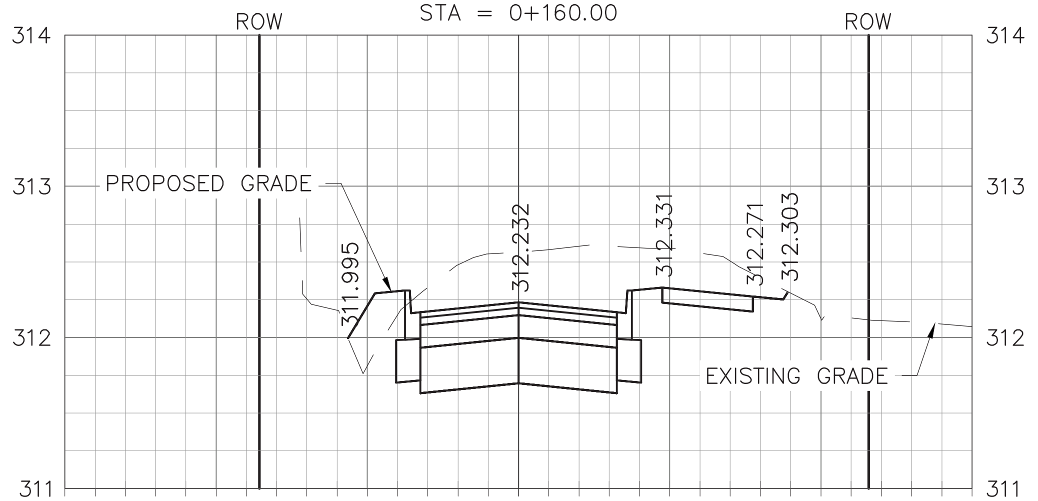

HORIZONTAL = 1 : 250

VERTICAL = 1 : 50

Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

NISKA ROAD

SAMPLE LINE CROSS-SECTIONS 0+100 TO 0+160

Drawn	Checked	Date	Figure No.
C.F.	A.V.	JULY 2017	F-02
Scale		Project No.	
HOR: 1:250 VER: 1:50		-	

File: T:\Pete\City of Guelph\173704 Niska Road Design\NISKA - Plan & Profiles (2016).dwg Date Plotted: November 2, 2017 - 11:03 AM

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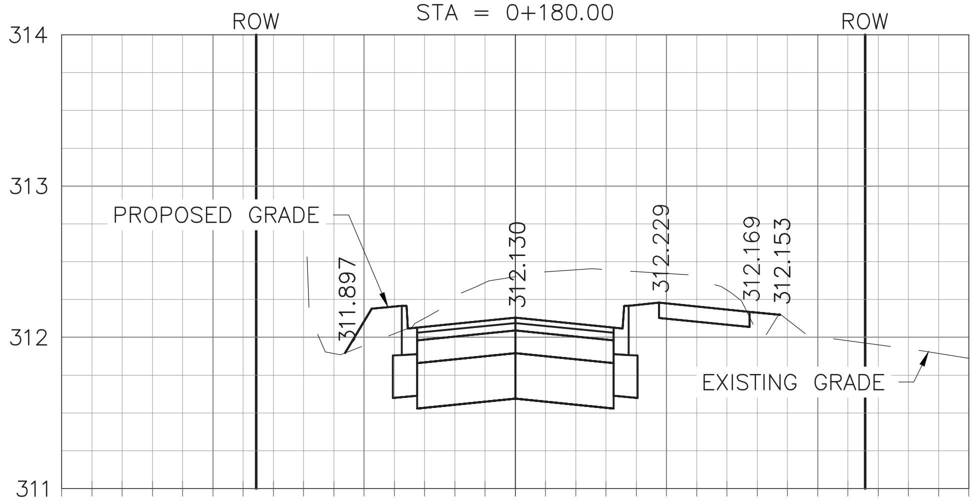

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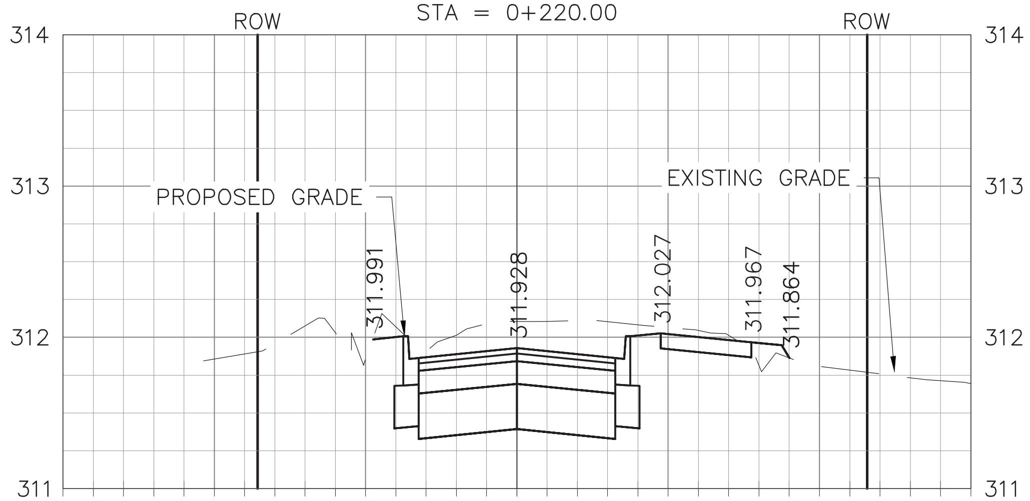

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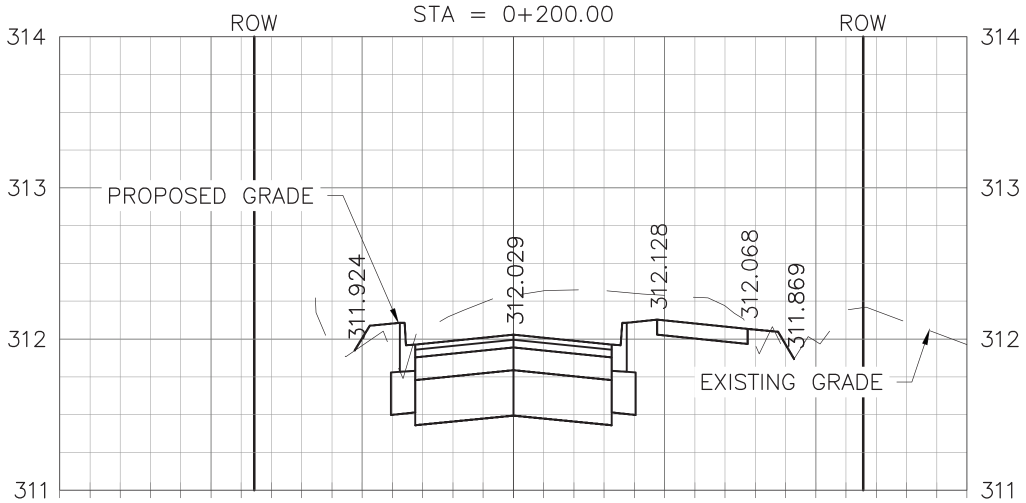

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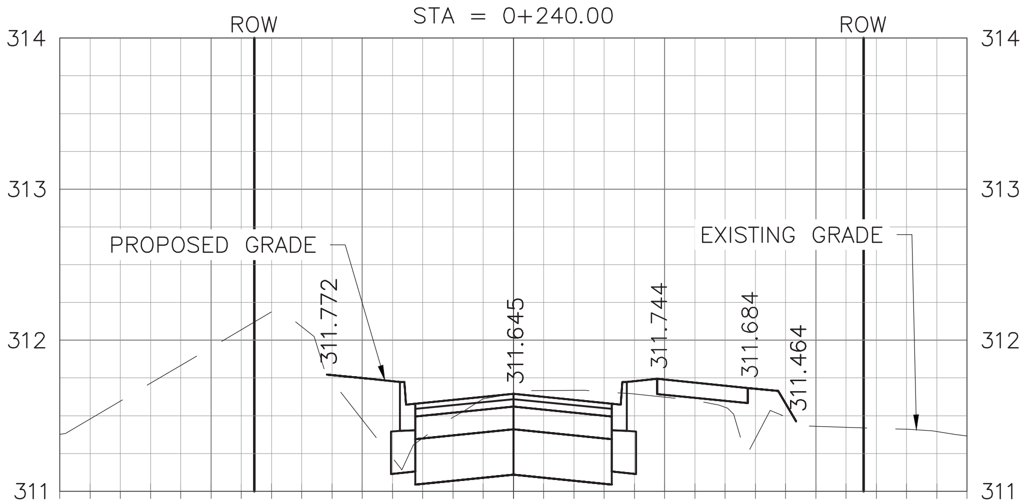

HORIZONTAL = 1 : 250

0 5m 10m 15m

VERTICAL = 1 : 50

0 1m 2m 3m

DRAFT

Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

NISKA ROAD

SAMPLE LINE CROSS-SECTIONS 0+180 TO 0+240

Drawn	Checked	Date	Figure No.
C.F.	A.V.	JULY 2017	**F-03**
Scale		Project No.	
HOR: 1:250 VER: 1:50		-	

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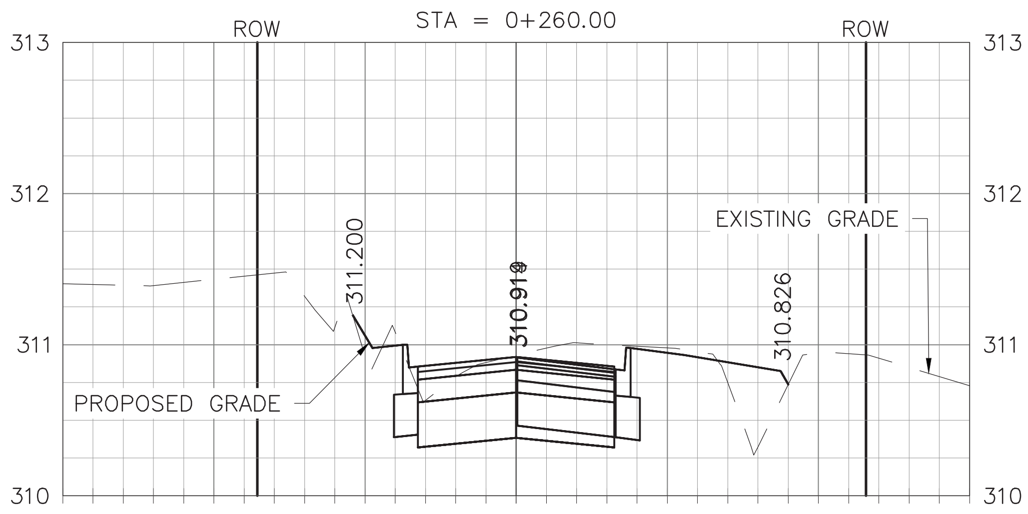

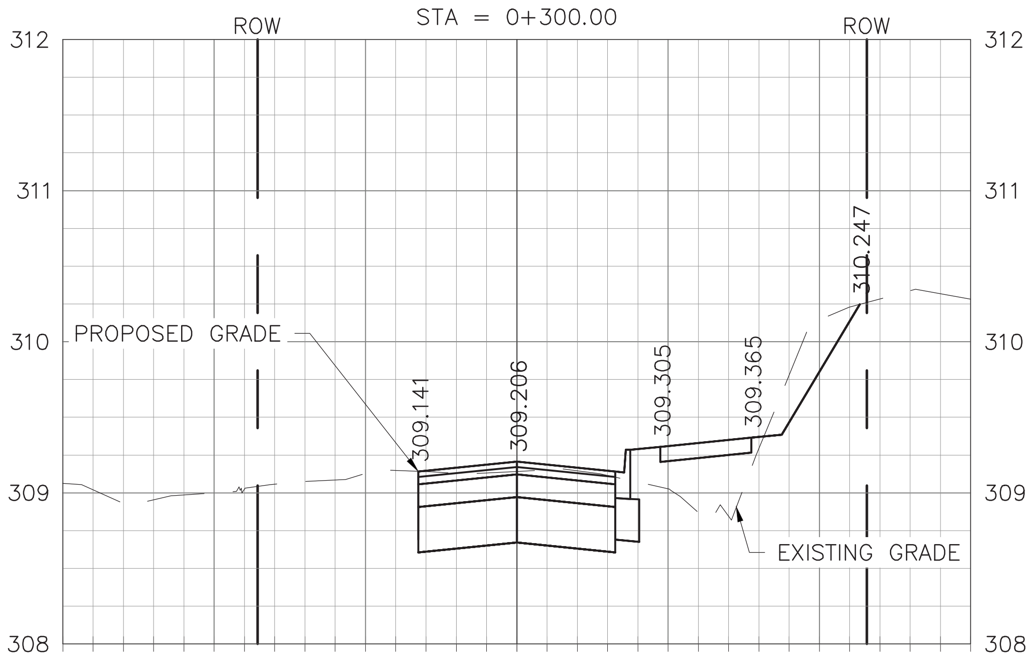

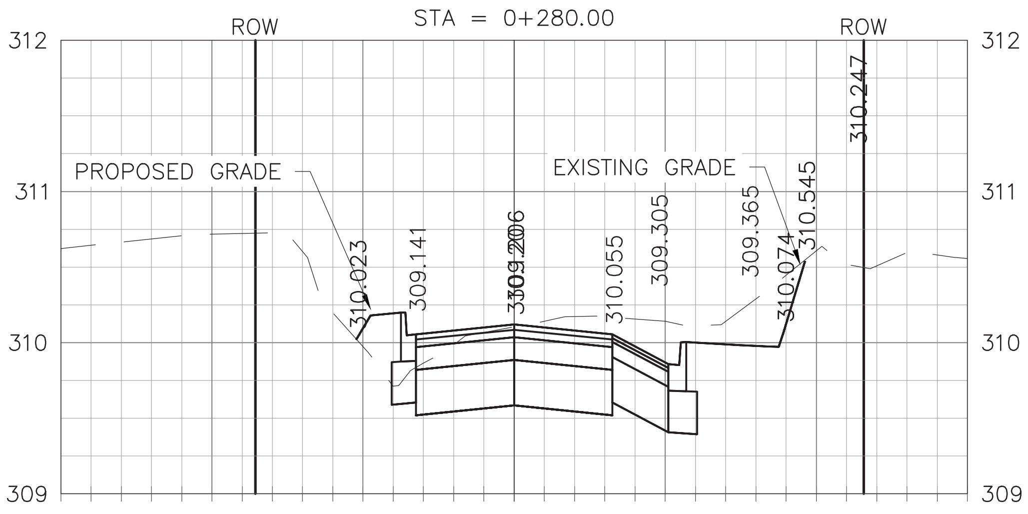

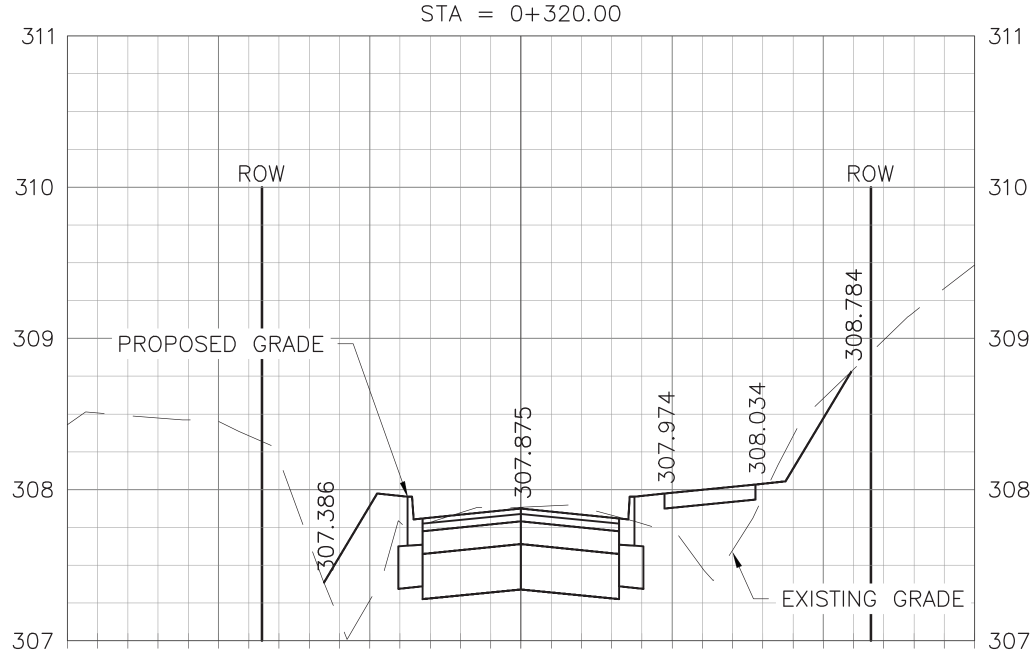

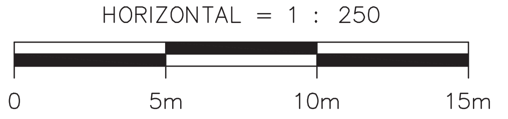

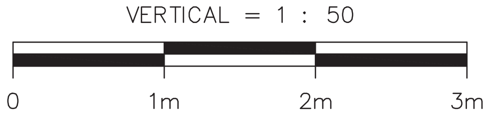

DRAFT

Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

NISKA ROAD

SAMPLE LINE CROSS-SECTIONS 0+260 TO 0+320

Drawn	Checked	Date	Figure No.
C.F.	A.V.	JULY 2017	**F-04**
Scale		Project No.	
HOR: 1:250 VER: 1:50		-	

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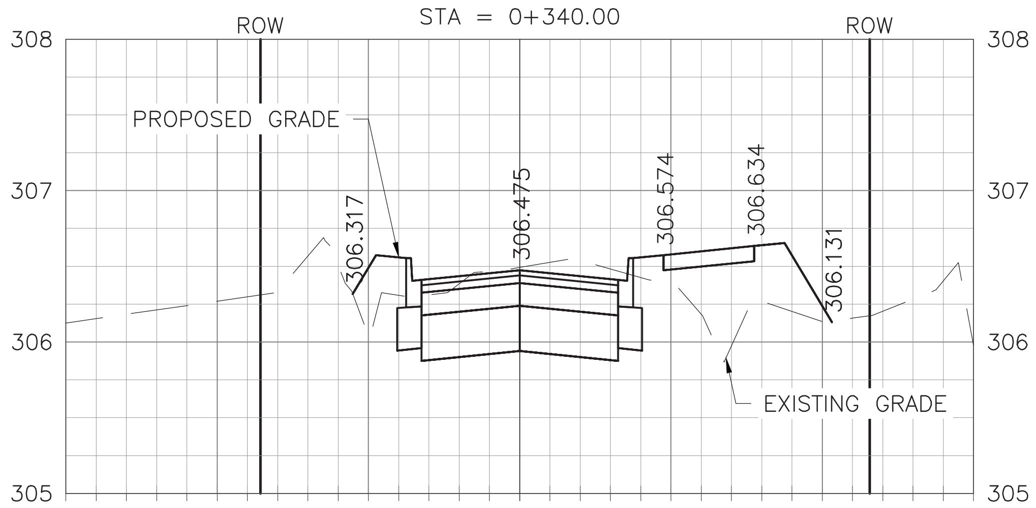

