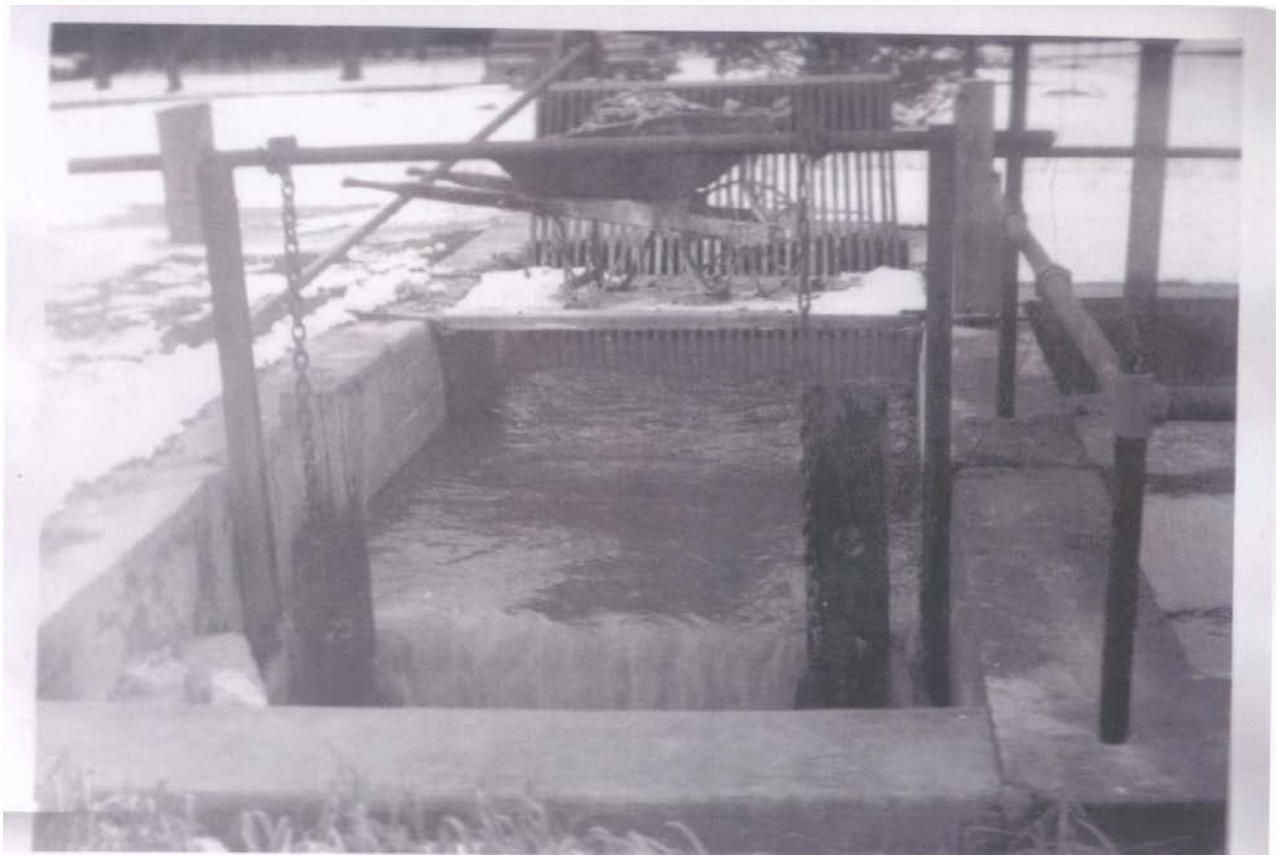
City of Guelph
Wastewater Treatment



The Historical Perspective

Prologue

> History: *A chronological record of events, as of the life or development of a people or institution, often including an explanation of or commentary on those events.*

It was in the fall of 2001 when we began our journey into discovering the history of wastewater treatment in the City of Guelph. We quickly learned that this was not going to be an easy task, as historical records on wastewater were not in abundance. Periodically dedicating time over 18 months saw us wind along a very fascinating path. As well as coming across some very old and interesting documents, we also met some new faces and were reacquainted with some familiar ones. We feel we have been rather successful, and thorough in discovering the available information for this project. We could not have gathered the amount of information we have without the help of many. Assistance from the City of Guelph Clerks division and Waterworks department was very much appreciated. In particular, we would like to acknowledge Ms. Kathleen Wall (Guelph Museums) for her help in attaining some of the fantastic facility pictures. Also to Mr. Steve Robson (CH2M Hill), for all of his efforts that went into preparing a very successful visit for us, at the CH2M Hill Toronto Office. Last but not least, to Mr. Wayne Key, plant superintendent, for his interest and full support of this project, from its' inception to completion.

Everyone has heard of being in the right time at the right place. We are so pleased that we were in this right time and right place, so we could be the ones to be the first to document a complete history of wastewater treatment in Guelph. The timing could not have worked out better as it has allowed all of us to celebrate 100 years of environmental stewardship.

Enjoy!

John DenHoed, Tim Robertson

May 31st 2003

TABLE OF CONTENTS

Introduction

Wastewater treatment has really evolved over the past century. The discovery and realization in the late 1800's that illness and sickness could be passed through sewerage was the catalyst for the treatment of sewerage. In the early 1900's the City of Guelph began the daunting task of constructing a treatment plant, and a sewer infrastructure throughout the City. The plant is located on the west side of Guelph just north of the Speed River and west of the Hanlon Expressway, and serves a population of over 105,000 people. By the mid 1920's Guelph was one of four communities in Ontario using the activated sludge process. This progress has continued throughout the century, and the City now has a wastewater treatment plant that is capable of producing high quality effluent. Advancements in treatment options continue to be researched and developed, and Guelph's wastewater treatment plant is actively participating in a variety of these research and trial projects.

