CITY OF YORKTON

WATER TREATMENT PLANT
WASTEWATER REUSE
FEASIBILITY STUDY

December 2011
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1 Introduction

On January 25, 2007, the City of Yorkton and the Federation of Canadian Municipalities (FCM) entered into a jointly funded study entitled “City of Yorkton Water Treatment Plant Wastewater Reuse Feasibility Study”. Funding administered by the FCM was made available through the Federal Government’s Green Municipal Fund. Associated Engineering was retained by the City of Yorkton to provide engineering and management services for this study.

1.1 Background

In 2003, the City of Yorkton retained Associated Engineering to provide planning, design and project management services for upgrading and expansion of the existing water supply and treatment systems. At the time of project initiation, the raw water system consisted of fourteen (14) groundwater wells located within five (5) separate raw water sources and the treatment system consisted of four (4) small antiquated water treatment plants. Although it was determined that most of the wells were in relatively good condition, all four of the water treatment plants were found to be operating beyond their useful service lives and requiring either major upgrades or replacement.

In January 2005, Associated Engineering completed a comprehensive Water System Development Plan as part of the overall upgrades program. The plan outlined new construction and existing facility upgrades that would be required to meet the City’s 2030 projected water demands. As part of the overall plan, it was recommended to construct a new centrally located water treatment plant to replace the existing water treatment plants.

The existing and projected water demands that were established in the Water System Development Plan are summarized as follows:

- 2005 Actual Average Day Demand: 6 ML/d;
- 2005 Actual Maximum Day Demand: 10 ML/d;
- 2030 Projected Average Day Demand: 13 ML/d; and
- 2030 Projected Maximum Day Demand: 33 ML/d

In 2007, construction began on the Queen Street Water Treatment Plant (QSWTP), which was designed to produce a maximum of 33 ML of potable water per day utilizing three (3) independent treatment trains. Phase I was limited to the construction of two (2) treatment trains providing a maximum of 22 ML/d of potable water production. Phase I of the QSWTP was successfully commissioned in the spring of 2011. Phase II will include installation of a third treatment train, and will be constructed when the additional treatment capacity is required by the City of Yorkton.
The QSWTP makes use of the following treatment processes:

- Aeration;
- Detention for iron oxidation;
- Chemical oxidation, using both chlorine and potassium permanganate for manganese oxidation;
- Flocculation to agglomerate oxidized iron and manganese;
- Detention to allow further reaction between manganese and oxidation chemicals;
- Upflow roughing filtration to remove larger floc and reduce gravity filter loading; and
- Filtration with anthracite and manganese greensand.

A process flow diagram of the water treatment process can be found in Appendix A.

### 1.2 Objective

During the pre-design of the QSWTP, the issue of backwash wastewater treatment and disposal was discussed and various options were evaluated. In efforts to focus on the water treatment design and construction, the City of Yorkton elected to construct a common force main from the QSWTP to the existing gravity sanitary sewage collection system. The force main was sized to convey both sanitary wastewater and process wastewater generated at the QSWTP. The wastewater would then be conveyed via the gravity sewer system to the City’s existing wastewater treatment plant for treatment and final disposal. The intent was to utilize the force main for process wastewater disposal until such time a more environmentally sustainable means was identified to treat the wastewater on-site and ultimately reuse the effluent at or near the QSWTP site.

The main objective of this study was to identify and confirm the viability of a long term, cost effective and environmentally responsible system to treat, dispose of and re-use process wastewater generated at the QSWTP. It was also the objective of the City to reduce the hydraulic load on the existing sewage collection system and wastewater treatment plant, therefore providing additional system capacity to facilitate growth within the community without having to expand the wastewater treatment plant.

### 1.3 Approach

The City’s approach to achieving the study objectives was to include community involvement along with professional services. The City’s philosophy included maximizing community involvement through special interest groups serving the community and executing the direction utilizing professional planners, engineers and hydrogeologists.
2 Study Criteria

2.1 Study Participants

In order to match the City’s philosophy of maximizing community involvement through special interest groups, the study team included many of these groups in the background data collection and option development processes. The study involved the following participants:

- Yorkton Environmental Services providing study leadership;
- Assiniboine Watershed Stewardship Association (AWSA), providing overall study coordination services;
- Yorkton Public Works;
- Yorkton Leisure Services;
- Yorkton Wildlife Federation;
- Saskatchewan Wildlife Federation;
- Yorkton Soccer Association;
- Yorkton Active Transportation Collaborative;
- Ducks Unlimited Canada - Yorkton Office;
- National Research Council;
- Ministry of Environment; and
- Saskatchewan Watershed Authority.