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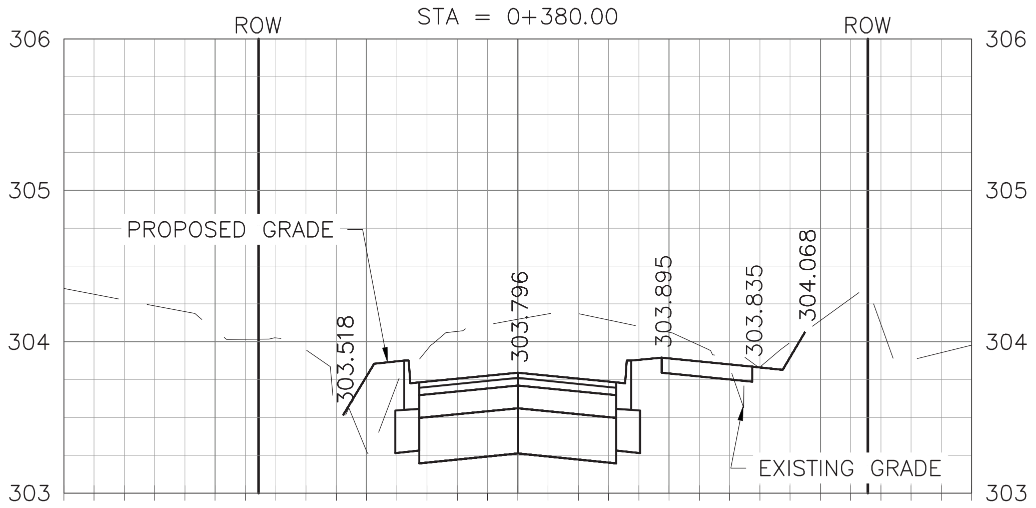

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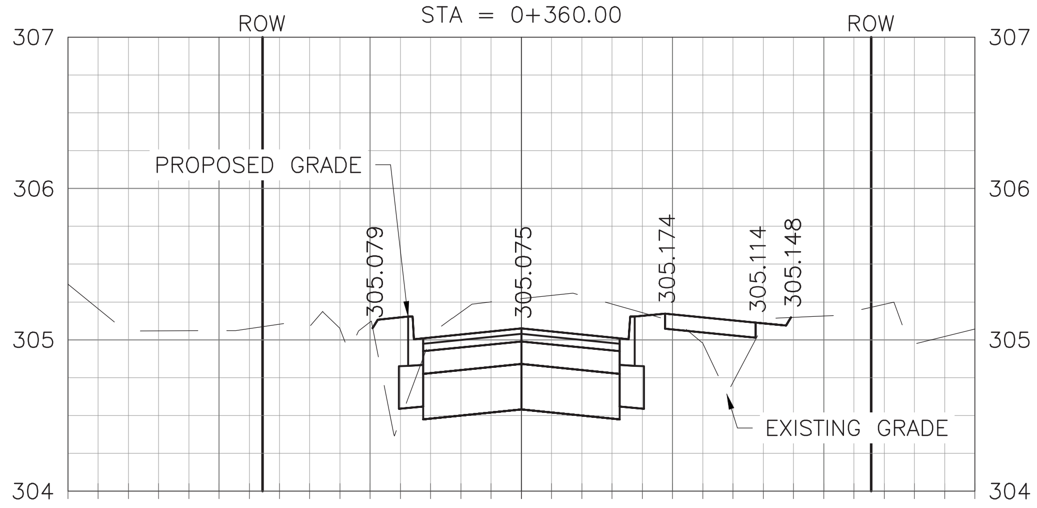

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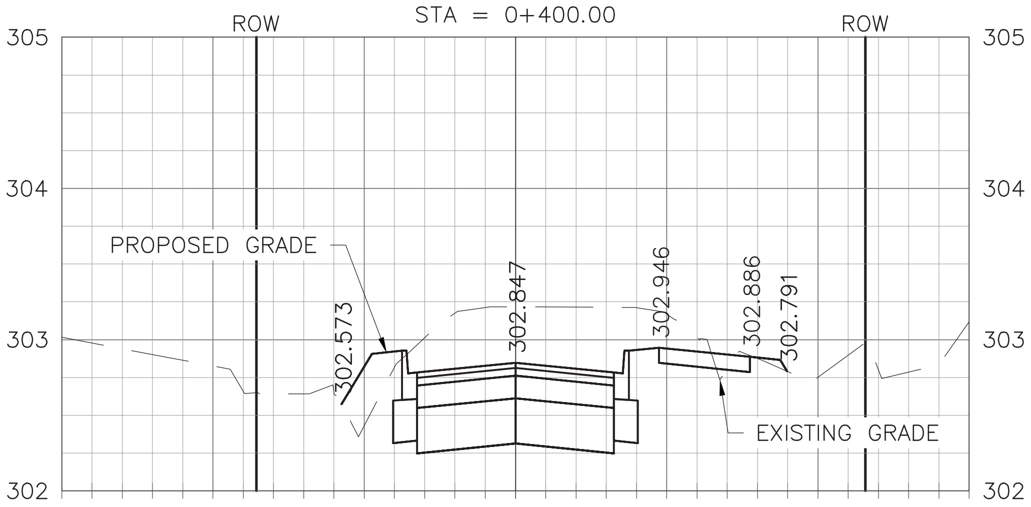


HORIZONTAL = 1 : 250

0 5m 10m 15m

VERTICAL = 1 : 50

0 1m 2m 3m

Client

CITY OF Guelph

ENGINEERING SERVICES

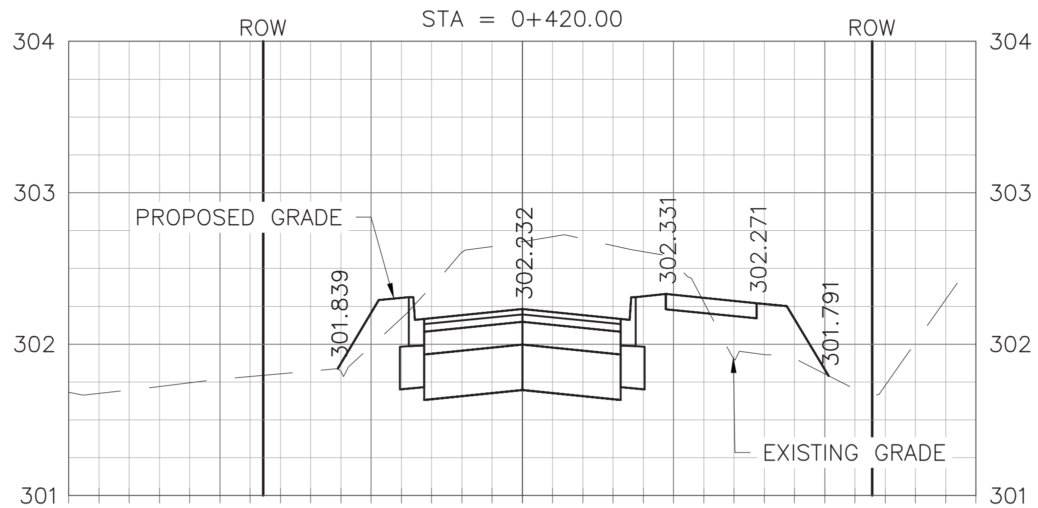
Figure Title

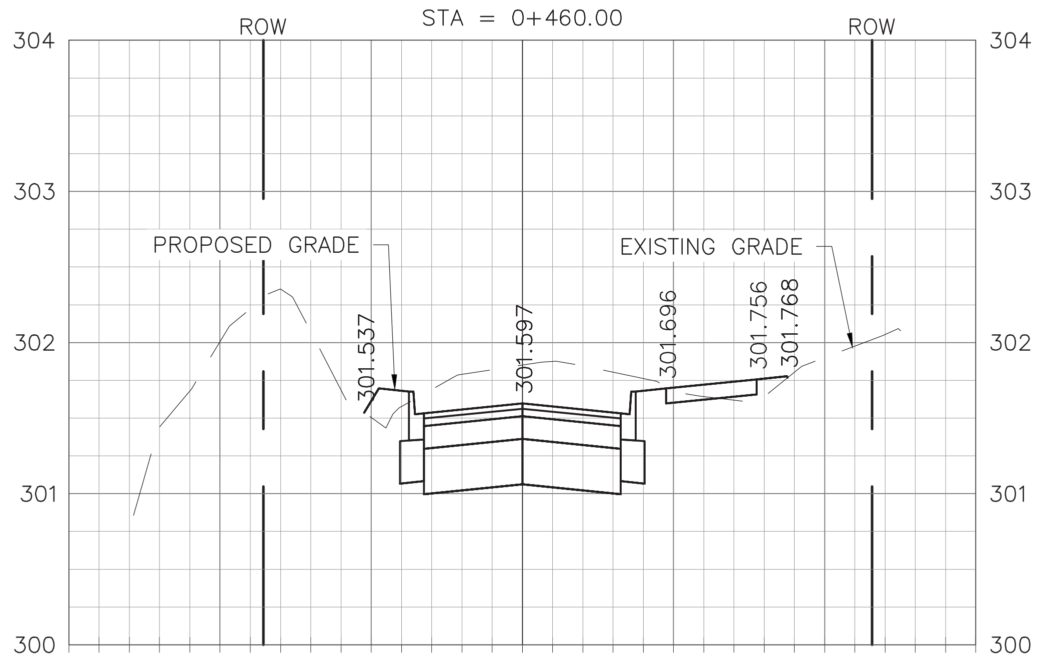
NISKA ROAD

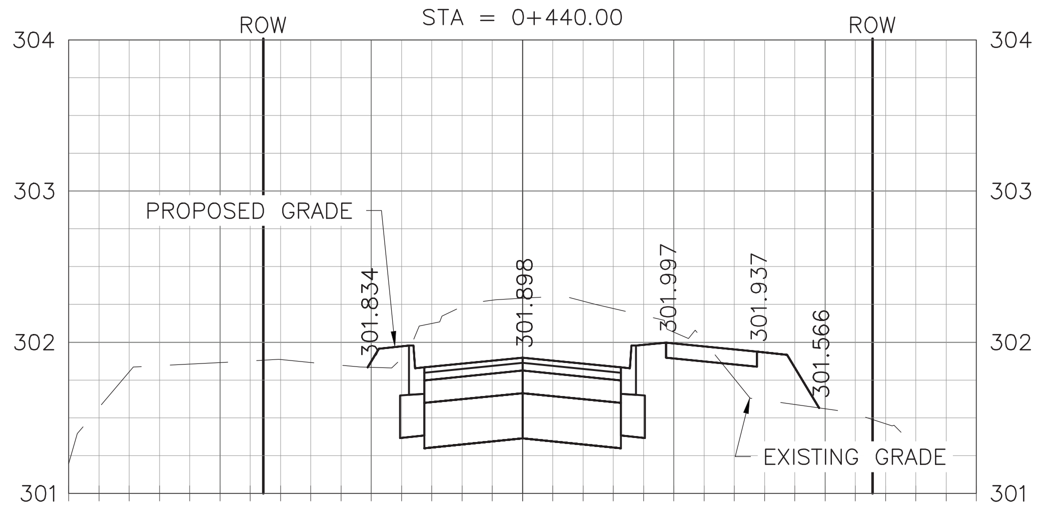
SAMPLE LINE CROSS-SECTIONS 0+340 TO 0+400

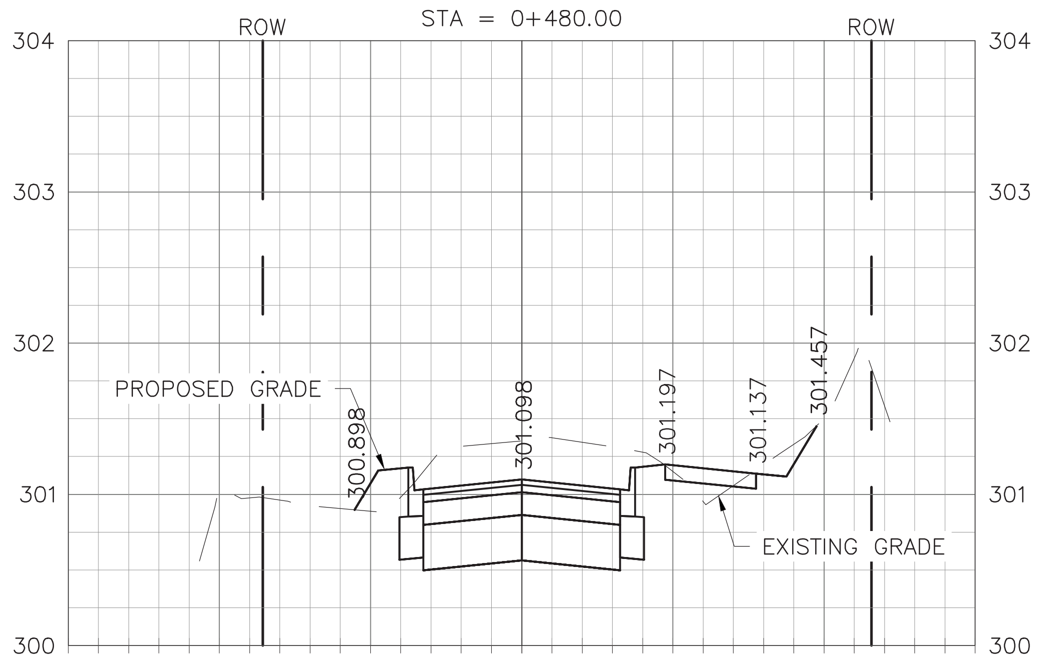
Drawn	Checked	Date	Figure No.
C.F.	A.V.	JULY 2017	F-05
Scale		Project No.	
HOR: 1:250 VER: 1:50		-	

File: T:\Pete\City of Guelph\173704 Niska Road Design\NISKA - Plan & Profiles (2016).dwg Date Plotted: November 2, 2017 - 11:05 AM









HORIZONTAL = 1 : 250

VERTICAL = 1 : 50

Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

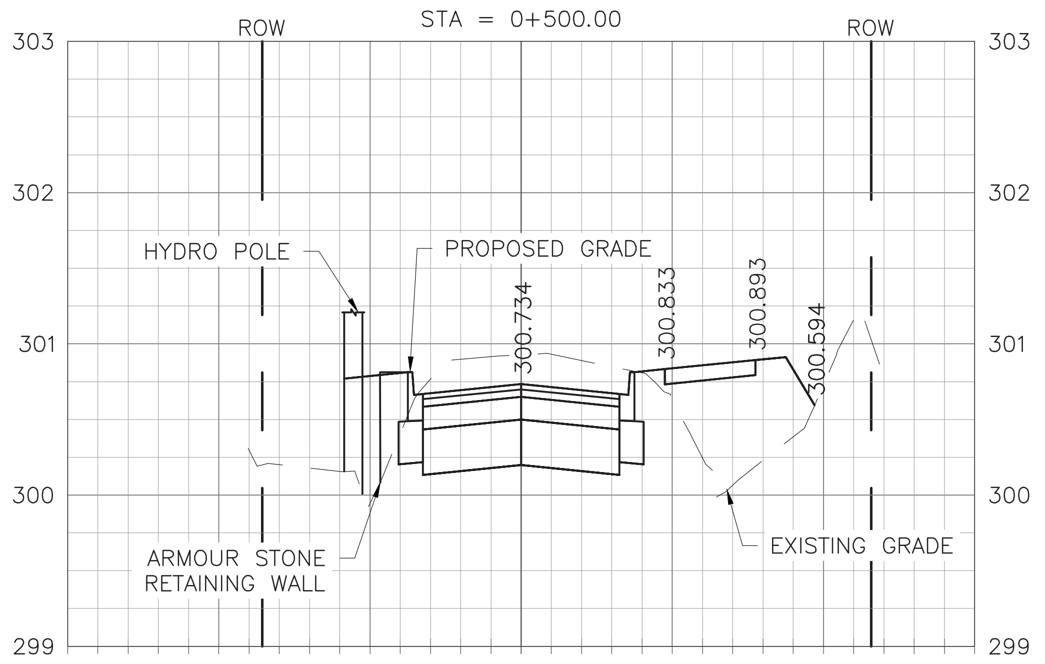
NISKA ROAD

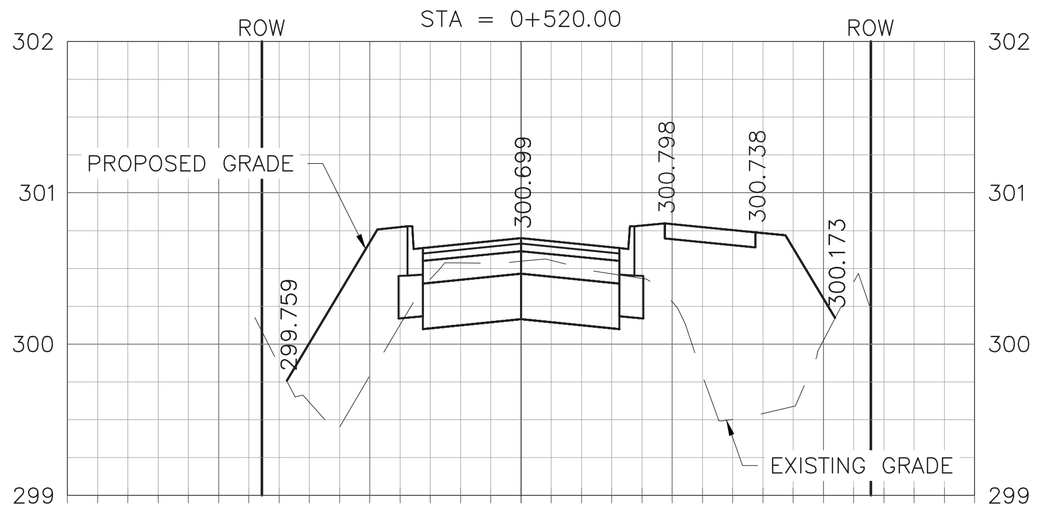
SAMPLE LINE CROSS-SECTIONS 0+420 TO 0+480