1900-1919

The continual breakout of different diseases such as cholera, typhoid, and dysentery within the City of Guelph highlighted the need for improved sewage handling. The population of Guelph in 1901 was approximately 11,500, and there was concern that the growth of the population was being restricted because of the lack of a sewerage system. In 1902, Dr. Howitt, the Medical Officer of Health, recommended that a sewerage system be put in place.

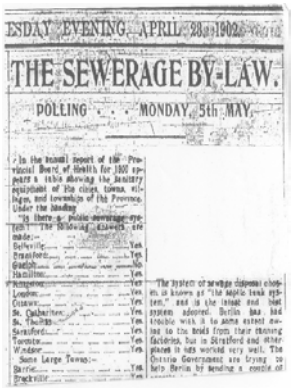
> "There is no question about the advisability of having sewerage, not only as a matter of public health, but as regards the future prosperity of the City. No doubt there are many people who would have located in Guelph if we had had sewerage—people of means. They will not locate in the town, no matter whatever other advantages we may have, unless they have modern conveniences in the way of sewerage."

Dr. H.O. Howitt, Medical Officer of Health.

The City engineer, Mr. Hutcheon, prepared plans and estimates for a sewerage system and these plans were approved by Dr. Bryce of the Provincial Board of Health. The system would consist of two septic tanks measuring 120ft. by 30ft by 7ft with a combined

capacity of 200,000 gallons. The effluent from these septic tanks would then flow into one acre gravel beds.

The Board of Trade voted in favour of supporting the sewerage system with 573 to 303 vote. Mr. C.H. Rust, an engineer, out of Toronto suggested in his report that the location of the sewerage system be at the south west end of town. The land below Sleemans was selected, but was actually in Guelph Township. The township agreed to allow the City to purchase the required land on the condition that a grove of Norway spruce trees be planted along the roadway to hide the view of the sewerage farm. The trees were planted then and are still lining the roadway to this day. The system itself would allow for sewage to flow to the sewerage farm through sewers and upon arrival be screened and go through 2 septic tanks where the watery effluent would flow into the gravel beds. It was determined that the average household produced 20 gpd at a strength of 3lbs of organics to every 200 gallons of water.


ESDAY EVENING, APRIL 28, 1902.

THE SEWERAGE BY-LAW.

POLLING . . MONDAY, 5th MAY.

Dr. Willis Chipman was retained by the City as a consulting engineer to coordinate the building of the sewerage farm. In a report dated May 2, 1902 he recommended that the sewer system in the City be a separate system which would send just sewage to the sewerage farm, while storm water would go to the river. He also endorsed the septic tanks and gravel bed as proposed by Mr. Hutcheon and Mr. C.H. Rust. On April 7, 1903 Mr. Hutcheon was instructed to build the 2 covered septic tanks along with a stone toolhouse and influent channel. The cost of the project was $4,304.55 which also included two pumps, an electric motor, and gate valves. By November 1, 1903 the construction was far enough along to allow the system to be put into use. The gravel filter beds were not required at this point due to the low number of users on the sewerage system.

The City passed by-law 494 on July 4, 1904 which required the filling up of water closets and cess pools within the City due to health dangers. This sewerage would be directed to

the sewerage farm for treatment. The final report for 1904 noted that there was very little suspended matter making its way to the river. Future construction of the gravel filter beds would help the quality even more. Dr. Chipman reported that the sewers had a lot of infiltration, and that the current system would not be able to handle all of the sewerage from the City. He also recommended that the flow and temperature in the main sewer be measured before the septic tanks and after. He also suggested that the entire system, including sewers, be annually inspected. His final point was that the sewer department should be recognized on the same level as the light and power, and railway commissions.

In 1906 the septic tanks were cleaned for the first time. Approximately 80% of the two tanks were filled up with sludge which was removed. The rate of flow through the tanks was determined to be 100ft/minute, and there were about 1,800 users at the time. The incoming sewer pipe was less than 50% full with flow.

The sewerage committee received a report from Dr. Chipman in August of 1907 that recommended the addition of 2 septic tanks and 2 filter beds. The tanks would be duplicates of the original septic tanks. The City decided to go ahead and construct 2 new septic tanks parallel with the original tanks. The cost of these tanks was $4,435. By November of 1908 the new tanks were in use, and the whole grounds were surveyed for future use. Two slow gravity filter beds designed by Mr. F. McArthur were added in 1909 measuring 40ft. by 200ft.

The dilemma of paying for sewerage was very controversial around this time. The popular theory was that those using the system should pay for it. The Ontario government stepped in to resolve this situation by enacting a special act which legalized the municipality's sewerage by-law. The province also specified criteria for determining the sewerage rate. Throughout the City sewers were being constructed and this construction carried on as the City grew. From 1910 until 1920 there were no major changes at the sewerage farm.