The study involved the following professional service firms to coordinate and execute the works requested by the study participants as approved by the City of Yorkton:

- Crosby Hanna & Associates for landscape architecture and planning;
- Beckie Hydrogeologists Ltd. for hydrogeological services;
- Ground Engineering Consultants Ltd. for geotechnical engineering services; and
- Associated Engineering for management and engineering design.

2.2 Concept

The study concept was developed over a number of meetings with the various participants. The kick-off meeting was held on April 12, 2007 with the City of Yorkton, Beckie Hydrogeologists Ltd. and Associated Engineering in attendance. The objective for the meeting was to confirm the study concept based on informal discussions with the special interest groups and numerous City of Yorkton staff members. Subsequent meetings helped to refine the concept, and are covered in more detail later in the report.
It was agreed upon by all kick-off meeting participants that the final concept needed to be simple, robust and environmentally friendly. The meeting resulted in the following study scope items:

- Use of gravity sedimentation pond(s) to reduce the concentration of oxidized minerals from the process wastewater;
- Use of wetland(s) to polish the effluent exiting the sedimentation ponds;
- Use of infiltration pond(s) to induce effluent into the local aquifer (artificial recharge);
- Construction of a sports field to utilize infiltrated ground water for irrigation;
- Utilization of an existing well to provide irrigation water for the sports field, local tree nursery and community gardens from the local aquifer; and
- Inclusion of a public education component.

A copy of the kick-off meeting minutes can be found in Appendix B.

2.3 Literature Search and Review

Since the proposed treatment process of sedimentation, wetlands and artificial recharge is a relatively new approach to process wastewater treatment, a literature search was conducted to find information on similar projects constructed in North America. Projects using each of the three main components were identified, however most involved the use of only one of the components for treatment. These projects included the following:

- Several water treatment plants that utilize sedimentation ponds to settle out the oxidized minerals, silts, algae, and other solids that accumulate as a by-product of the treatment process. However, most of these treatment systems typically discharge back into the environment without additional treatment;
- Projects where wetlands have previously been used for treatment of municipal and industrial wastewater, not generally for the treatment of process wastewater; and
- In the United States of America, several artificial aquifer recharge projects which have been constructed, most utilizing storm water runoff or highly treated municipal wastewater as a supply source for aquifer recharge.

From the review, only one completed project was found utilizing sedimentation, wetlands, and artificial recharge for the treatment of water treatment plant process wastewater. In 2009, the community of West Elgin, Ontario, completed work on one of the first backwash wastewater processes in Canada to use wetlands to treat and polish the process wastewater from the water treatment plant. Process wastewater high in suspended solids and process chemicals, is sent to wetland retention ponds for treatment. Once the water polishing process is complete, much of the water exfiltrates from the ponds, helping to recharge the groundwater and maintain the wetland.

The process is simple, maintenance free, environmentally friendly, and provides the community with a space full of native plants, wildlife and fish. Capital cost was approximately one-third that of the estimated cost for a conventional process water treatment system and since the process removes the need for clarifiers and additional chemicals for treatment, operational costs are
expected to be very low. The community was left with an attractive space, complete with walking paths, and naturally treated process wastewater which meets the guidelines set by the Ministry of Ontario. A copy of the article obtained from the Environmental Science and Engineering Magazine can be found in Appendix C.

### 2.4 Regulatory Requirements

Regulatory requirements for any Canadian project are complicated when it comes to jurisdiction and the associated environmental approvals. There are a number of regulatory bodies that exist at both the provincial and federal government levels that need to be considered when initiating a project that directly impacts the environment. These organizations include, but are not limited to, Saskatchewan Ministry of Health, Saskatchewan Ministry of Environment, Saskatchewan Watershed Authority, Health Canada, Environment Canada, and Fisheries and Oceans Canada.

This study was reviewed in detail for regulatory compliance and associated jurisdictions. The review concluded that none of the study components fall within the jurisdiction of federal regulatory agencies. At the provincial level, it was determined that the Saskatchewan Watershed Authority and/or the Saskatchewan Ministry of Environment would likely have jurisdiction for this study.