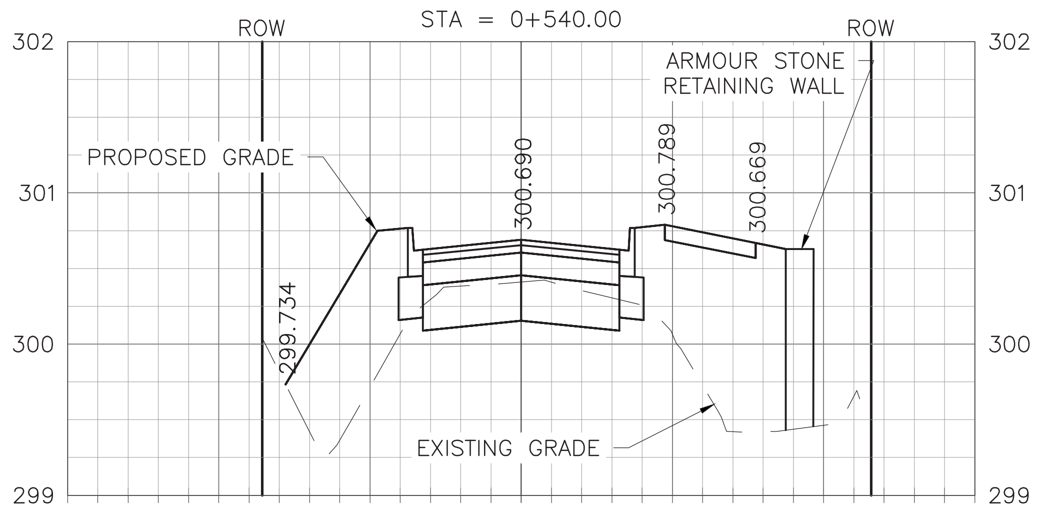
Drawn	Checked	Date	Figure No.
C.F.	A.V.	JULY 2017	F-06

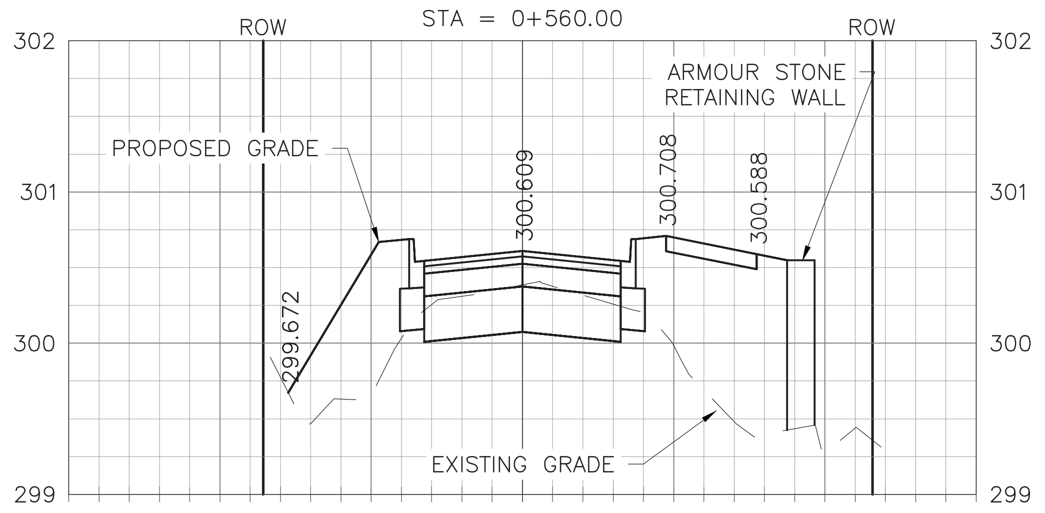
Scale	Project No.
HOR: 1:250 VER: 1:50	-

File: T:\Pete\City of Guelph\173704 Niska Road Design\NISKA - Plan & Profiles (2016).dwg Date Plotted: November 2, 2017 - 11:05 AM









HORIZONTAL = 1 : 250

VERTICAL = 1 : 50

DRAFT

Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

NISKA ROAD

SAMPLE LINE CROSS-SECTIONS 0+500 TO 0+560

Drawn
C.F.

Checked
A.V.

Date
JULY 2017

Figure No.
F-07

Scale
HOR: 1:250 VER: 1:50

Project No.
-

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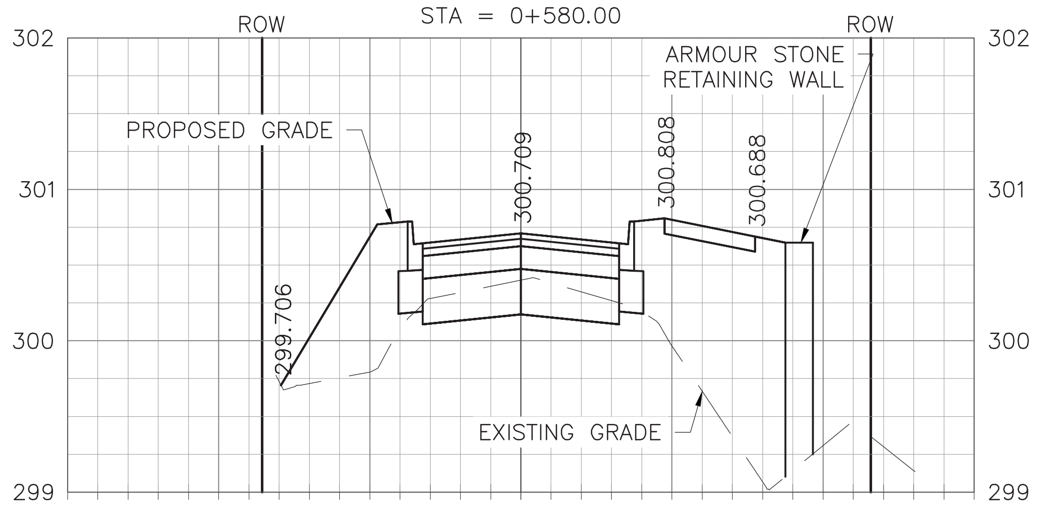
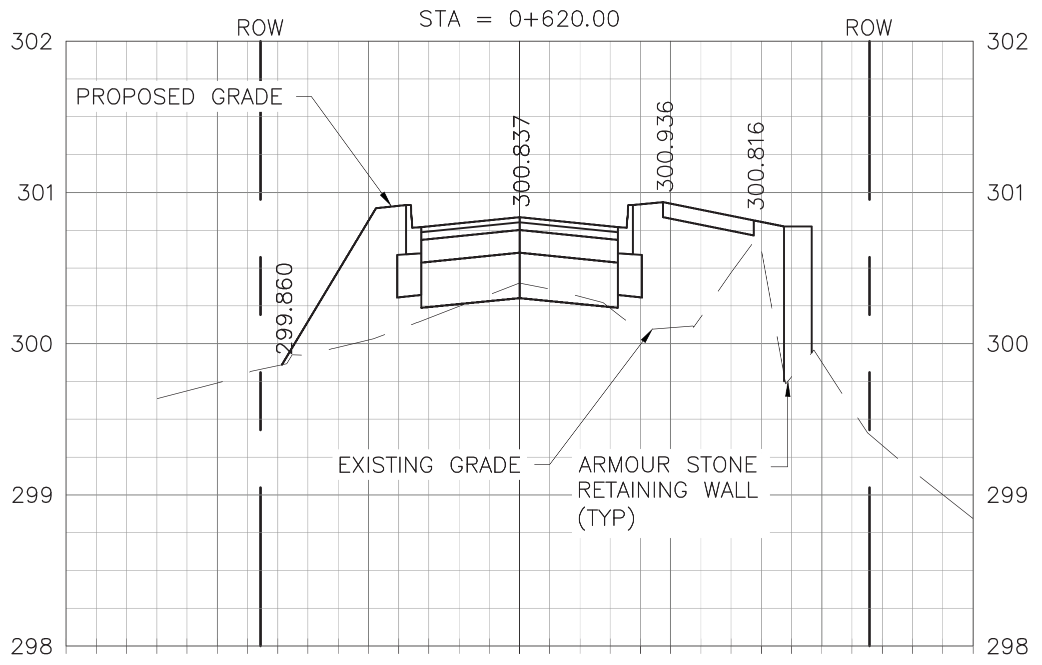
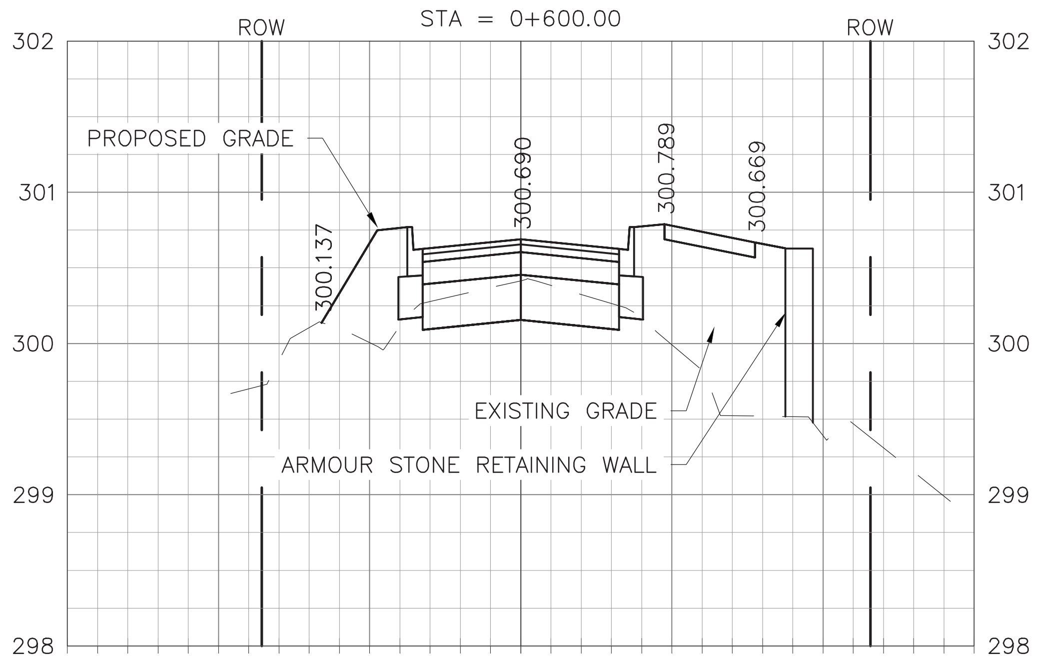
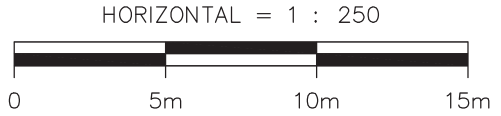
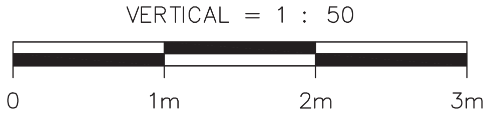










DRAFT

Client

CITY OF Guelph

ENGINEERING SERVICES

Figure Title

NISKA ROAD

SAMPLE LINE CROSS-SECTIONS 0+580 TO 0+620

Drawn	Checked	Date	Figure No.
C.F.	A.V.	JULY 2017	**F-08**
Scale		Project No.	
HOR: 1:250 VER: 1:50		-	

File: T:\Pete\City of Guelph\173704 Niska Road Design\NISKA - Plan & Profiles (2016).dwg Date Plotted: November 2, 2017 - 11:06 AM

DELEGATE ATTACHMENTS - Laura Murr

Nov. 11, 2017

Dear Members of the River Systems Advisory Committee:

After the Dec. 3. 2015 Niska EA Special Council Meeting, the Heritage Speed River Working Group commissioned the well-respected engineering firm, B.M. Ross, to assess the heritage Niska Road Bailey Bridge as part of our peer review of the Niska Road EA Process. The resulting report was submitted to the City of Guelph and to the MOECC as part of our Part II Order request to the Minister.

If you review the attached report it addresses the uniqueness and stability of the historic abutments and the bridge. We are surprised that this report was not referenced in the HIA you will be reviewing as part of your agenda on November 15 since it supplied new information re the abutments not contained in any previous reports. The 1994 Gamsby and Mannerow bridge assessment indicated that the abutments were stable. BM Ross assessment of the stability of the abutments was similar with a recommendation for repair of the mortar.

Our consultant B.M. Ross and Associates is experienced in the assessment of heritage bridges and their abutments. They conducted the EA for the 117-year-old single lane Green Bridge in downtown St Marys ON.

http://stmarysindy.com/2016/12/02/restored-green-bridge-ribbon-cutting-held-nov-27/

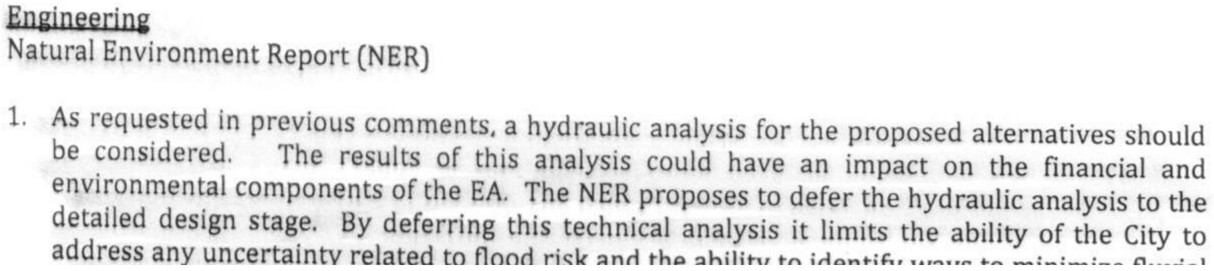
https://www.ourperth.ca/news-story/6548060-mclean-taylor-secures-contract-for-green-bridge-rehabilitation/

During the Green Bridge EA process a decision was made to withdraw the initial Class EA and not replace the bridge. This saved the municipality a great deal of money and preserved a heritage structure valued by the community.

BM Ross concluded in their Bailey bridge Report on pg. 8 that there was “no urgent needs for the bridge now”, that bridge was safe for pedestrians and cyclists with a further 30 years of service if repairs estimated at $258,000 plus HST were done. Unlike the Green Bridge parts to repair the bridge are readily available. Therefore, we were surprised when the city closed the bridge to pedestrians and cyclists within a year of receiving this report.

We are now receiving new hydrogeologic, natural heritage, tree, and other information that has been collected since the EA was circulated for the 30-day public comment period. Unlike the EA for the proposed downtown bridge at the Metalworks, the city chose to conduct these studies after the EA was deemed complete by Burnside and the City. The information being presented to you at your meeting should have been collected and become part of the EA and used in the determination of the preferred solution. It was not why not?

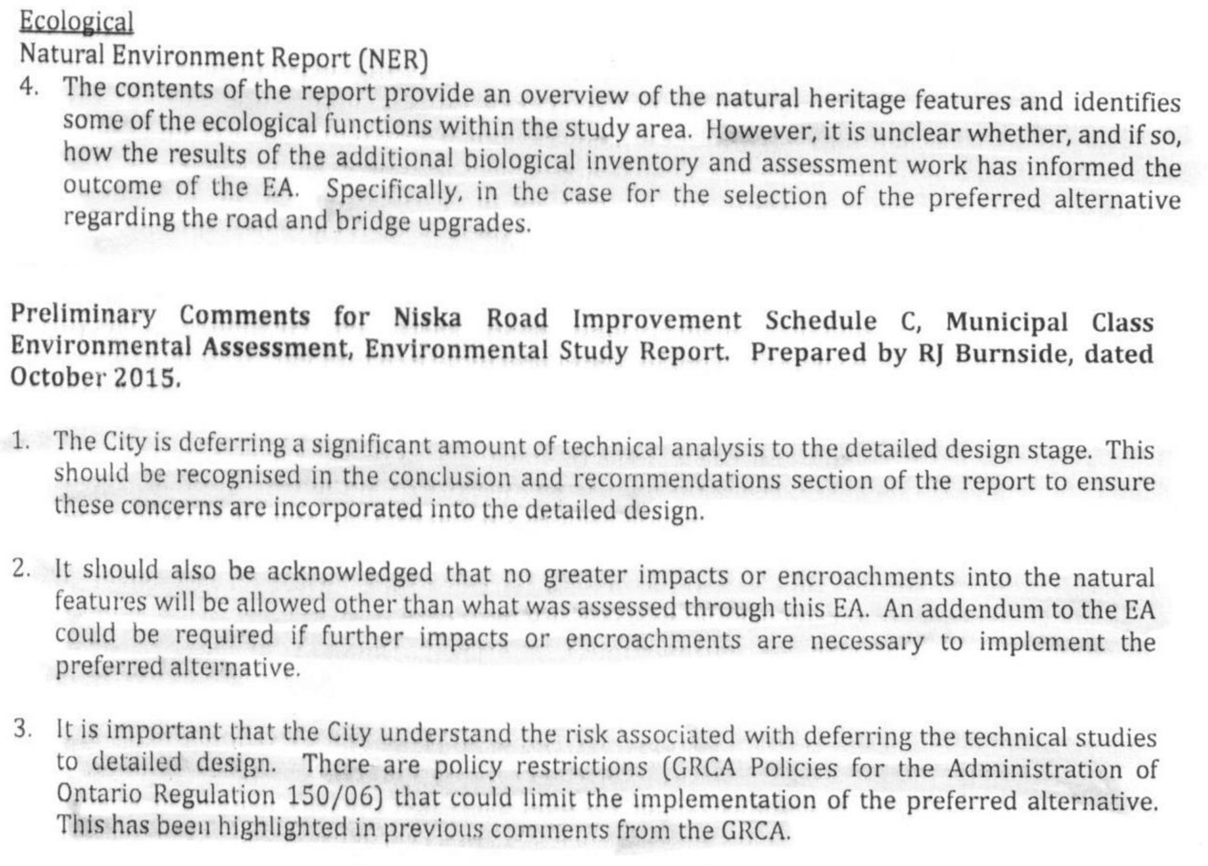
As part of our Part II request to the MOECC we raised concerns about the level of detail and lack of technical information option. We had very serious concerns with respect to the lack of detail and potential negative impacts and protection of the sensitive ecology of the area. These same concerns were identified in the Dec. 3, 2015 GRCA letter to Don Kudo (see entire letter attached). This letter was never shown to Guelph City Council before their EA approval decision was made. Was it ever submitted to RSAC for their consideration. see excerpts below identifying important GRCA concerns:



Engineering

Natural Environment Report (NER)

1. As requested in previous comments, a hydraulic analysis for the proposed alternatives should be considered. The results of this analysis could have an impact on the financial and environmental components of the EA. The NER proposes to defer the hydraulic analysis to the detailed design stage. By deferring this technical analysis it limits the ability of the City to address any uncertainty related to flood risk and the ability to identify



Ecological

Natural Environment Report (NER)

4. The contents of the report provide an overview of the natural heritage features and identifies some of the ecological functions within the study area. However, it is unclear whether, and if so, how the results of the additional biological inventory and assessment work has informed the outcome of the EA. Specifically, in the case for the selection of the preferred alternative regarding the road and bridge upgrades.