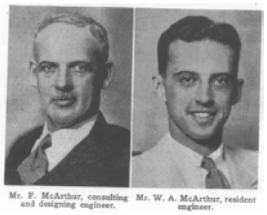
1920-1929

The Provincial Board of Health, in February of 1920, suggested that alterations be made to the sewage disposal plant so that the sanitary condition would be improved. The current treatment level was not adequate because of the increased amount of flow coming to it. The number of connections on the sewer system, about 5,000, had increased flow so much that the plant was incapable of sufficiently treating the sewage. Mr. F McArthur suggested converting the septic tanks into aeration tanks to take advantage of the new activated sludge process. The population of Guelph in 1920 was approximately 21,000. The alterations and additions to the plant took place in 1922, and thereby Guelph became the fourth city in Ontario to adopt the activated sludge process for treating sewage. Brampton in 1916 was the first in Ontario to use this process followed by Timmins and Woodstock both in 1921. Mr. F. McArthur, consulting engineer, was in charge of this project. The alterations and construction was done in a way that allowed for the original structures to be used as much as possible. A major problem that was encountered was that the original tanks were quite shallow (7ft.), which required the new tanks to also be shallow in order for the hydraulics of the plant to work smoothly. A settling tank which measured 7.5ft.wide and 6.5ft.deep was constructed which would take the flow from the newly modified aeration tanks. This tank would allow for solids to settle to the bottom where they would then be pumped via an air lift pump to the sludge drying beds, or returned to the aeration tanks. The old gravity filters had been converted to sludge drying beds. A new detritus tank, aerated channels, and a power plant were also constructed at this time.

The key to the activated sludge process is the aeration tanks. The sewage flows into the plant through the detritus tank and screening chamber. From here it enters the aeration tanks where it is mixed with some return activated sludge that is pumped from the settling tank. The sewage, now called mixed liquor, then flows into the settling tank where the majority of the suspended matter settles out. From here the watery effluent flows directly to the river. This construction allowed the sewage disposal plant to have a treatment capacity of about 2.5mgd.

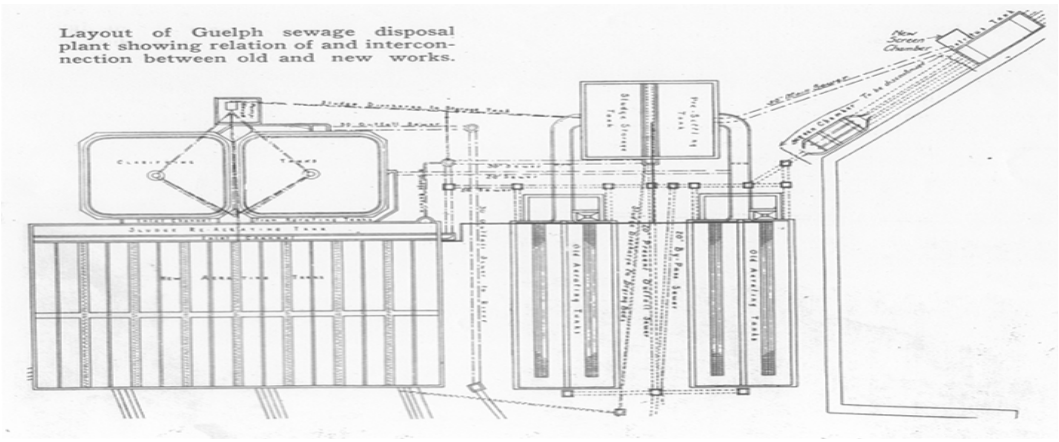
1930-1949

By 1934 the population of Guelph was reaching 23,000 and the flow to the sewage disposal plant had reached close to 4mgd. On April 3, 1934 the City authorized Mr. F. McArthur to make additions to the sewage disposal plant, and his son was appointed resident engineer. The Department of Health, on September 4, 1934, issued the City with an order to increase the capacity of the plant up to 4mgd. so that the treatment of the sewage would be improved to a satisfactory level.



Mr. F. McArthur, consulting and designing engineer. Mr. W. A. McArthur, resident engineer.

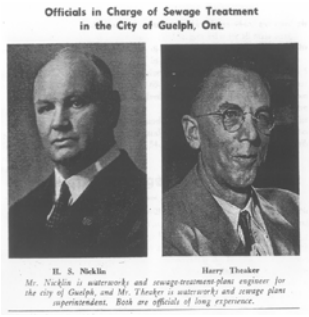
The construction included four new aeration tanks measuring 8ft. by 9ft. by 88ft. each. Two new 50ft.by 13ft.by 15ft.Imhoff/Dorr final settling tanks were also constructed. The influent area was modified to allow for better grit removal and improved screening. The existing settling tank was changed to allow half of the tank to be a primary clarifier and the other half a sludge digestion tank. To support the new tank construction and modification three new air compressors were installed in order to provide air to the aeration tanks and channels. A horizontal centrifugal sludge pump was installed in the new pumphouse located by the new settling tanks. The sludge drying beds were enlarged so that they could adequately deal with the amount of sludge being produced. Construction was difficult at times because of the close rock bed under the soil that had numerous fissures in it. This required the floors to be extremely thick to prevent hydrostatic pressure from cracking the tank floors. Also, due to the minimal difference in invert from the river level to the plant influent the tanks are said to be the shallowest of any in Ontario.



Layout of Guelph sewage disposal plant showing relation of and interconnection between old and new works.

Once the construction was completed Mr. H.S. Nicklin, a city Engineer, began operating the plant. The plant remained basically unchanged for the next 20 years. The flow to the plant steadily grew as the City continued to grow in population.