#### 2.4.1 Saskatchewan Watershed Authority

In Saskatchewan, the Saskatchewan Watershed Authority (SWA) leads the management of the province’s water resources to ensure safe drinking water sources and reliable water supplies are available to the people of Saskatchewan. According to the SWA website, the SWA is responsible for the following:

- Administration and control of all Authority-owned water management infrastructure including Gardiner, Qu’Appelle, Rafferty and Alameda Dams;
- Maintenance of an inventory of the quantity and quality of ground and surface water, and administration of the allocation of water;
- Regulation and control of the flow of water such as rivers, lakes, and reservoirs;
- Representation of Saskatchewan in interprovincial and international water sharing agreements and other water management discussions;
- Approval of water works for the maintenance and enhancement of water quality and availability, including approval and dispute resolution for the construction and operation of drainage works;
- Provision of flood forecasting and identification of flood susceptible areas;
- Promotion of the efficient use of water for environmental and socio-economic benefit;
- Undertaking of watershed studies and research and preparation of evaluations of the state of watershed resources in the province;
- Management of watersheds to meet aquatic ecosystem and fish habitat needs;

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Development and implementation of watershed protection plans through public consultation and in cooperation with local communities;
Delivery of various components of Saskatchewan’s Safe Drinking Water Strategy;
Provision of assistance for erosion control, maintenance of channels, and maintenance of water control works; and
Coordination of implementation of waterfowl conservation programs in accordance with the North American Waterfowl Management Plan including preservation, management and development of breeding habitat.

Due to the inclusion of wetlands and artificial recharge in the study scope, the SWA was approached about possible regulations pertaining to these activities. The SWA advised the study team that because the study involves a waste stream from the Yorkton water treatment plant, it would be regulated by the Saskatchewan Ministry of Environment. Representatives of the SWA stated that no approval or allocation would be forthcoming from the groundwater division of SWA for this study. SWA correspondence dated September 30, 2010 can be found in Appendix D.

2.4.2 Saskatchewan Ministry of Environment

The Saskatchewan Ministry of Environment (MOE) is responsible for protection of the environment and promotion of the sustainable use of natural resources within the province. According to the MOE website, the Ministry fulfills its mandate by promoting stewardship of the air, land, water and wild plants and animals throughout the province. Key responsibilities in relation to natural resources include the management of forests, wildland fire, Crown land and fish and wildlife. The ministry also has responsibilities in preventing pollution of air, water and land in the province, which it delivers through activities such as co-ordinating the environmental assessment program, air quality monitoring, water quantity and quality management to reduce downstream degradation, and control of potential impacts of contaminated sites, hazardous substances, landfills and other sources of pollution.

At the initial stakeholder meeting held on Tuesday, March 2, 2010, the Ministry of Environment confirmed that they would be responsible for regulation of the implementation works resulting from this study and would do so under the existing permit for the QSWTP. Accordingly, all correspondence related to the regulatory component of this study was directed to the MOE.

The MOE noted that when the recommendation(s) from the study were ready for implementation, an application for Approval to Construct would be required. If approved, the approval would be granted under the City’s water treatment plant Approval to Construct permit. The aforementioned permits can be found in Appendix C.
Effluent from the sedimentation ponds would be subject to the Saskatchewan Surface Water Quality Objectives. These objectives were developed to support the management, protection and enhancement of the surface water resources of the province and provide a means for evaluation of water quality. A copy of the objectives can be found in Appendix D.

2.5 Backwash Wastewater Volume

As mentioned previously, Phase I of the QSWTP was constructed to provide treated water at a maximum flow rate of 22,000 m$^3$/day. Completion of Phase II of the project will include the installation of a third treatment train, bringing the maximum plant capacity for treated water production to 33,000 m$^3$/day. Since the volume of process wastewater produced is directly related to the volume of treated water processed, a relationship had to be established between the two to estimate future capacity requirements for the wastewater reuse study.

During design of the QSWTP, a pilot plant was run for the proposed process. The pilot process suggested that the backwash wastewater generated should be less than 5% of the potable water production volumes. This was consistent with industry standards and thus was used for the purposes of the QSWTP design.

Once the QSWTP was commissioned, additional data was collected to determine a more precise value for the process wastewater flow from the WTP. The QSWTP design provided backwashing of each gravity and upflow roughing filter after the production of 5,000 m$^3$ of filtered water. Since it was determined that the volume of wastewater generated from the backwash of each gravity filter and upflow roughing filter was around 180 m$^3$ and 70 m$^3$, respectively, it was calculated that the discharged process wastewater volume was equivalent to approximately 5% of the total treated flow. This value was used for conceptual sizing of the wastewater reuse system.