Preliminary Comments for Niska Road Improvement Schedule C, Municipal Class Environmental Assessment, Environmental Study Report. Prepared by RJ Burnside, dated October 2015.

1. The City is deferring a significant amount of technical analysis to the detailed design stage. This should be recognised in the conclusion and recommendations section of the report to ensure these concerns are incorporated into the detailed design.
2. It should also be acknowledged that no greater impacts or encroachments into the natural features will be allowed other than what was assessed through this EA. An addendum to the EA could be required if further impacts or encroachments are necessary to implement the preferred alternative.
3. It is important that the City understand the risk associated with deferring the technical studies to detailed design. There are policy restrictions (GRCA Policies for the Administration of Ontario Regulation 150/06) that could limit the implementation of the preferred alternative. This has been highlighted in previous comments from the GRCA.

Note comment (3) under preliminary comments; "it is important that the city understand the risk associated with deferring the technical studies to the detailed design stage". It is my understanding that the GRCA did not complete their technical review of the EA before the 30-day comment period and approval of the EA. You may want to request a copy of their technical staffs review before any decision or recommendations.

Now the city is presenting new information including the presence of federally endangered species and other species of concern. As part of the EA working Group we had previously requested bat studies which were never done as part of the original EA. We also questioned the lack of studies and technical detail leading to uncertainties with respect to protection and future impacts of road and bridge reconstruction to the MNRF provincially significant PSW, seeps, regional wildlife corridor, deer wintering yard, significant overwintering waterfowl area, impacts to fisheries, heritage protection etc. This lack of detail during the original EA calls into question whether the original EA final preferred option of the 2-lane bridge and road reconstruction meets provincial interests with respect the EA Act and the PPS for the long-term protection of the environment.

The economics of a solution costing less than 1/3 of a new replacement bridge, combined with the recent finding of federally endangered species, the importance of preserving a major regional riverine/wetland wildlife corridor to the Grand River and protecting matters of provincial interest should be considered before any further design options are selected. The impacts of major road traffic on of the breeding and foraging habitat federally endangered bats has not yet been considered therefore no design decision should be made. Attached is information regarding the impacts of roads on bats. The wetland extends up to the edge of the road on the north side.

I found a juvenile dead milkshake near the entrance of the former Kortright Waterfowl park this summer. I sent pictures to Ken Vanderwahl and the consultants positively identified the snake it is not in the report. Where are the surveys of species using the river? Was a fisheries survey conducted?

I walk this area almost everyday and have noted an increase in wildlife crossing the closed road and using the forest edges. Walking down the closed road you can now smell the forest an experience known in Japan as Fresh Air bathing found to be beneficial for human health. I believe that the value of this area as a present and future area to experience nature and the river in a natural setting without the noise, light and air pollution from traffic has been vastly downplayed and its value under rated in the selection of the EA options. In 1976 Guelph City Council directed the GRCA to purchase this area to protect it from development. The bridge was to be closed and become the entrance to the Hanlon Creek Conservation Area, so Guelph residents could experience the peace and beauty of nature. What has happened to that vision instead we have replaced it with a traffic corridor. If and when Guelph grows to 191,000 Niska Road with a 2-lane bridge will become nothing more than a major regional bypass from Wellington 124 on a local width road thru the regional wildlife corridor and a residential neighbourhood.

A Six Nations Elder once told me that when we walk on this earth we are walking on the faces of the coming children and you will see their tears in the rain that falls. Please consider the precautionary principle in your deliberations and defer any design decisions at your meeting.

Sincerely

Laura Murr

Heritage Speed River Working Group

123 Downey Road

Guelph ON N1C 1A3 519 824 3606 bearjakey@rogers.com

Attachments:

BM Ross Bailey Bridge Report -0 previously submitted with delegation request

Dec. 3, 2015 GRCA letter re Niska EA to City of Guelph – Don Kudo

Information re bats and roads.

Grand River Conservation Authority
400 Clyde Road, P.O. Box 729 Cambridge, ON N1R 5W6
Phone: 519.621.2761 **Toll free:** 866.900.4722 **Fax:** 519.621.4844 **Online:** www.grandriver.ca

December 3, 2015

Don Kudo, Deputy City Engineer/Manager, Infrastructure Services
City of Guelph
1 Carden Street,
Guelph, ON N1H 3A1

RE: **Municipal Class Environmental Assessment**
Niska Road Improvements from Downey Street to the City Limits

The Grand River Conservation Authority (GRCA) appreciates the opportunity to provide the City with input into the Niska Road Improvements Environmental Assessment. Staff have completed a review of the Natural Environment Report and Technical Stormwater Management Memorandum. Comments on these reports are provided below.

Preliminary comments on the Niska Road Improvements Schedule C Municipal Class Environmental Assessment-Environmental Study Report (EA) are also included; however staff did not receive this document in time to circulate to GRCA technical staff for review. Additional comments will be issued once staff have reviewed the document.

Overall, the GRCA has a concern with the limited degree of impact assessment completed for the analysis of the alternatives. Several technical elements of which are required to complete a full impact assessment and to satisfy GRCA policy requirements for a permit under *Ontario Regulation 150/06* have been deferred to detail design. Therefore, GRCA is requesting that these items be identified in the recommendation section of the EA and a clear commitment from the City to incorporate the technical findings of these reports into the design of the preferred alternative. It should be noted that no further impacts on the natural environment, other than what was assessed in the EA, will be permitted in the detailed design process. Any additional impacts on the environment that are identified during the detailed design could trigger the need for an addendum to the EA.

Technical Comments:

The following comments are based on a review of:

Niska Road Municipal Class EA, Natural Environment Report, City of Guelph. Prepared by RJ Burnside and Associates. Dated July 28, 2015.

Technical Memorandum- SWM Ptarmigan Drive 900m west, Rural vs Urban Cross Section. Prepared by RJ Burnside Associates. Dated September 3, 3015.

Consideration for these comments will also be required to receive any approval under *Ontario Regulation 150/06* for the construction of the preferred alternative.

Engineering

Natural Environment Report (NER)

1. As requested in previous comments, a hydraulic analysis for the proposed alternatives should be considered. The results of this analysis could have an impact on the financial and environmental components of the EA. The NER proposes to defer the hydraulic analysis to the detailed design stage. By deferring this technical analysis it limits the ability of the City to address any uncertainty related to flood risk and the ability to identify ways to minimize fluvial impacts. It is our understanding that Niska Road is to be raised thus potentially increasing flooding hazards, the GRCA therefore requests that an analysis of the preferred design alternative be included as an essential and required element of detailed design.

SWM Technical Memo

2. This is a conceptual discussion favouring an urban road cross-section, due to its smaller footprint, along with some stormwater treatment on GRCA lands. Further analysis is required and an assessment of the impacts is needed. From a conceptual engineering perspective, both options that include a plunge pool and dispersal outlet from a sediment deposition area on GRCA lands maybe feasible provided property ownership and ecological concerns are identified and addressed. Concept 1, with a storm sewer outlet to a ditch some 150m from the Speed River may be acceptable if there are concerns with concept 2 and 3.

3. Elements of a low-impact development approach to all designs should be incorporated.

Ecological

Natural Environment Report (NER)

4. The contents of the report provide an overview of the natural heritage features and identifies some of the ecological functions within the study area. However, it is unclear whether, and if so, how the results of the additional biological inventory and assessment work has informed the outcome of the EA. Specifically, in the case for the selection of the preferred alternative regarding the road and bridge upgrades.

5. Wetland boundaries were verified by the GRCA on June 4, 2015. These boundaries should be mapped and labelled clearly in Figure 1.

6. As previously stated in comments, sections of the evaluation table need to be reconciled. For example, Criterion 1- Designated Sites, it states "Potential for encroachment into Designated Site as a result of construction activities..." However, this impact has not been quantified and no assessment has been detailed in the matrix or report. Similarly, Criterion 2- Terrestrial Habitat and Biology, it states, "Potential temporary impacts on adjacent terrestrial habitat and biology as a result of construction activities...", again there has been no quantification of the impact or assessment to identify appropriate mitigation measure. The GRCA has similar concerns for the matrix assessment for the Road improvement component of the EA.

7. The proposed bridge and road construction footprint, design and specifications also need to be clarified so that potential ecological impacts are more clearly understood. In addition,

mitigation measures that will be (as oppose to could be) implemented need to be confirmed. For example, the GRCA recognizes there is a potential for an improvement in aquatic and terrestrial habitat features and functions by increasing the width of the bridge span. It should be demonstrated how this will be achieved.

8. Section 8 has reiterated GRCA wetland and watercourse policies only but does not specify the magnitude or extent of the impacts associated with the various alternatives. Furthermore, it is unclear how Table 8.1 would be useful in this regard or how the information has informed the review and selection of a stormwater management option that would minimize negative or adverse impacts on receiving water bodies and associated wetland areas on and off GRCA lands. Further discussion and clarification of site specific impacts and mitigation measures is warranted.

SWM Technical Memo

9. Identification of actual impacts and an assessment of those impacts has not been fully completed for either the rural or urban-cross section related to the SWM strategy. Further analysis is required in order to determine the appropriate alternative for the SWM strategy. Quantifying the impacts of the alternatives on the natural environment is required. For example, will wetland removal be required for the construction of the plunge pool, and if so, what impacts would that have on the hydrological function of the wetland.

10. The last point in the memo suggests that a partial rural cross section upstream of the bridge will be considered. The statement is unclear. Figure 1 illustrates a storm sewer on the east side of the bridge discharging to a plunge pool and outletting to the Speed River on the downstream side of the bridge. The location of the partial rural cross-section, and associated road side ditches, should also be illustrated. Please elaborate.

11. With respect to options for water quality control; bio-swales are preferred over rip-rap channels and oil/grit separators. Similarly, given the potential for high peak flows, higher levels of dissolved contaminants, and the need for periodic maintenance, a curb and gutter is less preferred than an open swale.

Technical Advisory Comments

12. It is recommended that the checklist of breeding birds obtained from the Ontario Breeding Bird Atlas database be supplemented with Ebird records. For example, several species of waterfowl are known to inhabit ice-free sections of the Speed River during the winter months.

13. A fully annotated list of plant and animal species observed within the study area should be appended to the final ESR. Locally and provincially significant species should be highlighted.

14. Section 4.2.5. of the report should be updated to reflect the results of fish surveys conducted by the GRCA in the summer of 2015. Two cold water species, namely Brook Trout and Mottled Sculpin, were recorded by staff. The results of these surveys should be summarized in the current RA and taken into consideration during the detailed design stage. For instance, a cold water timing window would be applicable along this watercourse.

Property Comments

15. As presented in previous comments, clarification is required to determine the extent of encroachment onto GRCA lands. Throughout the supporting documents for the EA, there are conflicting statements regarding the degree of encroachment onto GRCA lands. This needs to be confirmed and documented in the EA. For example, if access or temporary encroachment is required for construction, it should be identified in the report. If lands are required to facilitate the implementation of the preferred alternative, that should be identified as well. At a minimum, there have been encroachments identified for the SWM solution and a proposed canoe launch, but no discussion in the report regarding the arrangements required to implement this. There has also been no impact analysis completed to support the level of suggested encroachment on GRCA lands. It is a concern that the EA is making supporting statements regarding these encroachments with no further analysis or discussion with the GRCA about the feasibility of the encroachments on GRCA lands.

16. As an adjacent property owner, the GRCA has concerns that there will be impacts to the flood elevations based on the preferred alternative. To date, there has been no acknowledgement of this concern in any of the supporting documentation. GRCA technical staff have also expressed their concerns above on this issue.

Preliminary Comments for Niska Road Improvement Schedule C, Municipal Class Environmental Assessment, Environmental Study Report. Prepared by RJ Burnside, dated October 2015.

1. The City is deferring a significant amount of technical analysis to the detailed design stage. This should be recognised in the conclusion and recommendations section of the report to ensure these concerns are incorporated into the detailed design.

2. It should also be acknowledged that no greater impacts or encroachments into the natural features will be allowed other than what was assessed through this EA. An addendum to the EA could be required if further impacts or encroachments are necessary to implement the preferred alternative.

3. It is important that the City understand the risk associated with deferring the technical studies to detailed design. There are policy restrictions (GRCA Policies for the Administration of Ontario Regulation 150/06) that could limit the implementation of the preferred alternative. This has been highlighted in previous comments from the GRCA.

4. As part of detailed design, the following studies will be required. It is highly recommended that the City submit Terms of Reference for each of the studies to ensure the scope of work addresses GRCA concerns.
    a. Hydraulic analysis of the preferred alternative. This study should demonstrate how the City intends to meet the policy requirements for development within the floodplain.
    b. Hydrogeological analysis to assess the impacts of the preferred alternative on the wetlands and river/creek systems. A quantitative and qualitative impact analysis on the hydrological form and function of the wetland and river (and creeks if required) for the preferred alternative.

   c. Detailed assessment of the design options for the implementation of the SWM strategy. This will include an assessment of the hydrological impacts on the surrounding wetland and river, as well as an analysis on how to deal with potential fluvial impacts of the outlet.
   d. Financial analysis for any encroachments required for implementation of the preferred SWM strategy

5. It should be acknowledge that encroachment on to GRCA lands will only be considered for the SWM strategy and that no other encroachments will be considered other than what was identified in the EA.

6. As identified in previous comments, the GRCA would like to reiterate our support for the recommendations presented in the Niska Road Cultural Heritage Landscape Addendum, completed by Unterman McPhail Associates, dated April 2014.

   The staff (City of Guelph) report titled, Niska Road Improvements- Schedule C Municipal Class Environmental Assessment, dated December 3, 2105 states, "While the project team considered the revised November 9, 2015 recommendations from the Heritage Guelph Advisory Committee, the preferred options and mitigation strategies identified through the EA are consistent with the Cultural Heritage Evaluation Report (CHER) and CHER Addendum findings and recommendations and also consistent with the City Heritage Planner's recommendations". Through discussion with City staff it is our understanding that a heritage designation (cultural heritage landscape) is not being recommended to council at this time.

7. On page 22-23, there is reference to GRCA Owned Lands. The description provided on page 22 provides an accurate depiction of the current situation. However, the rest of the text provided on page 23 is not necessary for this document and has typos throughout suggesting it was taken from email correspondence. Please delete the text on page 23.

Should you have any questions or require additional information please contact Samantha Lawson, at 519-621-2763 ext. 2210.

Sincerely,

SLawson.

Samantha Lawson
Manager of Property

cc. April Nix, Environmental Planner (Policy), City of Guelph (email)
Leonard Rach, Project Manager, R.J. Burnside and Associates Ltd. (email)
Nicole Smith, Senior Terrestrial Ecologist, R.J. Burnside and Associates Ltd. (email)

Chapter 3
Bats and Roads

John Altringham and Gerald Kerth

Abstract The effects of roads on bats have been largely neglected until recently, despite growing evidence for profound effects on other wildlife. Roads destroy, fragment and degrade habitat, are sources of light, noise and chemical pollution and can kill directly through collision with traffic. The negative effects of roads on wildlife cannot be refuted but at the same time road building and upgrading are seen as important economic drivers. As a consequence, infrastructure projects and protection of bats are often in conflict with each other. There is now growing evidence that fragmentation caused by roads reduces access to important habitat, leading to lower reproductive output in bats. This barrier effect is associated with reduced foraging activity and species diversity in proximity to motorways and other major roads. The effects of light and noise pollution may add to this effect in the immediate vicinity of roads and also make bats even more reluctant to approach and cross roads. Several studies show that vehicles kill a wide range of bat species and in some situations roadkill may be high enough to lead directly to population decline. Current mitigation efforts against these effects are often ineffective, or remain largely untested. The limited information available suggests that underpasses to take bats under roads may be the most effective means of increasing the safety and permeability of roads. However, underpass design needs further study and alternative methods need to be developed and assessed.

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Applied Zoology and Conservation, Zoological Institute and Museum,
University of Greifswald, Greifswald, Germany
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C.C. Voigt and T. Kingston (eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*, DOI 10.1007/978-3-319-25220-9_3

3.1 Introduction

The global road network gets longer, wider, faster and more complex as existing road systems are upgraded and new roads are built. Despite the widely acknowledged need to reduce our dependence on fossil fuel and growing concerns about the environmental impact of roads, improved communication by road, and even the act of road-building itself, are often seen as essential economic drivers. As road networks expand, traffic volumes increase and congestion remains a problem. A few statistics highlight the pervasive nature of our road networks: only 2 % of Germany is made up of landscape fragments greater than 100 km^2 (Jaeger et al. 2007) and only 17 % of the US landscape is more than 1 km from a road (Riiters and Wickham 2003). In 2012, the UK had 395,000 km of roads, of which over 50,000 km are major roads and 3700 km motorways (Defra 2013). Major roads account for only 13 % of all UK roads, but carry 65 % of the traffic. 50 % of all traffic is on motorways and other major roads in rural areas. Almost 20 % of major road length is dual carriageway. Over 3200 km have been added to the UK network in the last decade and many more have been upgraded.

Roads have several negative impacts on animals. First, building roads and their ancillary structures destroys habitat directly. Secondly, the resulting road network fragments the landscape, potentially restricting animal movements, thereby blocking their access to the remaining habitat. Thirdly, roads are also sources of light, noise and chemical pollution, and so degrade the habitat around them. Moreover, the increased human access provided by roads usually accelerates urban, commercial and agricultural development and increases human disturbance in many ways, e.g. through increased recreational pressure and the introduction of non-native predators and other invasive species. Finally, fast moving traffic kills animals directly. Broad reviews of the effects of roads on vertebrates include Bennett (1991), Forman and Alexander (1998), Trombulak and Frissell (2000), Coffin (2007), Fahrig and Rytwinski (2009), Laurance et al. (2009), Benítez-López et al. (2010), and Rytwinski and Fahrig (2012). Surprisingly, despite the many ways in which roads can impact on wildlife, it is only in the last 20 years that significant attention has been given to what is now often referred to as 'road ecology' (Forman et al. 2003). Little of this attention was directed at bats. Moreover, the few existing studies on the impact of roads on bats have all been carried out in North America and Europe.