1950-1959

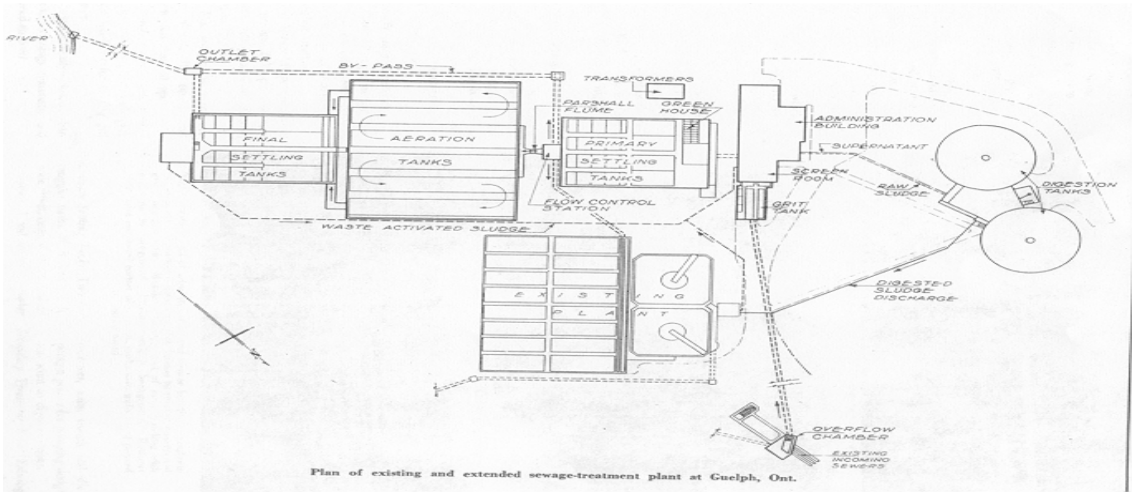

Officials in Charge of Sewage Treatment in the City of Guelph, Ont.

H. S. Nicklin — Harry Theaker

Mr. Nicklin is waterworks and sewage-treatment-plant engineer for the city of Guelph, and Mr. Theaker is waterworks and sewage plant superintendent. Both are officials of long experience.

Further expansion was required as a result of population growth and the additional servicing of the College Hill area of Guelph Township and the Ontario Agriculture College. This 1957 expansion was to take capacity to accommodate a population of 60,000, which was forecasted by 1975. Major consideration of design was given to the low flows of the Speed River. During the summer months the design plant flow 6MGD (27240m^3) would be significantly greater than that of the rivers flows. (Keep in mind that the Guelph Dam was not in operation until 1976). For this reason a highly purified effluent would be required and design of the plant was carried out with this as the driving factor.
Gore and Storrie Limited supervised the construction of what we recognize today as plant #2. This major expansion included an aerated grit channel tank, followed by mechanical bar screens and a Barminutor which macerated course matter from the flow. Once macerated, it was then released back into the flow. The grit was removed through a grab bucket method and placed on a truck for final disposal. This bar screen room is presently our storage room. The new facilities primary settling was in the form of two rectangular tanks each being 96ft by 32 ft by 10 ft. These tanks were equipped with longitudinal and transverse sludge collectors, scum troughs, and diaphragm pumps for pumping sludge and scum to the digesters. Approximately 50% of the solids will have settled out and collected at this stage. A flow control station was added after the primary tanks where the flow would be split between the new plant and the existing plant. The split was approximately 60:40 respectively. Two new three pass rectangular aeration tanks 110 ft in length were added, along with three sludge return pumps and three air compressors. Additional final settling capacity was acquired through the construction of two new final tanks, 91 ft by 32 ft by 12 ft. As with the primary tanks these too were equipped with mechanized longitudinal and transverse sludge collectors. The solids removed from the

flow would now be reduced in a two stage sludge digestion process, through to the addition of two new 65 ft diameter by 29 ft high digesters. Sludge was to be pumped to digester #1 where the breakdown of the organic matter took place. The gas collected at this stage was used for heating. The sludge would then flow to the second digester where the overflow was separated and the digested sludge was pumped to trucks or to the sludge storage tanks.



Plan of existing and extended sewage-treatment plant at Guelph, Ont.

Non process related construction included what we recognize today as the first level of the administration building, which was attached to the bar screen room. Also the green house attached to the west end of the primary building. Plant superintendent at the time, Harry Theaker and his staff used this to grow plants for landscaping the grounds. Just this past year repairs to the brick and glass were undertaken, to enable staff to carry on what Mr Theaker started.

1960-1969

In 1964, the construction of a chlorine building and two chlorinators to disinfect the effluent through gas chlorination. The location of that building is what today houses the sodium hypochlorite day tank and storage tanks.

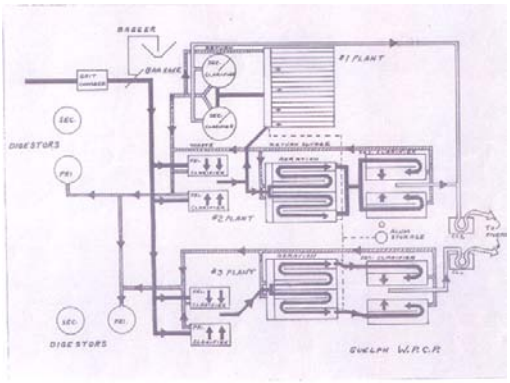
With additional annexation, and an anticipated growing student population at the University of Guelph, further expansion was identified. So in 1967, Guelph underwent a 4MGD (18160m^3) expansion which would take its' total capacity to 10MGD (45400m^3). At the time, this expansion was anticipated to be adequate until 1980; at which point another 4MGD (18160m^3) expansion would take the facility to 1995.