2.6 Backwash Wastewater Quality

In order to meet the requirements for discharging process wastewater to the environment, the wastewater treatment system needed to be able to reduce the levels of oxidized minerals and chlorine below the regulatory limits referenced earlier in the report. In order to determine approximate detention times for sedimentation to occur, a series of jar tests were completed in 2006, and again in 2009. Samples from the jar testing were submitted to the Saskatchewan Research Council (SRC) for analysis. The results indicated that a detention time of approximately 30 minutes would be required to settle the oxidized minerals from the process wastewater. It is important to note that the samples were not tested for chlorine as the existing water treatment processes incorporated post filter chlorination only and thus no chlorine was present in the process wastewater.
The treatment process used at each of the old smaller water treatment plants involved the use of a polymer to aid in the removal of iron and manganese. However, the QSWTP was designed to minimize the use of chemicals including flocculants and filter aids such as alum and polymers. Flocculants and filter aids are commonly used in the water treatment to reduce the time for coagulation and flocculation and therefore reduce settling time of large floc. As a result, the study team did not feel comfortable using the sedimentation time resulting from the jar tests completed on the old process and decided to wait until commissioning of the WTP was completed to finalize the required sedimentation time.

Once the QSWTP was commissioned in 2011, the project team carried out the same jar tests as in 2006 and 2009. The results of these tests were significantly different; resulting in a sedimentation time of approximately 24 hours.

The QSWTP was designed to operate with pre-chlorination, post chlorination or a combination of both. As a result of this flexibility in operations, it was decided to proceed with the wastewater treatment concept regardless of chlorine levels that would be experienced in the process wastewater if pre-chlorination was utilized during operation. The City would have the flexibility to simply use post chlorination only in the process or add a de-chlorination chemical such as sodium bi-sulphite to the process wastewater should chlorine residual be an issue downstream of the sedimentation ponds. Regardless, the issue of chlorine residual was considered to be easy to deal within the confines of the water treatment process and thus was not considered a problem for the purposes of this study.

The results of the 2006, 2009 and 2011 analysis can be found in Appendix E.

3 Existing Site Conditions

3.1 Zoning

Logan Greens was the proposed study site, and is defined as follows: East of Gladstone Avenue, North of Queen St., West of Hwy 9, and south of the residential lots located off of Logan Crescent. This area was zoned by the City of Yorkton as Parks and Recreational (PR) with an Environmentally Sensitive (ES) Overlay. A copy of the District Zoning plan can be found in Appendix F.
The City of Yorkton has defined the purpose of the Parks and Recreational district as an area to establish and preserve for both passive and active recreational opportunity, as well as community facilities and functions. Permitted and discretionary uses for the PR District, as determined by the City of Yorkton, are outlined below:

Permitted uses:
- Essential Public and Utility Services
- Farming (Agriculture Field Crops Only)
- Public Parks and Playgrounds
- Uses Accessory to Permitted Uses
- Uses Accessory to Discretionary Uses

Discretionary uses:
- Community Facilities
- Convention / Exhibition Facilities
- Greenhouses / Plant Nurseries
- Participant Recreation – Indoor
- Participant Recreation – Outdoor
- Tourist Campgrounds

Other stipulations:
- The maximum principal building height is 12.6m or 3.0 storeys.
- The maximum land area that may be built upon shall be no more than 40% of the developable area.

The area was zoned as Environmentally Sensitive due to the shallow aquifer that underlies most of the study site. This requires any site development to be approved by the City of Yorkton. The geotechnical and hydrogeological conditions at the site are discussed in more detail later in the report.

3.2 Topographical Survey and Aerial Photography

The entire site was surveyed with Global Positioning Satellite (GPS) survey equipment. All existing surface features were surveyed and ground spot elevations were collected for purposes of generating site contours. A copy of the topographical survey results and aerial photo can be found in Appendix F.
3.3 Existing Infrastructure

The existing infrastructure at the proposed site consisted of buried water mains, gas lines, power cable and telecommunications. There was also overhead power on-site that serviced the existing well pump houses. With the exception of the water lines and the overhead power lines, most of the infrastructure was located on the site perimeter, providing open access for development works. An existing infrastructure plan can be found in Appendix F.