Globally many bat species are endangered (Racey and Entwistle 2003; Jones et al. 2009), including regions with a dense infrastructure such as North America and Europe (Safi and Kerth 2004). As a consequence, in Europe, for example, bats are of high priority for conservation and all bat species have been strictly protected for two decades by European law (CMS 1994). Despite the importance of bats in conservation, rigorous, peer-reviewed studies on the impact of roads on bats have only begun to be published in the last few years. Only over the last decade it has been widely accepted that roads must have an effect on bats. As a result, mitigation against these effects is becoming increasingly integrated in the road building process and practical mitigation guidelines have been published in a number of countries (e.g. Highways Agency 2001, 2006; Limpens et al. 2005). However, the precise nature and scale of the effects of roads on bats were mostly unknown, and as a consequence mitigation has often been poorly monitored and therefore rarely informed by sound evidence (Altringham 2008; O'Connor et al. 2011).

This review describes the ways in which roads do or may affect bats, discusses the available evidence in relation to each, and where appropriate suggests action for the future, in terms of both research and conservation action. Because work on the impacts of roads on bats is still scarce and biased towards the temperate zone, some work on other animals will be discussed, in particular birds, to help fill important gaps. Roads can affect bats in many ways, and because the mitigation solutions will to some extent be unique to each, the mechanisms will be discussed separately. However, there is considerable interaction between them and the impacts in many cases are cumulative, so some topics will appear under more than one heading.

To our knowledge almost no studies have been published yet that investigated the effects of railways on bats (but see Vandevelde et al. 2014). However, as linear development features, they have the potential to disrupt bats and will be discussed briefly at the end of the review.

3.1.1 Bat Life History

In order to assess the impact of roads on bats, an important consideration is of course the biology of the bats themselves. Bats are small mammals with the life history strategy of very much larger species (e.g. Barclay and Harder 2003; Altringham 2011). They have taken the low fecundity, long life option, often producing only a single pup each year, but frequently living for more than 10 years and not unusually 20 or more (e.g. Barclay and Harder 2003; Altringham 2011). Any external factors that reduce reproductive success, increase mortality, or both, can lead to severe population declines—and recovery will be slow (e.g. Sendor and Simon 2003; Papadatou et al. 2011). Furthermore, bats typically have large summer home ranges compared to other similar sized mammals and many bats migrate over considerable distances between winter and summer roosts (Altringham 2011). Finally, bats are highly gregarious (Kerth 2008). As a result, negative impacts of roads on local bat colonies can affect large numbers of individuals simultaneously. Because of their particular life history, bats are susceptible to a wider range of environmental disturbances than many other small mammals.

3.1.2 Bat Conservation Status

A substantial number of the more than 1200 extant bat species are considered to be endangered (Racey and Entwistle 2003; Jones et al. 2009). Reasons for the decline of bats include habitat loss, pollution, direct persecution and diseases (Jones et al.

2009). Several of these threat factors are also relevant during the construction and maintenance of roads. In Europe, all bats are strictly protected, as all are listed in Annex 4 of the Habitats Directive, and several species have designated protected areas because they are also listed in the Annex 2 of the Habitats Directive (Council Directive 92/43/EEC). As a consequence, whenever bat populations are likely to be adversely affected by the construction of roads, environmental assessments are required and mitigation often becomes a necessity. Thus assessments of bats have been carried out during many recent infrastructure projects (e.g. Kerth and Melber 2009) and this process will continue to be important in the future.

3.2 The Effects of Roads on Bats—Habitat Destruction, Fragmentation, Degradation and Collision Mortality

3.2.1 Loss of Habitat

Road development frequently involves the removal of trees and buildings that hold potential or actual bat roosts. The removal of trees, hedges, scrub, water bodies and unimproved (‘natural’) grassland also reduces available foraging habitat. The road surface alone destroys significant areas of habitat: 7 ha for every 10 km of 7 m wide, two-lane road. Roadside hard shoulders, verges, junctions, service areas and other structures remove yet more potential habitat. As a result, road construction leads to the permanent loss of habitats for bats and thus is likely to reduce population sizes directly.

3.2.2 The Barrier Effect

Roads are potential barriers to flight between roosts and foraging sites and between summer, mating and winter roosts. They could therefore reduce the available home range size and quality and may restrict migration, which could increase mortality and reduce reproductive potential. Roads may act as barriers because they interrupt existing linear flight lines, because some species are reluctant to cross open ground, because some species avoid lit areas (road and vehicle lights) and, at least initially, because they represent sudden changes in the bats’ familiar landscape. Roads may therefore fragment habitat, decreasing its accessible area and quality. Since habitat area and quality are major determinants of population size, then habitat fragmentation will lower the sustainable population size.

Barriers such as roads may also limit the flow of individuals between populations with two major consequences. First, barriers may slow the recovery from local population declines since recruitment of individuals from neighbouring populations (“rescue effect”) will be reduced and this will further increase the probability of local extinction. Secondly, barriers may also reduce gene flow between populations and increase inbreeding, reducing individual fitness and increasing the risk of local extinction. Genetic isolation such as this can only occur with very low levels of dispersal. These factors may only be significant for rare bat species that already have small and fragmented populations. Of course it may be that they are rare because of their susceptibility to these and other anthropogenic pressures.

Genetic isolation as a direct result of roads has not been studied in bats. In several other mammal species an effect of roads on genetic population structure has been found (Frantz et al. 2012). For example, Gerlach and Musolf (2000) have shown that populations of bank vole are genetically different either side of a four-lane highway. However, even in bat species such as Bechstein's bat, *Myotis bechsteinii*, for which barrier effects of motorways haven been shown to occur in the summer habitat (Kerth and Melber 2009), local populations living in an area with several motorways show only weak genetic differentiation (Kerth et al. 2002; Kerth and Petit 2005). In accordance with the findings on Bechstein's bats, population genetic studies on other temperate zone bats typically found no or very little evidence for genetic isolation on the regional scale (Moussy et al. 2013), despite the dense road network in Europe and North America. This suggests that in the temperate zone roads probably have no significant effect on gene flow in most bat species. For tropical bats much less data on population genetic structures are available but the situation may be different from the temperate zone. In general, mammal and bird species living in tropical rainforests are often particularly reluctant to cross open areas (Laurance et al. 2009). Moreover, unlike most bats in Europe and North America, tropical bats often mate close to or at the breeding sites of the females. Both features make tropical bats likely to suffer more from fragmentation by roads by means of restricted gene flow than temperate zone bat species. Clearly, further studies are needed to test this.

There is considerable evidence to suggest that roads act as barriers to bats during foraging and movements between different day roosts (roost switching) in the summer habitat. Bats have been shown to make major detours to avoid roads or to find appropriate crossing points (e.g. Kerth and Melber 2009). This behaviour could lead to longer journeys that consume time and energy or even deny bats access to parts of their habitat. In the study by Kerth and Melber (2009) of 32 radiotracked, female Bechstein's bats, only three individuals, belonging to two different maternity colonies, crossed a four-lane motorway cutting through a German forest to forage (Fig. 3.1). All three bats used an underpass to cross the motorway. Other bats from four nearby colonies did not cross the motorway. Moreover, during roost switching none of the colonies crossed the motorway. In addition, foraging areas of females were smaller in those colonies whose home range was bounded by the motorway, relative to those bounded by more natural forest edges. Importantly, females in colonies bounded by the motorway had lower reproductive success than other females, persuasive evidence for the adverse effects on reproductive output. In the same study, six barbastelle bats, *Barbastella barbastellus*, belonging to one maternity colony, were also tracked and five made several flights

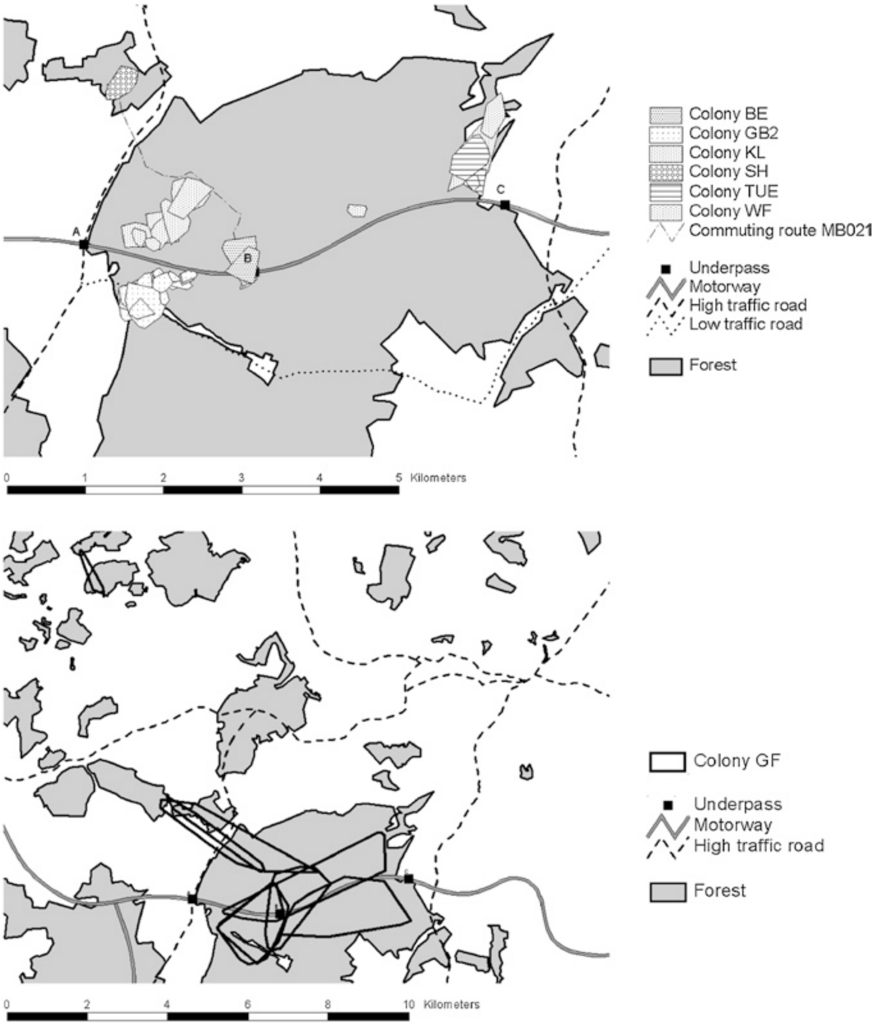

Fig. 3.1 Home range use of two forest bat species living close to a motorway in Germany. The *upper picture* shows the polygons depicting the individual foraging areas of 32 Bechstein's bats belonging to six different colonies living in a German forest that is cut by a motorway. The *lower picture* shows the polygons depicting individual foraging areas of six barbastelle bats belonging to one colony living in the same forest as the Bechstein's bat colonies. From Kerth and Melber (2009)

over the road itself (Fig. 3.1). Moreover, the barbastelle bat colony used roosts on both sides of the motorway. These findings highlight the fact that the effects of roads are species-specific, as will be discussed in more detail later. Berthinussen and Altringham (2012a) observed only three bats flying over a six-lane motorway, all belonging to *Nyctalus* species, at heights above 20 m. *Nyctalus* species are known to fly high and to forage in open spaces (e.g. Jones 1995), behaviour that is likely to make them less susceptible to the barrier effects of roads and to collision mortality. The absence of other species of bat flying over the road in this study suggests that the severance of linear elements by the road may have caused the abandonment of previous flight lines.

Roads may be perceived as barriers by bats for several reasons: open spaces and artificial light expose them to predation, and moving traffic and noise may be seen as threats. Small gaps (<5 m) in cover along flight routes can interrupt commuting bats (e.g. Bennett and Zurcher 2013), but many species will cross open spaces, even those adapted to forage in woodland (e.g. Kerth and Melber 2009; Abbott 2012; Abbott et al. 2012a; Berthinussen and Altringham 2012b), although they will typically do so close to the ground (e.g. Russell et al. 2009; Abbott 2012; Abbott et al. 2012a; Berthinussen and Altringham 2012b). Abbott et al. (2012a) observed low-flying species crossing at sites where mature hedgerows had been severed by the road, even when the gap was >50 m. However, Abbott (2012) found that the rate of bat crossing decreased with increasing distance between mature hedgerows on opposite sides of the road, suggesting a greater barrier effect. Russell et al. (2009) reported that reduced cover at the roadside reduced the number of crossing bats.

That some bats will cross roads is not an indicator that open roads are not a problem—the proportion of bats that do cross may be very small and they are at risk of collision with traffic. The presence of traffic does appear to have a direct effect on the likelihood of crossing, since Indiana bats, *Myotis sodalis*, reverse their flight paths and exhibit anti-predator avoidance behaviour in response to approaching vehicles (Zurcher et al. 2010; Bennett and Zurcher 2013). No specific study has been made of crossing behaviour in relation to traffic volume and road width but anecdotal evidence suggests that it matters. For example, in the study of Kerth and Melber (2009) an individual Bechstein's bat that flew over a two-lane road did only cross a four-lane highway through an underpass. Light and noise are discussed below.

Evidence for a barrier effect is seen in other studies. Berthinussen and Altringham (2012a) found that total bat activity, the activity of the most abundant species (*Pipistrellus pipistrellus*) and the number of species, were all positively correlated with distance from a 40 year-old, six-lane, unlit motorway in rural north-west England (30–40,000 vehicles/day). Total activity increased more than threefold between 0 and 1600 m from the road. These effects were consistent over the two years of study and similar results were obtained on a rural motorway in south-west England (25–90,000 vehicles/day) (Berthinussen 2013). Unpublished work (A. Berthinussen and J.D. Altringham, in preparation) shows that this effect can extend to single carriageway (two-lane) roads. The most likely explanation for this spatially extensive reduction in bat activity is a long-term barrier effect, possibly in combination with increased mortality, driving colonies away from the road, and this is discussed further below.

3.2.3 Roadkill

Bats that attempt to cross roads risk collision, and hotspots for mortality have been found where flyways cross roads and where there is favourable habitat for bats on both sides of a road (e.g. Lesiński 2007; Russell et al. 2009; Medinas et al. 2013). Although agile and manoeuvrable in flight, most bat species fly at low speeds (<20 km/h) and many fly close to the ground (0–4 m: e.g. Russell et al. 2009; Berthinussen and Altringham 2012b), particularly when crossing open spaces. In contrast to the majority of birds, most bats also spend most of the time they are out of the roost in flight. They make extensive use of linear landscape features, such as woodland edges and hedgerows along roads, for foraging and as navigational aids when commuting and several recent studies have shown how important these linear elements are to bats (e.g. Boughey et al. 2012; Frey-Ehrenbold et al. 2013; Bellamy et al. 2013). Flying close to such edges may also reduce predation risk. In combination, these behavioural traits make bats highly vulnerable to moving vehicles when either foraging along roads or when attempting to cross roads on commuting flights. Being small, bats can probably be pulled easily into the slipstream of passing vehicles. Russell et al. (2009) watched over 26,000 bat crossings (primarily little brown bats, *Myotis lucifugus*) on a highway in the USA. Bats approached the road using tree canopy cover and fewer bats were recorded crossing where cover was absent. The lower the cover, the lower the bats crossed the road. Where bats were forced to cross an open field on leaving the roost most did so at a height of less than 2 m. Berthinussen and Altringham (2012b) recorded bats of four or more species crossing roads at mean heights well below 5 m (Fig. 3.2).

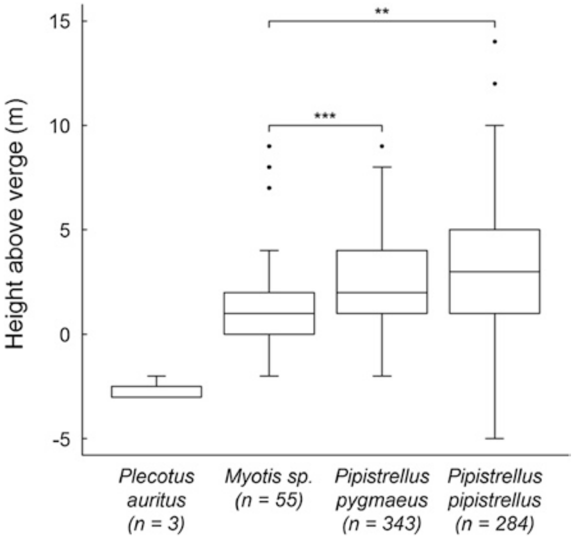

Fig. 3.2 Boxplot of flight height above verge height of identified crossing bats. Median with upper and lower quartiles. Significant differences shown for *Myotis* and *Pipistrellus* species $^{**}P < 0.0005$, $^{***}P < 0.0001$. Verges are elevated on either side of the road and are above road height, therefore negative values indicate bats flying across the road below the height of the verge. From Berthinussen and Altringham (2012b)

Lesinski (2007) recorded bat casualties on an 8 km section of two-lane highway by weekly searches for carcasses over four summers. Casualties ranged from 0.3 bats/km/year in built-up areas to 6.8 bats/km/year where roads were bordered by trees. However, a study by Slater (2002) of the rate of removal of 'carcasses' (small pieces of chicken!) by scavengers on Welsh roads, suggests that a census of this kind may underestimate wildlife road kills as much as 12–16 fold, since dawn scavengers typically removed small carcasses within 30 min. More recently Santos et al. (2011) have also shown that bat carcasses persist on roads in Portugal for a similarly brief period due to scavenging. Teixeria et al. (2013) studied roads in Brazil and found that roadkill estimates increased 2–40 fold when scavenging and low detectability were accounted for. This wide variation was due to taxonomic differences and bats would be at the high end of this range. In addition, small bat carcasses are difficult to spot and many will be thrown clear of the road or carried some distance on the vehicle, suggesting that underestimates will be even greater. Arnett (2006) found that humans (in the absence of scavengers) were able to find only 14 and 42 % of bat carcasses placed at two wind farm sites and Mathews et al. (2013) reported that humans found only 20 % of bat carcasses at wind farms, relative to 73 % found by dogs. Road mortality studies will therefore inevitably under-estimate true mortality rates.