This expansion included a new 48” diameter western trunk line. There was another aerated grit channel built beside the one constructed in 1957. To accommodate the increased hydraulic loading, an additional channel between the screen room and primary tanks was constructed. There was also a new channel built to provide flow to the two new 48 ft by 62 ft by 10 ft primary settling tanks. These tanks were designed for a flow of 6MGD (27240m^3) in order to provide for a longer retention time for a higher recycle of solids. Two automatically timed plunger pumps were installed to pump raw sludge from the new primaries. In order to accommodate flexibility of treatment, two new 85 ft by 20 ft by 14 ft deep step aeration tanks were built. A new blower building located between the new aeration basins and final tanks, housed three blowers which included the blowers that were moved from the administration building in order to reduce noise levels. As mentioned, two new 53 ft by 62 ft by 12 ft final sedimentation tanks were constructed. These tanks could be used in common operation or independently and were design to provide three hours detention time. Two return activated sludge pumps as well as a waste activated sludge pump were added below grade in the previously mentioned blower building. Built across the end of the final effluent tanks was the chlorine contact tank which provided a fifteen minute retention time based on the maximum flow rate. The two existing chlorinators were to provide a maximum of 120 lbs per day of chlorine.
The effluent was to be discharged via a new 60” diameter outlet sewer which would also allow capacity for future plant expansions. Sludge digestion capacity was increased with addition of two new 65 ft diameter digestion tanks similar to the two built in 1957. The tanks used gas recirculation for mixing and utilized the gas from the digestion process in a boiler for heating the new buildings and digestion tanks. This expansion took approximately fifteen months to complete.

1970-1979

Guelph sewage treatment in the 1970’s could be classified as one of fine tuning and leading edge. As a result of intensive studies on the Speed River, the Ontario Ministry of Environment imposed strict requirements for Guelph’s effluent. (see *table 1.0)* The City accepted the challenge of providing a much improved effluent but was also concerned

about seeking out new processes with significantly less power consumption and smaller footprints from conventional systems.



In 1971, 25% of the flow was diverted for eight weeks to conduct a phosphorous removal experiment through the addition of alum. The success of this experiment resulted in the 1973 arrival of two 8000 gallon alum tanks, for improved phosphorus removal through chemical addition.

Continuing the quest to improve the quality of the effluent delivered to the Speed River, the City of Guelph investigated tertiary treatment. By 1979, Guelph boasted one of the largest installations in North America of an attached growth biological process known as Rotating Biological Contactors (RBC's). This process oxygenates ammonia, converting it to nitrate, or in other words nitrification. Thirty two units were installed in four trains of eight. Not only was this a very effective method of nitrification but it was also very energy efficient which was paramount during this time. Today, the effluent from plants one, two and three are still "polished" by this process The second stage of this two stage tertiary treatment was the construction of two automatic backwash filters. The effluent passes through a 200mL layer of anthracite followed by a 200mL layer of sand removing additional suspended solids and resulting in a very high quality effluent. Since chlorination had be the last stage of sewage treatment the existing chlorine contact chamber had to be moved so it would receive the effluent from the sand filter. The new chlorine contact chamber was designed for a thirty minute detention time.

With such an improvement in the quality of the effluent released to the river, the plant essentially increased its' capacity by 9000 $m^{3,}$ or the equivalent of 10,000 additional people.

Towards the end of the decade the initial work began on the operations control room display board. This display board would alert operators of equipment currently running as well as indicating any equipment that may have gone into alarm.

By the end of the decade Guelph was regarded as one of the more modern facilities in Canada.

Table 1.0

The table below shows the required changes to the quality of effluent as directed by the Ontario Ministry of Environment. The 1979 values were what dictated the design of the RBC's and Sand filters.

City of Guelph Final Effluent Criteria

	1975	1979
Daily Flow	45000m^3/d	55000m^3/d
Suspended Solids	15mg/L	12mg/L
BOD_5	680kg/d	680kg/d
Phosphorous	1mg/L	0.5mg/L
NH_3-N	22mg/L	6mg/L
TOD	123mg/L	30mg/L

1980-1989

With a population of approximately 70,000 the sewage treatment plant now handled an average flow of 55 ML/day. In 1980 the effluent outfall to the river went through some minor reconfiguration in order to improve the flow to the river. Sludge handling was reviewed and it was decided to build a dewatering facility. In 1983 construction of the facility took place. It was built where the original septic tank and toolhouse from 1903 was located. The facility was constructed in a manner that allowed for the original look of the stone toolhouse to be kept, and the remaining exterior of the building used similar stone work in an effort to match the original look. The new dewatering facility contained 2 new filter belt presses along with pumps and polymer tanks that would allow the digested sludge to be dewatered from about 3% to 18% solids. Another part of the building was a sludge loading bay which would remove the sludge from the presses and deliver it into trucks.

The headworks facility was also constructed in 1983. Two new Archemedes screw pumps were installed to draw the influent up from the incoming sewers to an elevation

from which the sewage would flow via gravity through the primary and secondary treatment tanks. Just after the archemedes pumps two self cleaning bar screens were installed along with two grit tanks complete with a grit removal system. The grit and screenings that were removed were then transferred to a dumpster area that is enclosed in a garage. This system is still in use today, and the benefit of having this system contained within a building is that the odours are greatly reduced.