4 Geotechnical Investigation

Ground Engineering Consultants Ltd. (GECL) was retained by the City of Yorkton to conduct a geotechnical investigation for the Queen Street Water Treatment Wastewater Reuse Feasibility Study. The objective of the investigation was to define the soil and groundwater conditions at the site and use this information to provide design recommendations for the proposed ponds and wetlands.

A total of 16 test holes were drilled to depths of 4.6 to 12.2 metres into the sand unit (aquifer) that underlies the site. Standpipe piezometers were installed in five (5) of the 16 test holes for groundwater monitoring purposes. The stratigraphy at the site was found to be variable but generally consisting of surficial clay and till strata underlain by a sand stratigraphic unit (aquifer) in which the City has existing production wells. The elevation of the top of the sand unit varied from 497.0 metres (at the west end of the site) to 503.8 metres. The piezometric surface was measured at elevations ranging from 498.0 to 500.8 metres, however, this elevation will vary seasonally depending on rainfall and pumping volumes from the City production wells.

A laboratory testing program was carried out on the soil samples to determine if the surficial soils were suitable for lining the ponds. The hydraulic conductivity of the till soil was determined to be in the order of 3.5 to 4.2 x 10-9 cm/s on remolded samples of till. On this basis, it was determined that the till could be used to line the ponds. A liner thickness of 600 mm compacted to 100% Standard Proctor density was recommended. The till was also recommended for use in constructing the dykes. Compaction of the dykes was specified at 97% Standard Proctor density. A 150 mm thick sand cover was recommended to protect the liner from desiccation.

A copy of the final geotechnical report can be found in Appendix G.
5 Hydrogeological Investigation

Beckie Hydrogeologists Ltd. (BHL) was retained by the City of Yorkton to provide hydrogeological services related to the Water Treatment Plant Wastewater Reuse Feasibility Study. BHL has been providing professional hydrogeologic services to the City since 1998 and have developed a strong working knowledge of the aquifer systems in the vicinity of Yorkton.

The City of Yorkton relies completely on groundwater to satisfy their municipal water requirements and as of 2011, operates thirteen (13) production water wells that have been grouped into five (5) separate well fields. The QSWTP overlies one of the aquifers known as the Logan West Valley Aquifer.

The proposed concept plan for this study involves a mixture of treated QSWTP wastewater and storm water runoff flowing east by gravity from a wetlands area(s) into a proposed infiltration pond. The infiltration pond will be constructed so that its base fully penetrates the top of the underlying Bredenbury Aquifer. Based on hydrogeological data compiled during this study, it is theorized that the infiltrating water will artificially recharge both the Bredenbury Aquifer and the hydraulically connected Logan West and Logan East Valley Aquifers.

The additional groundwater that would become available from the Logan West Wellfield as a result of the proposed artificial recharge would be extracted from test well PW2B-2011 and then used as irrigation water for the proposed sporting fields, the local tree nursery and the community gardens.

Information from three test water wells and five piezometers installed during this study was used during the preparation of the hydrogeologic report. Additional hydrogeologic testing and data analyses are required over time to more completely assess the feasibility of the proposed concept plan. Therefore, it is recommended that the new test wells and the new and existing piezometers be monitored with use over the next three years. The data collected during this period should then be utilized by a hydrogeologist to more accurately determine the extent and magnitude of the artificial infiltration and the effect of this infiltration on the Bredenbury and Logan Valley Aquifer systems and on the production and irrigation wells that are developed within these aquifers.

A detailed hydrogeologic report can be found in Appendix H.
6 LEED® Certification Suitability Analysis

6.1 Background

LEED (Leadership in Energy and Environmental Design) is a Green Building Rating System that was developed to improve a building or community’s performance for better environmental and health performance. It is based on a system of prerequisite and optional credits, and a pursuer must achieve a minimum number to earn a desired level of certification. There are currently nine different LEED Canada rating systems designed for various types of projects. The rating systems are as follows:

- LEED® Canada for New Construction and Major Renovations™ (NC) 2009
- LEED® Canada for Core & Shell™ (CS) 2009
- LEED® Canada for Commercial Interiors™ (CI) Version 1.0
- U.S. Green Building Council LEED® for Schools™ (SCH) 2009
- U.S. Green Building Council LEED® for Healthcare™ (HC) 2009
- U.S. Green Building Council LEED® for Retail™ 2009
- LEED® Canada for Existing Buildings: Operations & Maintenance™ (O&M) 2009
- LEED® Canada for Homes™ 2009
- LEED® Canada for Neighbourhood Development™ (ND) 2009

LEED systems are designed to lower operating costs and increase asset value, reduce waste sent to landfills, conserve energy and water, be healthier and safer for occupants, and to reduce harmful greenhouse gas emissions.