A significant proportion of European bat species, occupying a range of ecological niches, have been documented as roadkill (e.g. Billington 2001–2006; Lesiński 2007; Lesiński et al. 2010). Woodland-adapted species should be most affected due to their characteristic low and slow flight, but this prediction was not supported by Lesiński et al. (2010), as noctules (*Nyctalus noctula*) were killed in significant numbers. Clearly other factors can play an important role locally. Forman et al. (2003, pp 120–122) show that wildlife collisions increase as vehicle speed and traffic volume increase, and with proximity to wildlife habitat and wildlife movement corridors. There are no data on bats relating mortality to speed and traffic volume, but there is no reason to believe they will be different from that of other taxa. There are data from bats to show that roadkill is greater in good habitat and at natural crossing points (Lesiński et al. 2010; Medinas et al. 2013). The effects of traffic speed and volume, road width and height, habitat characteristics, and bat species on rates of roadkill should be explored in greater depth to help us understand how best to mitigate against the effects of roads.

Collection of roadkill carcasses by Russell et al. (2009) led to a conservative estimate of an annual mortality of 5 % of the bats in local roosts. Altringham (2008) arrived at a similar estimate, based on conservative calculations for a road in the UK crossed by lesser horseshoe bats from a large roost (data from Billington 2001–2006). Theoretical studies (e.g. Lande 1987; With and King 1999; Carr and Fahrig 2001) show that populations of animal species with low reproductive rates and high intrinsic mobility, such as bats, are more susceptible to decline and ultimately extinction by the additional mortality caused by roads.

3.2.4 Habitat Degradation—Light, Noise and Chemical Pollution

Light Several studies (e.g. Rydell 1992; Blake et al. 1994; Stone et al. 2009, 2012) have shown that road lighting deters many bat species, notably slow-flying, woodland-adapted species such as members of the genera *Rhinolophus, Myotis* and *Plecotus*, from approaching the road. Lighting will probably exacerbate the barrier effect of roads, since those species reluctant to cross open spaces are also those most likely to avoid light. Both high-pressure sodium and white LED light deter woodland-adapted species, even at low intensity (Stone et al. 2009, 2012). Because light intensity drops rapidly away from the source and will often be blocked by vegetation, the effects of isolated sources are not likely to be far reaching in the landscape, but large arrays of high intensity lights will have a significant effect close to roads.

Light can also attract some bat species, in particular open air foragers such as *Nyctalus* and generalists like *Pipistrellus* (e.g. Rydell 1992; Blake et al. 1994), since short wavelength light attracts insect prey, concentrating them around lights and increasing bat foraging efficiency. This may be not be all good news, since bats exploiting insect swarms around lights may be at greater risk of collision with traffic.

As discussed above, many woodland-adapted bats avoid all forms of visible light, so insects around lights are not available to them. Many insects may indeed be drawn out of woodland towards lights, reducing prey availability to woodland specialists. This could effectively enhance the edge effect around woodland. This has yet to be demonstrated but is worth investigation. The chapter by Rowse et al. discusses the detrimental and beneficial effects of artificial lights on bats in detail.

Noise Most insectivorous bats rely on hearing the returning echoes of their ultrasonic echolocation calls to orientate, detect prey and even communicate. Some species locate and capture prey by listening for sounds generated by their prey, such as wing movements or mating calls. Traffic noise may mask prey-generated sounds and the lower frequency components of echolocation calls. During indoor flight room experiments, simulated traffic noise reduced the feeding efficiency of the greater mouse-eared bat, *Myotis myotis*, which typically hunts by listening for sounds made by its prey on the ground (Siemers and Schaub 2011). It is likely that habitats adjacent to noisy roads would therefore be unattractive as feeding areas for this and other species that glean their prey from the ground or vegetation by listening to rustling noises. Vehicle noise may also exacerbate the barrier effect: bats become less likely to fly across a road as traffic noise increases (Bennett and Zurcher 2013). Currently, there are no published field studies that have assessed the effect of traffic noise on bat diversity, abundance or breeding success. However, as described below, traffic noise, like light, is only likely to have a significant effect over relatively short distances.

Pollution Chemical pollution is another significant factor potentially affecting bats close to roads: transport is the fastest growing source of greenhouse gases. In the USA, over 50 % of domestic CO_2 emissions come from cars, putting 1.7 billion tonnes into the atmosphere every year—a major contributor to climate change. In addition there are the local effects of other chemical pollutants. Automobile exhaust gases close to a road have been shown to be associated with a decline in arthropod diversity and abundance (Przybylski 1979). Motto et al. (1970) and Muskett and Jones (1980) found significant effects on invertebrates of lead and other metals from cars up to 30 m from roads.

3.2.5 Species-Specific Effects

Body size, wing form, echolocation call structure and feeding and roosting ecology all determine how bats fly and use the landscape. Thus, it is not surprising that the effects of roads on bats are to a significant extent species-specific. Larger, fast-flying species, adapted to foraging in the open, appear from most studies to be less affected by roads (e.g. Kerth and Melber 2009; Abbott et al. 2012a; Berthinussen and Altringham 2012a), as they typically fly high above the ground. Their greater flight efficiency and speed relative to woodland-adapted species mean that even if they are forced to make long diversions to find safe crossing points or to avoid roads altogether, the consequences are likely to be less important. Smaller, slower flying, woodland-adapted species are more manoeuvrable and typically capable of gleaning and hovering but this necessarily makes them less efficient flyers (Altringham 2011). Woodland species are also more reluctant to fly in the open and tend to commute along linear features in the landscape such as treelines, waterways, and woodland edges. These features provide protection from weather and predators, are sources of insect prey, and provide conspicuous acoustic and visual landmarks for orientation. Figure 3.3 shows schematically the main patterns of flight and habitat use by insectivorous bats. It is unfortunate that the species most likely to be affected by roads, the slow-flying, woodland-adapted bats, such as *Rhinolophus* and some *Myotis* species, are also those that have suffered most from human activity in Europe and North-America and are at highest risk of extinction there (Safi and Kerth 2004).

3.2.6 Road Class and Speed

The greater width of motorways may make them more effective barriers (Berthinussen and Altringham 2012a) than most other roads. However, traffic density may be equally important (Russell et al. 2009; Zurcher et al. 2010; Bennett and Zurcher 2013) and many major non-motorway roads carry similar or greater traffic volumes, at comparable speed, to rural motorways.

Even minor roads are avoided by many bat species. In a habitat suitability modelling (HSM) study in northern England based on extensive acoustic surveys,

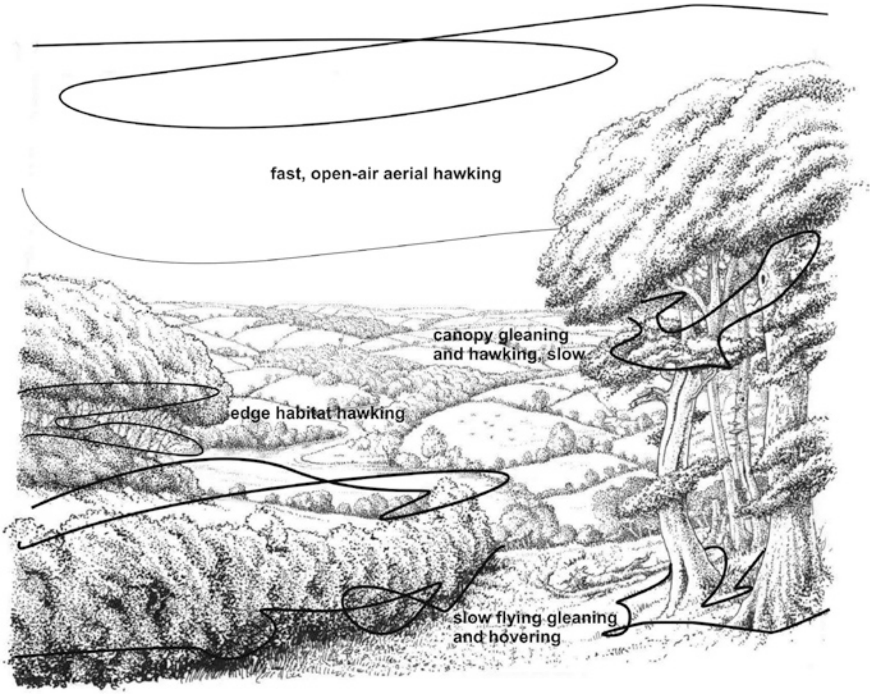

Fig. 3.3 Flight style and habitat use by insectivorous bats. Drawing by Tom McOwat

Bellamy et al. (2013) found that only *Nyctalus* and *Pipistrellus* species showed a positive association with roads and then only when roads were at low densities and in close proximity to woodland. This association is likely due to the use by bats of hedgerows along roads that connect to woodland. Other species, particularly woodland specialists, such as *Myotis* and *Plecotus* species, avoided roads and all species avoided roads when they became dense around settlements. All road classes were combined in this study, but minor roads predominate in the region, so the effects of major roads were probably underestimated. Studies of birds support these conclusions: Develey and Stouffer (2001) and Laurance et al. (2004) have shown that even narrow, unpaved forest roads can act as barriers to tropical forest birds.

In the absence of further work on bats we can look at other animals. Forman et al. (2003) demonstrated that roads act as significant barriers to a variety of mammals from voles to grizzly bears, that primary roads are significantly more effective barriers than secondary roads, and the barrier effect increases with increasing traffic volume. The effects in some cases are severe. Gerlach and Musolf (2000) have shown that populations of bank vole are genetically distinct either side of a busy four-lane highway (50 m wide, 30,000 vehicles/day), but not either side of a two-lane country road (10 m, 5000 vehicles/day) or a railway. Highways can be major genetic barriers even to large and mobile animals such as coyotes and lynx (Riley et al. 2006) or red deer (Frantz et al. 2012).

3.2.7 Cumulative Effects, Extinction Debt and the Importance of Scale

Most of the factors discussed above will be cumulative. The effects of each individually need not therefore be great for the combination to have a profound effect on a bat population. Furthermore, in many cases there will be a lag, known as the extinction debt, between cause and effect (e.g. Tilman et al. 1994; Loehle and Li 1996). This is illustrated in Fig. 3.4.

The effects of habitat loss and reduced habitat quality on the distribution of flying bats may be seen quickly, as bats alter their foraging and commuting behaviour to adapt as best they can to the altered landscape. Collision mortality, unless very high, may not have a significant and detectable effect for several generations. The barrier effect may take several more generations to show itself, since it is likely to involve the decline and/or relocation of nursery and other roosts, but it too may be rapid, for example when bats are completely excluded from key foraging areas. Although no data exist for bats, a study of the effects of roads on wetland biodiversity (birds, mammals, reptiles, amphibian and plants) suggests that the full effects may not be seen for several decades (Findlay and Bourdages 2000). This has important implications for monitoring the effects of roads and assessing the effectiveness of mitigation, as discussed later.

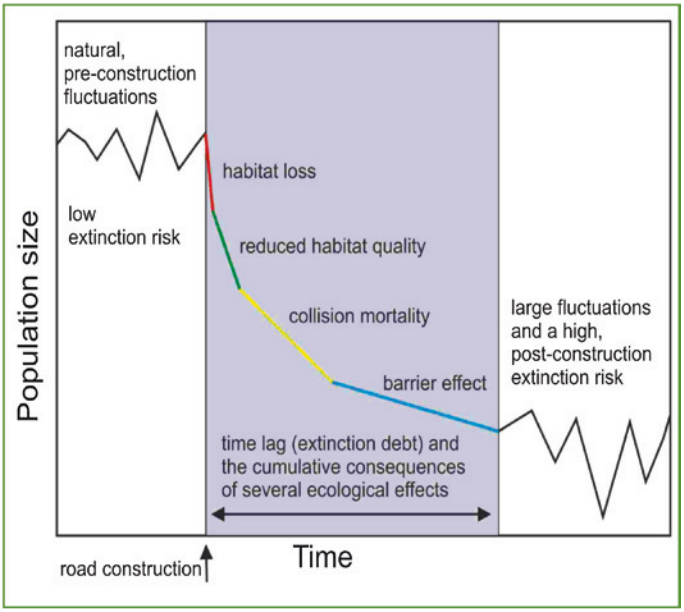

Fig. 3.4 The multiple causes of bat population reduction by roads and the delayed response (extinction debt). Adapted from Forman et al. (2003)

Berthinussen and Altringham (2012a) found that the decline in diversity and abundance of bats extended to at least 1.6 km from a motorway. Which of the above mechanisms contribute to this extensive effect? Low activity and diversity close to the road may be due to most or all of the factors identified: habitat degradation resulting from light, noise and chemical pollution, a barrier effect, or increased mortality due to roadkill. Noise pollution can contribute only to short-range effects, since noise levels in the study fell rapidly over the first 200 m and were close to ambient thereafter. Lab studies on the gleaning greater mouse-eared bat *Myotis myotis* (Schaub et al. 2008; Siemers and Schaub 2011) show that even species that hunt by listening for prey-generated noise are not likely to be affected by roads more than 60 m away. Light pollution was not considered by Berthinussen and Altringham, since the road sections studied were unlit. However, any effect of light pollution from road and vehicle lights is also likely to operate over relatively short distances, due to the inverse square relationship between distance and light intensity. In addition vegetation alongside of roads will further reduce the effect of light and noise pollution quickly. Road developments can disrupt local hydrology and polluted run-off may degrade wetland foraging habitats (Highways Agency 2001), but the scale of such effects will be very variable. As discussed above, chemical pollution is likely to be a factor only over relatively short distances unless dispersion is facilitated by drainage. The many processes that may be degrading roadside habitats need further study, but none of those discussed are likely to explain changes in bat activity over 1.6 km.

Reduced activity over long distances can however be explained by the combination of a barrier effect and increased mortality due to roadkill. The home ranges of temperate insectivorous bat species typically extend 0.5–5 km from their roost (e.g. Bontadina et al. 2002; Senior et al. 2005; Davidson-Watts et al. 2006; Smith and Racey 2008), and most species show high fidelity to roosts, foraging sites and commuting routes (e.g. Racey and Swift 1985; Entwistle et al. 2000; Senior et al. 2005; Kerth and van Schaik 2012; Melber et al. 2013). A major road built close to a nursery roost has the potential to reduce the home range area of a colony through both destruction of habitat and the severance of commuting routes that reduces access to foraging areas. The bats have several options. One is to continue to use the roosts close to the road with a reduced foraging area, reduced resources and reduced reproductive potential (Kerth and Melber 2009). The colony is therefore likely to decline. Alternatively bats may cross the road to maintain their original home range area. Local habitat loss and degradation and increased roadkill will compromise the colony, which may therefore decline. Mortality from roadkill is likely to be high since most species cross at heights that put them in the paths of vehicles (e.g. Verboom and Spoelstra 1999; Gaisler et al. 2009; Russell et al. 2009; Berthinussen and Altringham 2012b). Bats may waste time and energy by commuting greater distances, either away from the road to find new foraging sites, or to find 'safe' crossing points along the road to commute to their original foraging sites. All of these outcomes will reduce the reproductive output of nursery colonies (e.g. Tuttle 1976; Kerth and Melber 2009). Alternatively the colonies may relocate away from the road, into habitat that is presumably already fully exploited by other colonies. All 'solutions' will lead to a fall in bat density near to the road. The overall fall in habitat quality will most likely lead to reduced reproductive success and increased adult mortality and in long-lived bats these will have a profound effect on local colony size and overall population size (Sendor and Simon 2003; Papadatou et al. 2011).

Given the magnitude and spatial scale of the effects on bat activity and diversity observed by Berthinussen and Altringham (2012a), it is likely that barrier and edge effects, together with increased roadkill are having a strong negative effect on the demographics and distribution of local bat populations in proximity to major roads. Similar effects have been found in other vertebrates. Reijnen and Foppen (1994) showed that a decreased density of willow warblers up to 200 m from a major highway was due to the negative influence of the road on population sizes, with reduced breeding success and increased emigration of territorial males. Studies on breeding grassland birds revealed a decrease in density of seven out of 12 species, with disturbance distances up to 3500 m from the busiest roads (50,000 vehicles per day), with collision mortality being a major contributor (Reijnen et al. 1996). A meta-analysis of 49 studies that between them investigated 234 bird and mammal species, found that bird population densities declined up to 1 km, and mammal population densities declined up to 5 km from roads (Benítez-López et al. 2010).

3.2.8 Secondary Effects—Infill and Increased Urban and Industrial Development

Bypasses are frequently built in the countryside to divert traffic around rather than through population centres, to reduce congestion and improve the environment for people in the town or village. In addition to the direct effects of the road itself, there are frequently other consequences. The typically narrow strip of land between the settlement and the new road may be too small to support viable bat populations. This land is also frequently taken over by residential and industrial/commercial development and indeed this development is often part of the initial plan. This leads to further loss and degradation of habitat and a direct increase in traffic. Many of the secondary effects of roads are more severe in the tropics (Laurance et al. 2009), where roads allow people easy access to the remaining undisturbed habitats, which as a consequence suffer further degradation and an increase in the hunting pressure for bush meat, including bats.

3.3 Can Roads Benefit Bats?

Although the balance of the impact of roads on bats is clearly strongly negative, there are potential benefits.

Roosts Some of the ancillary structures built with roads, in particular bridges (e.g. Keeley and Tuttle 1999), can provide roosts for bats. Road bridges over water or wooded valleys are the most likely to be used, those over busy roads much less so. Old stone road bridges over water are widely used by bats, most notably by Daubenton's bat in Europe, but also other *Myotis* species and by *Nyctalus* species (e.g. Senior et al. 2005; Celuch and Sevcik 2008; Angell et al. 2013). In North America bridges are widely used by Brazilian free-tailed bats, *Tadarida brasiliensis* (e.g. Allen et al. 2011) and some other species (e.g. Bennett et al. 2008). Effective mitigation and compensation for the loss of roosting and foraging sites will make the environment close to a road more attractive to bats, but may do so at the expense of greater risk of collision with traffic.

Light Artificial light, particularly short-wavelength light such as mercury-vapour (not most LED lights) attract insects that are common prey to bats. Insect swarms around lights are exploited by open-air foraging bats such as *Pipistrellus* and *Nyctalus* (Rydell 1992; Blake et al. 1994; Stone et al. 2009, 2012). One consequence of this is that bats feeding around lights on busy roads may be at significantly greater risk of mortality from collision with traffic. The balance between the positive and negative effects will be dependent on species, topography, the position of lights, etc. and further study would be useful. A very thorough discussion of the positive and negative effects of artificial light can be found in the chapter by Rowse et al.