The dewatering facility added a third belt filter press in 1985 to increase the amount of sludge that the facility could process. In the headworks a rag press was installed so that the screenings were dryer and more compact when they dropped into the dumpster. This helped to reduce the weight and volume of screenings going to the landfill.

In 1987 the Guelph's population exceeded 78,000 and the sewage treatment plant was again expanded. Plant 1, which was originally built in 1934, was demolished and in its place a new conventional activated sludge plant was constructed. It consisted of two primary clarifiers, two aeration tanks, and two final clarifiers. In addition three 250hp aeration blowers were installed in the RAS/WAS gallery located in the basement between the aeration and final tanks. Three return pumps were installed in this gallery as well. One is considered a spare and the other two return the activated sludge from the final tanks to the aeration tanks. A wasting valve allows for some of the activated sludge to be wasted to the primary clarifiers where it settles with primary sludge. This sludge is removed from the primary clarifiers and pumped to the digesters via two raw sludge pumps. In the operations office the Displayco board was modified to show the new plant 1 equipment.

The electrical consumption at the sewage treatment plant was quite high especially due to the large need for aeration. In 1989, plants 2 and 3 were retrofitted with fine bubble aeration which allowed for up to three blowers to be turned off. This drastically reduced electrical usage. This project was partially funded by a forgivable loan from Ontario Hydro, and the plant was recognized with an award for energy savings. The loan was forgivable on condition that electrical consumption was reduced by 10,000 kilowatt

hours/year, and that the equipment was installed within two years and operated for at least three years. A total of 6,700 fine bubble diffusers were installed in the two plants. Plant 1 had been supplemented with ceramic fine bubble diffusers in 1988 and power usage was reduced by 400 kW. Overall, these projects greatly reduced the electrical consumption of the plant and actually increased the treatment capacity because of the increased oxygen transferral efficiency to the microorganisms.

1990-2003

The dewatering facility was again expanded in 1992. A fourth belt filter press was added as well as some more pumps and a screw conveyor that would deliver the sludge into a sludge bin. As well, the City decided to go ahead with the construction of a sludge composting facility. The dewatered sludge would go into the sludge bin and then be mixed with wood chips and recycle compost and then sent into one of the two primary bio-reactors. In the bio-reactors the composting action would take place, and temperatures would reach high enough to provide for pathogen kill. All the while air would be forced through the system so that it would remain aerobic. From here the compost would then be transferred into a third reactor for curing. After this it would be directed to trucks and delivered for an end use. Possible end uses for the finished compost were landscaping, agricultural, and daily cover at the landfill. Benefits of composting are the mass volume reduction, and that the nutrients in the sludge mostly remain in the finished compost. One possible problem with this type of composting is the odours emitted from the air that is forced through the compost. A unique solution was to bubble this air into the aeration tank of plant 1. This allowed for the odours to be removed while improving aeration without increasing energy demand. The facility was in operation by 1995.

In 1993 a cogeneration and energy facility was constructed. The purpose was to use the digester gas produced in the digesters to heat the buildings and the digesters. The digester gas was also used to produce electricity to help reduce the electrical demand of the plant. Two 240 kW cogeneration units were installed along with two boilers, and a gas room

that is equipped with full safety devices and a filter for removing hydrogen sulphide from the gas. An operations room was also added to allow for an area for staff to monitor the equipment through a SCADA computer system. This SCADA system is still in use, but has been modified and improved many times over the years. A key feature of the cogeneration units and boilers is that they also are able to operate off of natural gas. All the heat produced by these units is sent through heat exchangers or radiators to provide heat throughout the plant. If there is too much heat it is cooled by flowing through piping that is immersed in secondary effluent.

Digester cleaning and upgrading was done in 1994 to digester 1 and 2, and in 1997 to digester 3. The hot water system that heats the digesters was implemented on SCADA to allow for improved control and monitoring. A waste gas flare stack was added in 1998 to allow any excess digester gas produced to be burned off.

By 1999 the need for expansion was realized, because the plant was nearing flow capacity. Stage 1 expansion of a plant 4 began, which also included additions to the existing headworks, and a new set of sandfilters. The sandfilters were commissioned in the fall of 2001 which relieved some of the pressure on the existing sand filters. The additions to the headworks included a new archemedes screw pump and an additional bay that could hold a future fourth screw pump. Two new step screens were also added to improve the screening of the influent, and two aeration blowers were installed that can aerate the grit tanks and some of the channels throughout the plant. The new plant 4 begins with two primary clarifiers that can send effluent to plant 3 or plant 4 aeration tanks. Plant 4 then has two large aeration tanks that, in design, have a hydraulic retention time of about 14 hours each. The aeration tanks then feed two final clarifiers which flow into a new secondary effluent well. From here the effluent is pumped up to the influent channel of the sandfilters. The new plant was commissioned in early 2002. The wastewater treatment plant is now rated for a flow of 64 ML/day and the effluent is subject to stringent requirements as stated in the plant’s certificate of Approval. Table 2.0, shown below, outlines the changes to the certificate of approval effluent requirements.

Table 2.0

	1998	1999
Daily Flow	61000m^3/d	64000m^3/d
Suspended Solids	10.8mg/L	10mg/L
BOD_5	660kg/d	473.6kg/d
Phosphorous	0.45mg/L	0.38mg/L
NH_3-N	5.4mg/L	3.4mg/L
TOD	27mg/L	22mg/L

Conclusion

For the past century the City of Guelph has continuously improved and modified the wastewater treatment plant. The adoption of the conventional activated sludge process in 1922 placed Guelph as a leader in wastewater treatment in Ontario. This leadership has been repeated time and again with the expansions throughout the following decades. The addition of tertiary treatment in 1979 strengthened Guelph's commitment to the quality of effluent it produced. The plant now produces a high quality effluent that improves the condition of the receiving stream, and is a stable resource for a variety of downstream uses. Over the past century a strong heritage and base for wastewater treatment has been adopted in Guelph. The next century will present Guelph with the opportunity to continue to remain as one of the leading plants in Ontario.