Flight corridors In rural environments roads are often bounded by hedgerows or treelines. The wide verges often associated with hedges in landscapes managed for wildlife can be among the most species-rich habitats in some agricultural areas. Minor roads in particular can therefore be both foraging sites and commuting routes, but even major roads are used by some species (e.g. *Nyctalus leisleri*, Waters et al. 1999) where they are bounded by suitable habitat such as a woodland edge. Depending upon structure, this habitat could be used by a wide range of species. However, Bellamy et al. (2013) found that even low road densities had a negative effect on most species of bats, most noticeably the woodland-adapted species *Myotis* and *Plecotus*. Only the distributions of common pipistrelles and noctules had a positive association with roads at low to moderate densities and only when in close proximity (<100 m) to woodland. A similar result was found for railway verges (Vandevelde et al. 2014). As road density increased above moderate levels, the probability of presence of all species declined. The effects of roads of different classes have yet to be investigated in depth—the roads in this study were predominantly minor and rural.

3.4 Conservation in Principle: Avoidance, Mitigation, Compensation and Enhancement

In many countries, legislation has been passed stating that infrastructural development should be carried out in such a way as to minimise the impact of development on the environment, and on protected species such as bats in particular. In principle, there should be no net loss to the environment. In the European Union this is formalised in the Habitats Directive (Council Directive 92/43/EEC). In practice, the system is usually flawed, sometimes severely, due to a lack of knowledge, resources and commercial and political will. Poor goal-setting, planning and execution contribute to either failure, or the absence of any evidence for success, for all wildlife (Tischew et al. 2010) and bats in particular (Altringham 2008; Berthinussen and Altringham 2012b; Stone et al. 2013). As in many other areas of conservation a more scientifically robust, evidence-based approach is urgently needed. European policy and practice also involve a hierarchal approach, starting with avoidance of environmental damage, moving to mitigation when damage is deemed to be unavoidable, then compensation when mitigation is not possible or only partial. Finally, there is an increasing expectation that replacing like with like is not enough, particularly given the uncertainty of success in mitigation and the continued loss of biodiversity. When habitat is lost or degraded, some level of habitat enhancement must accompany development so that in principle, the habitat is better than it was before development. The reality is less than perfect.

The first step in a conservation strategy to minimise the impact of a new road should be to select a route that avoids important bat habitat. To be effective this requires an understanding of the behaviour and ecology of the affected species and detailed knowledge of their distribution. Our knowledge in both areas is growing but far from complete. One approach that can deliver detailed, site-specific information relatively quickly is GIS-based HSM, which can be based on existing data sets, such as those held by museums and record centres (e.g. Jaberg and Guisan 2001; Bellamy and Altringham 2015) or data collected specifically for the purpose, for example by acoustic survey (e.g. Bellamy et al. 2013). This approach yields fine scale distribution maps of probability of occurrence for each species with an estimate of reliability, providing a useful practical tool. However, the route that best avoids bats may not meet human social and economic criteria, particularly if conservation is undervalued. The next step is therefore to build the road in such a way as to mitigate against its effects—that is remove or minimise the many detrimental effects described above. In principle, mitigation under European legislation (Habitats Directive, Council Directive 92/43/EEC) reduces ‘damage’ to a minimum that is consistent with maintaining bat populations in favourable conservation status.

Where significant loss cannot be avoided, it is expected that compensation will provide alternative roosting and foraging habitat to at least make good the loss. The expectation now is that there is in fact habitat enhancement, to allow for uncertainties in mitigation and to promote long-term habitat improvement.

In practice, avoidance and mitigation are compromised by competing operational and financial constraints. Furthermore, for practical and economic reasons, habitat restoration and creation are long-term processes and it may be many years before these sites are useful to bats, by which time a disturbed bat colony may have been lost. As we will show in the following section, the absence of adequate and well-planned survey and monitoring means that the consequences of road-building and the effectiveness of current avoidance, mitigation, compensation and enhancement practices are all largely unknown (Altringham 2008; O'Connor et al. 2011). In some cases, they have even been shown to be ineffective (Berthinussen and Altringham 2012b).

3.5 Conservation in Practice

We are not aware of any cases in which proposed roads have been rerouted to avoid key bat habitat. Almost all work in this area concerns attempts to remove or minimise the damaging effects of roads. This has usually involved building structures that aim to guide bats safely under or over roads to reduce both the barrier effect and roadkill. The structures built may be multifunctional, for example underpasses for people and wildlife, and use by bats has often been an incidental and unanticipated use of structures built for other purposes, such a drainage culverts. Additional features include tree and hedge planting to guide bats towards crossing points, modified lighting schemes to achieve the same ends or deter bats from crossing at dangerous locations and a wide range of more general 'enhancements' to improve roosting or foraging opportunities.

3.5.1 Over-the-Road Methods: Gantries, Green Bridges, Hop-Overs and Adapted Road/Foot Bridges

Bat bridges or 'bat gantries' have been built on many UK and continental European roads in recent years. However, the most widely used design (Fig. 3.5) in the UK does not help bats to cross the road safely, even when on the line of pre-construction flyways and after up to nine years in situ as shown in Fig. 3.6 (Berthinussen and Altringham 2012b). Other designs have yet to be tested effectively. Berthinussen and Altringham (2012b) found that only a very small proportion of bats that approached gantries 'used' them (i.e. flew in close proximity to them) and for those that did, their flight paths were not raised above the traffic collision zone (Fig. 3.6). This failure of a widespread design highlights the need for effective monitoring and assessment to be an integral part of mitigation practice.

Overpasses built to carry minor roads or footpaths appear to be largely ineffective (Bach et al. 2004; Abbott et al. 2012a) and certainly less effective than underpasses as crossing points (Bach et al. 2004; Abbott et al. 2012a). Most of the structures evaluated have been no more than footbridges and road bridges, with no adaptations to encourage bats, such as tree or shrub planting or careful design of lighting. To date studies have assessed only use, not effectiveness, in that the criterion for success in most studies has been use by an unspecified proportion of bats. A more useful approach would be to assess what proportion of bats crossing a road do so with the aid of crossing structure (Berthinussen and Altringham 2012b).

Fig. 3.5 The most common bat gantry design in the UK—steel wires with plastic spheres at intervals that are intended to be acoustic guides for bats

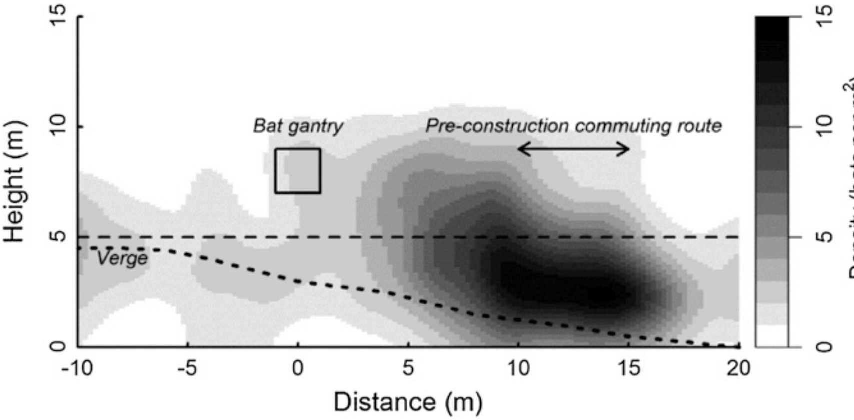

Fig. 3.6 Bat crossing activity at a 'bat gantry' that had been in place for nine years. Gaussian kernel and bandwidth of 1 m used (n = 1078). The gantry is located at distance 0 m on the x-axis, with distance from the gantry increasing to the *left* and *right*. The height of the gantry is marked by the *square* at 0 m, and the pre-construction commuting route is 10–15 m to the *right*. 'Unsafe' crossing heights are located below the *dashed line*, which is the maximum vehicle height in Europe. The *dotted line* marked verge shows the decrease in verge height above the road from *left* to *right*. From Berthinussen and Altringham (2012b)

Land or green bridges have been designed and built specifically for other wildlife, and if planted with tall vegetation and linked to existing bat flyways, they have obvious potential as bat crossing structures. As yet, few have been assessed, but bats have been shown to use one land bridge in Germany. Stephan and Bettendorf (2011) found that only a small proportion of woodland-adapted bats crossed a busy motorway using a new land bridge: most crossed the road itself at other locations. It will be interesting to see if bats adapt to it over time. Specific features of the design and connectivity to surrounding habitat of green bridges are probably critical factors for bat use—as they will be for other structures. Further research is required before conclusions can be drawn, but several features are likely to be positively related to use: their strategic location on known flightlines, connectivity to treelines, mature vegetation on the bridge, and bridge width.

'Hop-overs' (Limpens et al. 2005) have been put forward as a relatively low cost and unobtrusive way to encourage bats to cross roads at safe heights. These consist of close planting of trees up to the road edge on both sides of the road, with tall vegetation in the central reservation of wide roads. Branches should overhang the carriageway, ideally giving continuous canopy cover over the road. Safety concerns arising from overhanging branches may have led to reluctance to adopt hop-overs and even to remove trees from road margins. However, many roads have overhanging trees along their margins, so this is an illogical or at least inconsistent objection. The effectiveness of hop-overs has yet to be assessed. Russell et al. (2009) observed that bat flights across a 20 m road gap were at greater heights where bats approached the road along flight routes with taller roadside vegetation and Berthinussen and Altringham (2012b) found a positive correlation between road-crossing height and the height of the roadside embankment.

3.5.2 Under-the-Road Methods: Underpasses, Culverts and Other 'Tunnels'

Many studies show that a wide range of bat species use underpasses to fly beneath roads (e.g. Bach et al. 2004; Kerth and Melber 2009; Boonman 2011; Abbott et al. 2012a; Berthinussen and Altringham 2012b). However, most of these studies report only that a small number of bats of particular species were seen to fly through an underpass. In some cases not reported here underpasses were monitored using automated bat detectors with no guarantee that detected bats actually flew through the underpass. For an underpass (or indeed any other mitigation structure) to be effective it must help to maintain bats in favourable conservation status. That is, it must protect the population, not a few individuals, by making a road permeable and safe to cross. Assessing abundance, let alone changes in abundance, is very difficult without considerable survey effort. It is also difficult to measure changes in the permeability of a road to bats without monitoring a very large proportion of the bats in the vicinity of a newly built or upgraded road. Ideally, we would need data before the construction of the road and compare them with data after the road had been built. However, it is possible to determine whether the majority of bats at a location use an underpass (or bridge, gantry, etc.) to cross a road safely. Despite the existence of three underpasses within a 5 km stretch of motorway bisecting a forest, resident Bechstein's bats rarely used them and lost access to important roosting and feeding habitat (Kerth and Melber 2009). Lesser horseshoe bats made frequent use of three underpasses along a 1 km stretch of motorway, but 30 % still crossed directly over the road at traffic height

(Abbott et al. 2012b). Some bats have been recorded making extensive detours to avoid crossing roads (e.g. Kerth and Melber 2009 and references cited in Bach et al. 2004), but we do not know how prevalent this behaviour is: many bat species appear reluctant to deviate from their original flight paths after road severance (Kerth and Melber 2009; Abbott 2012; Berthinussen and Altringham 2012b). Where a road cuts through a dense network of flight routes it may not be straightforward providing a population with an adequate number of safe crossing points. Efforts to re-route bat flight paths, for example by planting new hedgerows linking old routes with new underpasses, should be undertaken well in advance of road clearance, and ideally tested for effectiveness before road opening. Bats were not diverted effectively to underpasses studied by Berthinussen and Altringham (2012b): the great majority of bats flew over the road, near to the original commuting routes. In the same study, one underpass on a known flightline was used by 96 % of the bats on the commuting route.

Underpasses are more likely to be used if they are well connected to the landscape by treelines, hedges or watercourses (Boonman 2011; Abbott 2012), but there is scope for further study in this area. Where possible, they should be located on pre-construction flight routes and tall enough to allow bats to pass without changing flight height or direction (Berthinussen and Altringham 2012b). Even with these precautions, a high proportion of bats may ignore the underpass and fly over the road above it, particularly if the underpass is too small. Underpass height, more than width, was the critical dimension determining the number of bats flying through underpasses in studies in Ireland (Abbott 2012; Abbott et al. 2012a, b). Required heights of underpasses will generally be lower for woodland-adapted species (~3 m) compared to generalist edge-adapted species (~6 m), and open-air species are more likely to fly high above roads. For small gleaning bat species, such as some *Myotis* species, which generally have small home ranges, it may be beneficial to build a higher number of small underpasses (Fig. 3.7) along a road instead of a few large underpasses, which then would by located outside of the home range of most individuals. Mitigation practice would benefit greatly from objective testing and reporting to determine if underpasses are actually providing safe passage for a high enough proportion of bats to protect a local population.

Bats can potentially make use of underpasses that are used by people during the day but have little use at night, such as pedestrian underpasses, minor roads, railways and forestry or agricultural tracks. Use could be maximised by restricting lighting in and around these underpasses, placing them on tree and hedge lines, and making smaller wildlife underpasses or drainage culverts larger to accommodate woodland-adapted bat species. Provision of well-placed, numerous and spacious underpasses should be integral to the overall design of road mitigation, particularly near major roosts. Roads built on embankments are likely to be particularly dangerous to bats, particularly when they sever treelines, since bats appear to maintain flight height on leaving the treeline, bringing them into collision risk over raised road sections. These sites are ideal candidates for underpasses, since they can be built relatively cheaply.

Fig. 3.7 A bat of the genus *Myotis* using a small underpass (about 2 m in diameter) to cross a motorway in Germany. Above the underpass, a wall was built to prevent bats from flying directly into the traffic. Similar walling/fencing has been used in the UK but has not yet been shown to be effective (e.g. Billington 2001–2006)

3.5.3 Light Avoidance

To reduce the potential for disturbance of roosts, flight routes and feeding sites lighting is often directed down toward the road surface, and light spill into the surroundings is minimised. However, since the most vulnerable bats, such as *Rhinolophus* species, fly close to the ground, downward pointing lighting may still have a significant impact on their behaviour. Restricting lighting in crossing structures such as pedestrian underpasses could increase their use by bats. In addition to choosing the intensity, wavelength and direction of lighting, it could also be controlled be timers and motion sensors. Lighting at river and stream crossings should always be avoided, as these are particularly important foraging areas and commuting routes for bats.

Conversely, light may be used to purposely deflect bats away from a dangerous flight route toward a safe crossing point. This has been done, but has not yet been tested for effectiveness and may exacerbate any barrier effect. This assessment is important not only to protect bats, but other wildlife too, since many species avoid light.

3.5.4 The Importance of Connectivity and the Maintenance of Existing Flightlines

An important consideration that is frequently referred to is the need to maintain existing flightlines. There is evidence to support this and it is clearly a sensible precaution. As discussed above, Berthinussen and Altringham (2012b) found that an underpass on a pre-existing flightline was used by 96 % of the bats crossing the road, but attempts to deflect bats to two other underpasses displaced from known routes were not successful.

An extension of this is the general recommendation to maintain and enhance a 'connected' landscape, i.e. a landscape with a broad range and high density of interconnecting linear features such as hedgerows and treelines. This would not only increase the value of the landscape for foraging and commuting, but may give bats more flexibility in how they adapt to a changing landscape and in particular the appearance of barriers in the form of roads. This makes intuitive sense, given the known behaviour of many bat species, and there is a growing body of evidence based on spatial analysis to support it (e.g. Boughey et al. 2012; Bellamy et al. 2013; Frey-Ehrenbold et al. 2013; Bellamy and Altringham 2015). These studies highlight, using different approaches, the importance of these features to bats, and also reveal species differences: woodland-adapted species (e.g. *Myotis*, *Plecotus, Rhinolophus*) and small generalists (e.g. *Pipistrellus*) make more use of (and are more dependent upon) these features than larger open-air species (e.g. *Nyctalus*, *Eptesicus*).

3.5.5 Habitat Improvement and Effective Landscape-Scale Planning

Some general forms of mitigation not specifically related to roads are also relevant, such as the planting of trees and the creation of ponds to replace lost habitat or enhance existing habitat as compensation for damage done by roads. Berthinussen and Altringham (2012a) have shown that the effects of major roads are less easily detected in high quality habitat. This is not a reason to build roads in high quality habitat, since a greater number of bats will still be affected than alongside a road through poor habitat, and the species affected may be more vulnerable. However, it is a reason to attempt to mitigate and compensate using habitat improvement, when a road is built in good habitat. Improvements must not increase roadkill or the costs may outweigh the benefits, so habitat design will be an interesting challenge.

Habitat improvement methods have not been tested effectively, so the scale of the benefits is generally unknown. Habitat improvement and creation obviously have the potential to be beneficial if done on an appropriate scale, but are unlikely to be effective in the short or even medium term, since new woodland and wetland take many years to become established. Over the time taken for habitat to mature, bat colonies may be lost, so long-term planning is needed. Considerable financial incentives may be needed to persuade landowners to undertake habitat improvement. Woodland and wetland creation are more likely to be used for compensation and enhancement than direct mitigation.

As discussed earlier, the Habitats Directive stipulates that in preparing development plans, the avoidance of damage is the preferred option. Mitigation and compensation should only be considered when alternative sites, routes or methods are unavailable and the avoidance of damage is not possible. There must also be over-riding social, economic or safety reasons for development. The planning of new road and rail routes now makes extensive use of GIS-based techniques to assist in the evaluation of the many factors involved. However, the environmental components of these analyses often rely on limited and biased data and do not take full advantage of the developing GIS and modelling techniques described earlier. GIS-based HSM is becoming widely used in ecology. HSM uses the detailed relationships between bat presence and habitat variables to build detailed and accurate distribution maps from relatively small datasets. Bellamy et al. (2013) and Bellamy and Altringham (2015) have used HSM to produce high resolution, accurate predictive maps of the distribution of eight bat species in the Lake District National Park. Similar maps have been, and are being, prepared for other protected areas. These techniques determine the associations between bats and their habitat over multiple spatial scales to give greater accuracy and ecological insight. As our knowledge of bat distributions improves, we will be in a better position to identify those routes that will have minimum impact on bats, and better able to devise appropriate mitigation strategies.

3.5.6 Rail

The effects of rail systems on both bats and other wildlife are even less well understood than those of roads. However, intuitively they have characteristics that may reduce their impact on wildlife. Rail systems are often (but not always) narrower than roads, giving them a smaller footprint and potentially creating a less-effective barrier to animal movement. Trains pass a given point on a network much less frequently than vehicles on roads, which are often continuous. On the busy East Coast line in northern England train noise was detectable for only 8 min/h and this noise decreased to background levels over very much shorter distances than road noise (Altringham 2012). It is nevertheless important that the effects of railways are assessed objectively, particularly in view of the proposed new HS2 line in England, on which trains will travel faster and more frequently. In a study on bat activity of railway verges, Vandevelde et al. (2014) found that bat of the genus *Myotis* seem to avoid the vicinity of railways whereas species foraging in more open space such as pipistrelle and noctule bats use railway verges as foraging habitat.

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File No. BR1197

January 21, 2016

Heritage Speed River Working Group
c/o Laura Murr
123 Downey Road
Guelph, ON N1C 1A3

Dear Laura

Re: Niska Road Bridge, Guelph

At the request of the Heritage Speed River Working Group, a site review of the Niska Road Bridge was conducted by B. M. Ross and Associates Limited. This report describes the observations, conclusions and recommendations that come from that site review.

The Bridge carries Niska Road over the Speed River at the boundary between the City of Guelph and the Township of Puslinch. It is understood that the bridge is owned by one or both of these municipalities. The Working Group has a special interest in the bridge and requested that BMROSS consider the feasibility of maintaining the existing bridge as a pedestrian bridge with use by bicycles and maintenance equipment. This report is independent of any Ontario Structure Inspection report, (OSIM) and should not be taken as a substitution for an OSIM report. Discussion on strength and deterioration is strictly related to opinions on the original condition and strength of any components. No structural analysis was made of any component.

Background of Structure

Engineers reports were made available from 1994, 1997 and the OSIM report from 2012. A review of these reports suggests that a previous superstructure collapsed in 1974 and the current steel panel truss bridge was installed in 1974 or 1975. Timber decking was replaced in 1996 and 2003. Steel stringers were replaced in 1996. Cross beams and other truss components were replaced in 2003.

The abutments are constructed of rough-cut limestone blocks and mortar. Although a date of construction was not provided, this style of construction was typically used for railway bridges in Wellington County since 1855 and for road bridges from 1867. Local history suggests that concrete was in use by 1895 and that the 1909 replacement of the bridge at Puslinch Sideroad 10 used concrete abutments. Based on this local history, it is likely that the stone abutments of the Niska Road bridge were built about 1900. Any of the original wingwalls are hidden or replaced by other retaining structures.

The wingwalls are made of concrete slab masonry with grout joints and are likely much newer than the abutments. Since 1997, precast concrete blocks were placed at the northwest wing to protect against some erosion reported there.

Site Review

The site review was made on December 12, 2015 by Andrew Ross, P.Eng. The site review was visual and tactile only. No material samples were taken or tested on site.

At the time, the water was at normal, or below normal levels. Using chest waders, access was available under the full span and width of the deck. No inspection vehicle or swing stage was used, so no tactile examination was available for most of the deck soffit or floor beams. This scope of inspection appears to match that available for the 2012 OSIM inspection.

Some dimensions were confirmed for use in calculating probable costs. Otherwise, dimensions from the OSIM report were used.

Observations, Recommendations and Conclusions

In general, the bridge spans 24.6 m east-west over the Speed River. Niska Road is very busy with a daily traffic count of about 3,700 vehicles in 2012 but the bridge is only a single lane width and a 5 tonne load limit. The superstructure is a half-through panel truss bridge with steel floor beams and a timber deck. The newer truss structure was set on older, cut stone abutments.

The bridge is likely salted in the winter, as is required for road safety. This is accelerating the rate of corrosion. Some steel and timber elements have been replaced. It is assumed that changing the service of the bridge to pedestrian only would mean that de-icing chemicals would no longer be used. In fact, snow storage may be desired for skiing or snowmobile use. The best way to extend the service life of this bridge would be to cease the use of salts.

The 2012 OSIM report that was made available and has a number of observations and measurements of elements. For this current report, observations were made with a view to maintaining or rehabilitating the existing structure and forecasting the probable cost of repairs to elements. Considering this, the following observations are noteworthy.

Railings

The panel trusses act as traffic barriers and railings. There are steel beam guide rails on the approaches but not over the deck. There are timber plank rub rails located just above the curbs. These may be a safety feature for bicycles or snowmobiles.

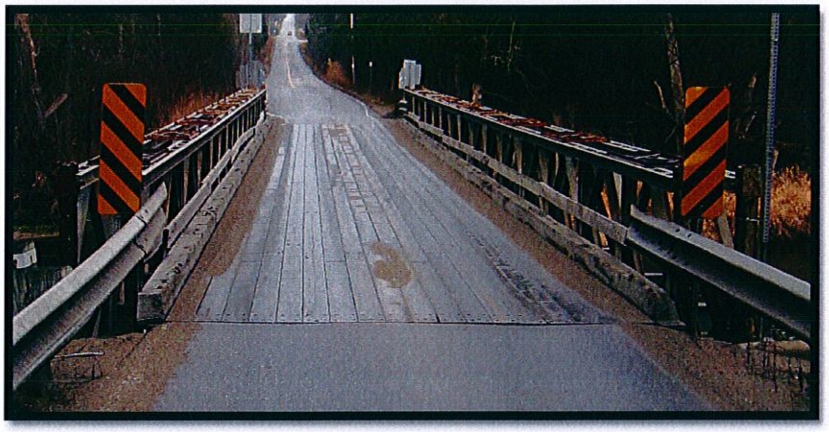
The top of the trusses measure 98 cm above the deck level. By the bridge code, pedestrian railings should be 105 cm above the deck and bicycle railings, (or combination railings), should be 137 cm above the deck.

The bridge owners should consider if the heritage appearance of the bridge over-rides the need for an increase in railing height. Assuming that code compliance would be desired, the probable costs will include the addition of a galvanized steel pipe rail and mounting posts to increase the railing height by about 40 cm.

Deck and Curb

The deck and curb are made of timber and are in fair to good condition. In their current state, no work would need to be done to replace them for use as a pedestrian bridge. Wood deck elements have a short service life because of abrasion from vehicle tires. The service life remaining will depend on how many years of vehicle traffic are continued.

The steel deck stringers supporting the timber is in a deteriorated condition. The service life of the wood deck will depend on the steel stringers beneath. When the steel stringers are replaced, it would be a good time to include new wood decking and curbs since they have to be physically removed anyway to access the stringers.



Trusses as railings, timber deck and curbs

Deck Beams

Supporting the wood deck are a series of 100 mm high steel stringers and 17 cross beams that are about 260 mm high. The steel stringers were reported to be in poor condition in the 1994 report and are assumed to have been replaced. However, they are now in fair-to-poor condition again with scaled rust evident. They should be replaced in about 5 years if the bridge is to continue for vehicle traffic; about 10 years for pedestrian traffic.

The steel cross beams have been replaced since 1994. The existing ones are hot-dip galvanized and have not rusted badly yet. They do show stains from the rusting of the stringers above. Currently, there is no need to repair or replace these cross beams.

Corroded stringers, stained cross beams

Trusses

The modular panel trusses are showing some light rusting. They appear to have been protected with zinc galvanizing and no loss of strength was observed. Only the end post braces showed significant rust so a repair should be budgeted for this.

Bearings

The truss structure has two bearings at each abutment. These were covered in debris at the time of the site review and are likely seized or corroded. It is recommended that new bearings be placed and protected. This need is not immediate and could be done in about 5 years.

Ballast Walls

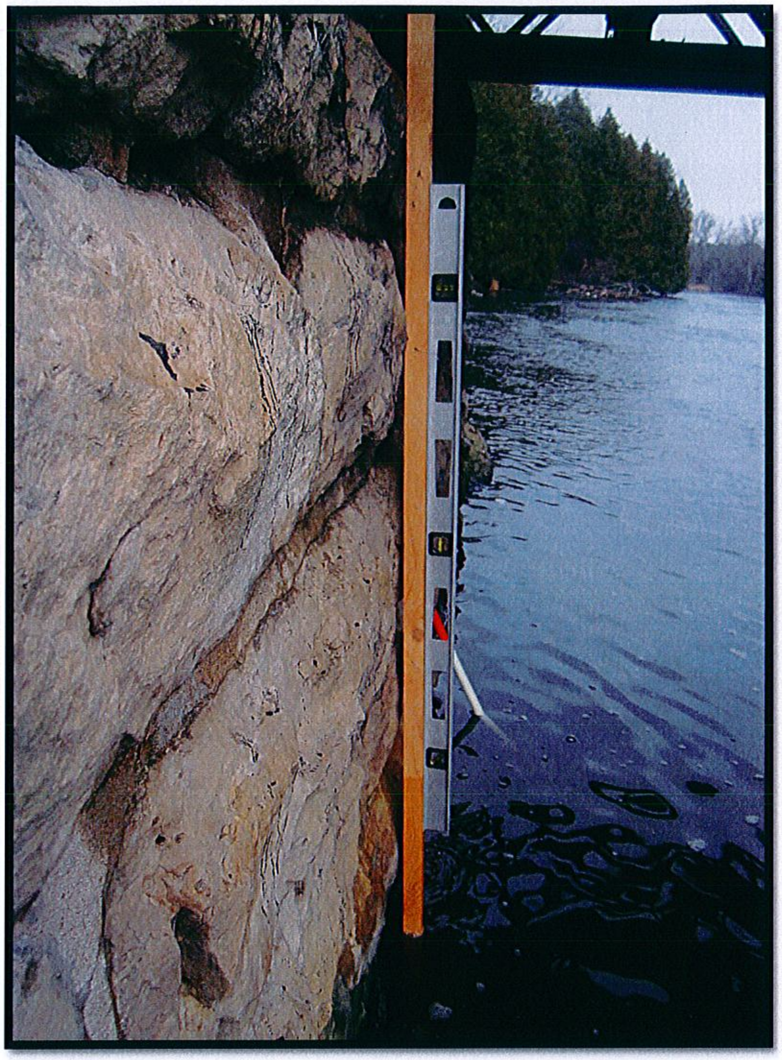
The ballast walls are the part of the abutments above the bearing seat that hold the road fill from spilling onto the bearings. These are made from timbers stacked on each other and have not been effective. Road fill has spilled through and the condition of the timber could not be determined. The next time that the approaches are re-surfaced or the deck is replaced, concrete ballast walls should be constructed to protect the bearings and the ends of the trusses.

Debris on bearing seat, timber ballast wall

Abutments

The abutments are made from rough-cut stone masonry forming a gravity retaining wall. It is estimated that about 30% of the mortar joints are in need of re-pointing. A soft, lime-rich mortar should be used. Some stone faces of the lower course of the east abutment have spalled about 100 mm deep. The area of spall is less than one square meter. These stones could be re-faced or replaced with new stones. Repairs should be done within about 5 years to prevent further loss of mortar or shifting of individual stones. Repairs will likely require some localized dewatering.

Both abutments are in good alignment and we could not observe any settlement or rotation. In fact, both abutments displayed a back-batter of about 5%. Typically, a designed back batter is about 1 in 12, or 8%. It is possible that the designer used 1 in 20 batter, or 5%. This shows that rotation has been very slight, if at all.



Masonry abutments still display back-batter.

An interesting feature of the abutments is that the upstream corners of both abutments use rounded stones to improve the hydraulic entrance to the bridge. This is a feature that we have not seen on other stone abutments and demonstrates a level of care in the design and construction.

Mortar loss at west abutment

Wingwalls

The stone abutments appear to be about 1.6 m thick. Independent masonry retaining walls are used as wingwalls at all four corners. These appear to be made of concrete slabs with a cement grout between units. The concrete slabs may be re-used sidewalks. Regardless, the retaining walls appear to be serving their purpose and no immediate repairs are evident. Some re-pointing with mortar or stiff grout could be done to maintain the condition of the walls. Vegetation should be removed as root growth will crack the walls.

The unreinforced masonry wingwalls are unlikely to pass analysis as structures to retain soils under prescribed loads. However, their successful long service life and current stability demonstrates that the internal properties of the earth fill have limited lateral pressures to acceptable levels. It will be important to enforce vehicle load limits and maintain a surface that prevents a significant amount of water from infiltrating into the backfill.

The owners should regularly inspect these retaining walls for signs of displacement or rotation. Stability could be improved by reducing the backfill (road), or ramping earth against the exposed sides. Alternatively, replacement with engineered systems such as modular block retaining walls could be use.

The northwest wingwall has been bolstered by pre-cast concrete blocks that were recommended in a 1997 report, to resist erosion by the river flow. The blocks were grouted together and an apron of grout resulted at the base. That grout apron is now undercut about 0.15 m high and 1.2 m deep.

Undercut at NW corner

This undercut is not an urgent problem as the scour has not reached the location of the original wing wall. However, swift currents at the bridge entrance may continue to work at the soil here and the existing scour may get deeper. It would be prudent to protect the concrete blocks and apron with a flexible mat of natural stone riprap that extends down to the level of the river bottom to prevent undercutting.

General

Based on the sum of the observations above, it is our conclusion that there are no urgent needs for this bridge at the present time. If it was converted to pedestrian use immediately, the only consideration might be for the installation of a higher handrail to meet code. However, the bridge carries pedestrians and cyclists now so the need is not a new one.

As a pedestrian bridge, a rehabilitation program should be considered in the range of 5 to 10 years that would see a replacement of deck stringers and planks, repairs to the stone abutments, replacement of bearings and ballast walls. The replacement of the deck also provides an opportunity to clean the bridge structure of residual salts. This will not be entirely successful as chlorides will still remain in laps, bolts and junctions. However, a thorough pressure wash program and cessation of any further salt applications will improve the service life of the bridge.

With such a repair program completed, the bridge may have a further 30 years of service life as a pedestrian bridge. It is likely that the 5 tonne load limit would still apply to service or maintenance vehicles. After 15 years, some repairs should be expected for more mortar pointing of the abutments, replacement of deck planks, and possibly some truss components.

A truss bridge like this one requires on-going maintenance including: cleaning of bearing seats and truss chords; replacement of worn or decayed wood decking; removal of vegetation. All bridges should be reviewed every two years under the supervision of a professional engineer.

Recommended Rehabilitation Program

The following outlines a program to rehabilitate the bridge for pedestrian and bicycle use. It is based on observations from December 2015 and valued in Canadian dollars for 2016. If delayed, inflation factors should be applied to the fiscal value and the quantity of deterioration, especially where de-icing chemicals are continued.

1. Mobilization, site access, demobilization	$ 20,000
2. De-water at abutments for repairs	$ 9,000
3. Replace spalled stones 1 m^2 @ $7,000	$ 7,000
4. Re-point stone masonry joints 72 m @ $120	$ 8,700
5. New deck timbers and steel stringers, 90 m^2 @ $720	$ 64,800
6. Pressure wash and environmental protection	$ 9,000
7. Remove and replace ballast walls	$ 14,000
8. Excavate, install drains, backfill	$ 8,000
9. Erosion control, NW corner	$ 6,000
10. Add handrails to trusses	$ 14,000
11. Replace bearings, 4 @ $4,000	$ 16,000
12. Replace truss end braces, 4 @ $2,500	$ 10,000
13. Allowance for repairs to concrete masonry retaining walls	$ 5,000
14. Contingency allowance	$ 20,000
15. Bonding and insurance	$ 6,000

Sub-total construction	$217,500
Permit and obtain approvals	$ 5,000
Design, contract and tender	$ 19,000
Construction review and contract administration	$ 16,500
Total probable cost	$258,000 + HST

This opinion of probable costs is appropriate to use to the end of 2017, after which point the bridge condition and costs should be reviewed again. A more accurate budget could be calculated after completion of preliminary design drawings and specifications and meetings with the bridge owner to define the scope of work. Such a budget refinement is recommended before applying for any grant funds.

Note that this probable cost is just for the rehabilitation of the bridge for use as a pedestrian and bicycle crossing. No allowance has been made for re-paving the approaches or providing road features such as barricades, parking or turning areas.

LICENSED PROFESSIONAL ENGINEER
A. I. ROSS
JAN 22/16
PROVINCE OF ONTARIO

The above is respectfully submitted.

B. M. ROSS AND ASSOCIATES LIMITED

Per ____________________
A. I. Ross, P. Eng.

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Science News *from research organizations*

Roads 'a serious threat' to rare bats

Date: June 6, 2016

Source: University of Exeter

Summary: Roads present a serious threat to bat populations, indicating that protection policies are failing, say scientists. Interestingly, the study found that male bats were considerably more likely to be killed in collisions than females.

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FULL STORY

Roads present a serious threat to bat populations, indicating that protection policies are failing.

The University of Exeter experts studied data collected across Europe and concluded that roads present "a real and growing danger" to protected bat populations. The research, funded by the Natural Environment Research Council (NERC), concluded bats were often reluctant to cross roads, disrupting their ability to reach feeding and roosting areas. The group also identified more than 1,000 bat fatalities caused by collisions with cars.

Dr Fiona Mathews, Associate Professor of Mammalian Biology at

Dr Fiona Mathews, Associate Professor of Mammalian Biology at the University of Exeter, said: "There has already been concern about roads severing the commuting routes of bats. Our research has now shown that road fatalities are also an important issue, particularly when rarer species such as barbastelle and horseshoe bats are affected.

"Because bats and their habitat are now highly protected throughout Europe, we might think that there is no cause for concern and there has been widespread media interest in the public money spent on 'bat bridges' and acoustic surveys for bats. Unfortunately these measures are often more of a box-ticking exercise than a means of offering real protection. We know from our research that bat casualties are extremely difficult to find on roads because of their small size: the true collision rate will therefore be at least an order of magnitude larger than that actually observed."

Interestingly, the study found that male bats were considerably more likely to be killed in collisions than females. Dr Mathews, who is who is also chair of The Mammal Society said: "The males may be forced into less favourable habitats near roads, as females tend to stick together in breeding grounds in prime habitat. "

The study, the first of its kind, has just been published in the academic journal *Mammal Review*.

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Dr Mathews said that the findings are particularly pertinent given the rate of new road building planned for the UK. "The UK Government currently has plans in the pipeline to spend more than £15 billion on new roads, including more than 400 miles of new motorway and road-widening schemes," she said. "Across Europe as a whole, an average of 70,000 km [43,500 miles] of new roads are built every year."

Dr Mathews said her research indicates that there is "no cause for complacency" in terms of the protection offered to bats in the UK and Europe. "We need a lot more consistent research on the real effects of road-building on bat populations. It is not enough to spend a lot of money on bat surveys if they are not carried out scientifically and consistently. We need to know a lot more about how roads affect bats. For example, tree lined minor roads posed less of a barrier to the movement of bats, but also increased the risk of collision with vehicles. Closed tree canopies might therefore encourage the bats to fly higher and remain safely out of the path of oncoming traffic. For major roads, wide green bridges and underpasses at points previously identified as commuting routes may be required."

"Roads and Bats, a meta-analysis and review of the evidence on vehicle collisions and barrier effects" by Amy Grace Fensome and Fiona Mathews, published in *Mammal Review* May 29, 2016.