References

Sewerage Committee Minutes, Guelph Public Library (Microfiche).

History of Guelph 1827-1927, Johnson, Leo A. 1931, 971.343 JOH C.17.

Guelph Evening Mercury Newspaper, Guelph Public Library (Microfiche).

Report on Waterworks System and Sewage Disposal Plant, Gore & Storrie Limited, August 18, 1967, Toronto, Ontario.

"Activated Sludge Sewage Treatment Plant for the City of Guelph", Engineering and Contract Record, Huch C. MacLean, October 17, 1934, Vol. 48 No. 42.

"Extending and Modernizing Guelph's Sewage Treatment Plant", The Municipal Utilities Magazine, F.J. Gladman and S. Galper, June 1958.

"Incentive to Change Pays Off at Sewage Treatment Plant", David Kosub, Civic Public Works, March 1991.

"Guelph Nitrification and Filtration Plant", Gore and Storrie Limited, Canadian Consulting Engineer.

"Population Study of Guelph", Department of Planning and Development, August 1988.

By-Laws, City Clerks Division, City of Guelph.

"Modern Sanitation & Water Supply", Wm. Storrie and A.E. Berry, for the International Engineering Congress in New York, September 1, 1939.

Order 34-D-3, Department of Health, September 4, 1934.

Mr. Russell Scott, Class IV Wastewater Treatment Operator, City of Guelph, 1983-present.

Public Works CommitteeMinutes, Guelph Public Library (Microfiche).

"Biological Survey of the Speed-Eramosa River 1970-71", D.S. Osmond, Ontario Water Resources Commission, Biology Branch, November 1971.

"Guelph Pioneers Water Pollution Control", Housing Ontario, Ministry of Housing, February, 1980.

"Pre-Design Report on Nitrification and Filtration Facilities for the City of Guelph Water Pollution Control Plant", Gore & Storrie Limited, Toronto, Ontario, 1977.

"Application of the MOE Blue Book at Guelph, Ontario", P.M. Crawford of Gore & Storrie for Ontario's New Water Quality Objectives- Design, Operational and Legal Implications Seminar, November 7, 1979.

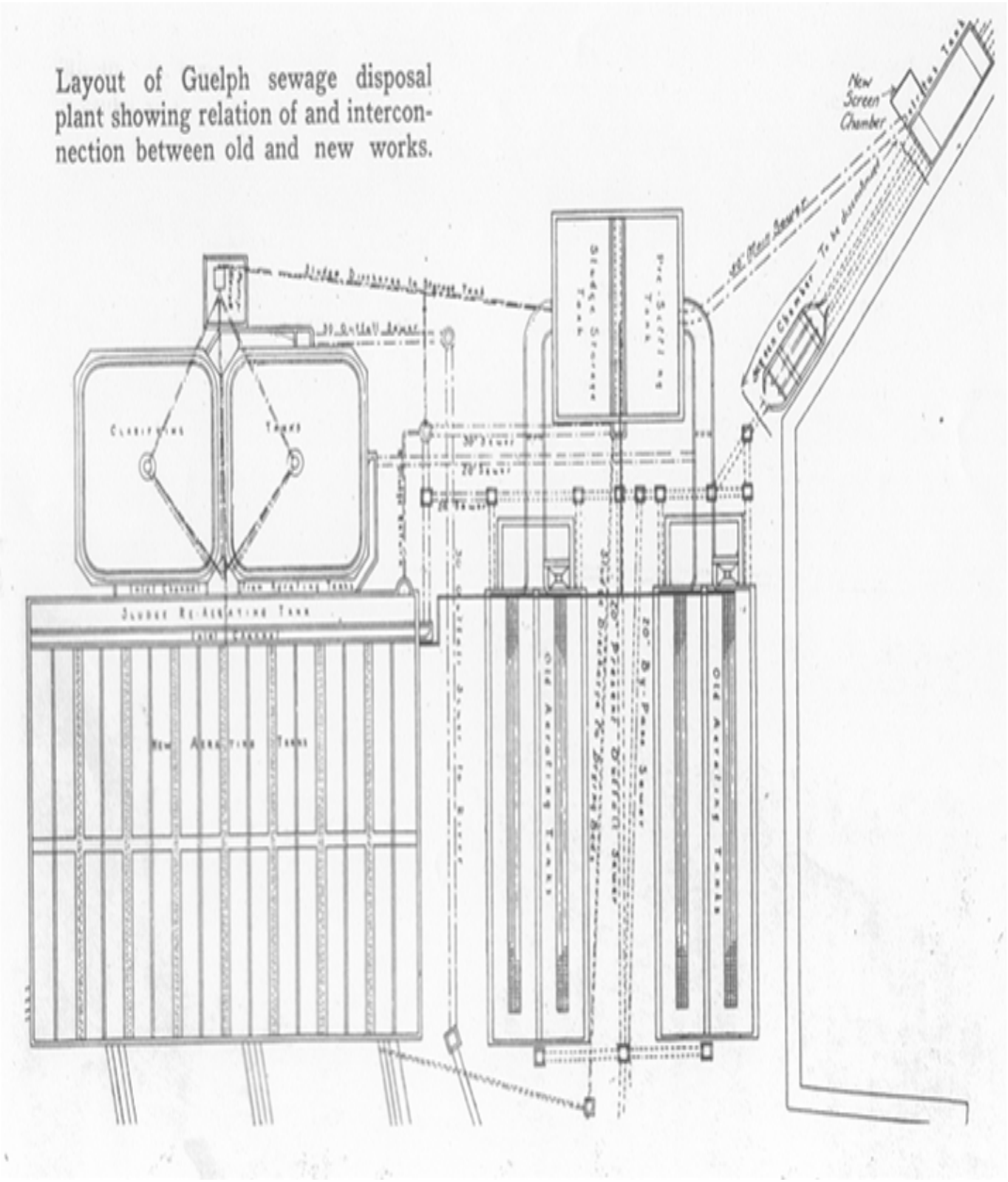
"Guelph Pioneers a Canadian First", G&S News, Gus Proietti, Gerry Lynch- Editor, Vol 7, No 4, August 1992.

"The Corporation of the City of Guelph Wastewater Treatment Plant Cogeneration and Energy Facility", CH2M Gore & Storrie Limited, Toronto, Ontario.

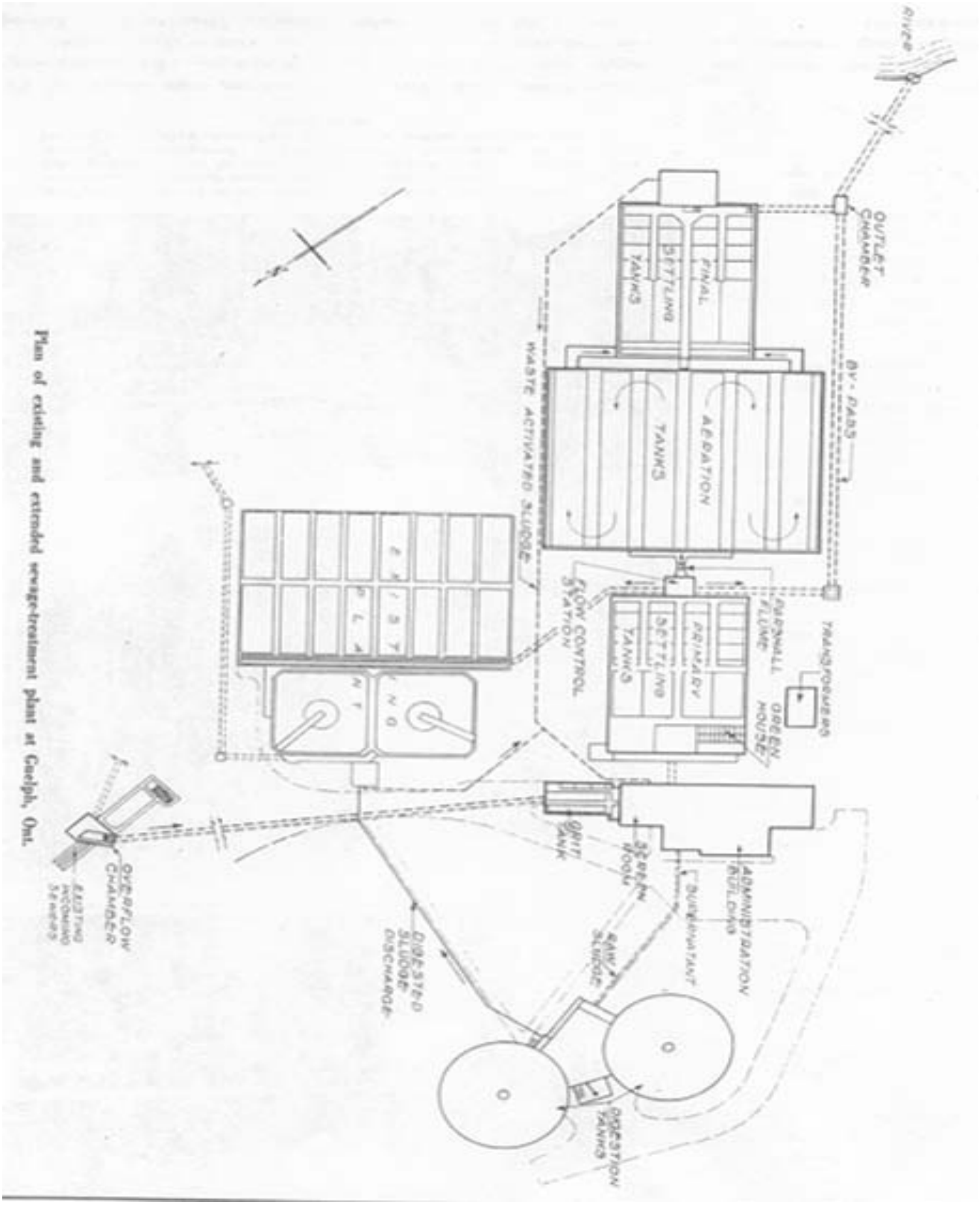
Appendix

Various plant pictures

Schematic of the new original Plant 1 and the existing treatment plant (1934)



Schematic of new Plant 2 & Digesters and existing treatment plant (1957)



Plan of existing and extended sewage-treatment plant at Guelph, Ont.

Schematic of route of flow through the treatment plant in the early 1970's.