The City of Yorkton water treatment plant wastewater reuse study was designed as a water reclamation system that will make use of some of the process wastewater coming from the City’s water treatment plant. Rather than directing filter backwash water from the water treatment plant to the City’s sanitary system, the process wastewater is to be diverted to two sedimentation ponds. Eventually the water will lead to a fish pond. This process will not only benefit the environment by creating a habitat for fish and other animals, but will avoid adding load to the City’s sanitary system. Costly infrastructure required to convey the wastewater and upgrade the City’s wastewater treatment plant is thereby avoided.

6.2 Suitability of LEED Certification

This study was compatible with several LEED (NC) and LEED (ND) credits related to site selection, smart location and linkage, water efficiency, and innovation. However, the majority of LEED prerequisites and credits were unable to be achieved because there was no building included in the study. Thus LEED certification was not possible.
6.3 LEED Concepts

The design team included several sustainable design features that were in line with LEED (NC) and LEED (ND). The following sections expand on how this study incorporated LEED concepts and references relevant LEED credits.

6.3.1 Sustainable Sites

- **Light Pollution Reduction:** This study had no lighting incorporated on the site, thereby aiding in reducing light pollution and improving night sky access for nocturnal animals. *LEED (NC) Sustainable Sites Credit 8.*

6.3.2 Water Efficiency

- **Water Efficient Landscaping, No Potable Use or No Irrigation:** Native shrubs and grasses comprised the majority of the landscaping, therefore no irrigation was required. Additionally, the Sedimentation Ponds will be filled with backwash water from the water treatment plant; this water will be later transferred to the fish pond. No additional potable water will be required to fill the ponds. *LEED (NC) Water Efficiency Credit 1.2. LEED (ND) Green Infrastructure & Buildings Credit 4.*

6.3.3 Energy & Atmosphere

- **Fundamental Building Systems Commissioning:** Commissioning the system is an important process to any project to ensure that things are installed and running as they were designed to. The water reclamation system connection inside the water treatment plant has not yet been commissioned, but is intended to be in the future. *LEED (NC) Energy & Atmosphere Prerequisite 1.*

6.3.4 Innovation & Design Process

- **Innovation In Design - Habitat Created:** Instead of altering the natural wildlife habitat in the development area, the study concept enhances it. The area now allows more wildlife to visit, which can create a much more diverse environment. There is the potential to provide wildlife a closer water source, more food, and more shelter in the trees, grass and shrubs that will flourish adjacent to the ponds. *LEED (NC) Innovation & Design Process Credit 1.1. LEED (ND) Smart Location & Linkage Credit 7.*
- **Innovation In Design - Water Reclaim:** The City of Yorkton’s water supply is sourced from a natural underground water aquifer. Potable water is used at the City’s water treatment plant for backwashing filters. Backwash water will be diverted to the two sedimentation ponds. From the sedimentation ponds, the water will move onto the effluent pond/wetland head waters, then to the fish pond and finally to an artificial recharge area. *LEED (NC) Innovation & Design Process Credit 1.2. LEED (ND) Innovation & Design Process Credit 1.*

- **Innovation In Design - Education/Outreach:** Since this study concept is an extension of the water treatment plant, guided school tours for the water treatment plant will continue on to the sedimentation ponds, effluent pond/wetland head waters, and the fish pond. In the future, educational signage will be placed throughout the development for those on tours, or for those traveling on recreational pathways nearby to read about the process. *LEED (NC) Innovation & Design Process Credit 1.3.*

6.3.5 **Smart Location & Linkage**

- **Long-Term Conservation Management of Habitat/Wetlands & Water Bodies:** This study is intended for long-term use. The system will replenish the fish pond without disrupting the natural habitat in the area, and the design life is a minimum of 50 years. *LEED (ND) Smart Location & Linkage Credit 9.*

6.3.6 **Green Infrastructure & Buildings**

- **Stormwater Management:** This study incorporated a stormwater management plan that collects local water runoff. There are three dry bottom stormwater detention ponds that will collect stormwater, then send the water on to the fish pond through linear wetlands. *LEED (ND) Green Infrastructure & Buildings Credit 8.*
7 Master Plan Development

7.1 Options Development

Following the kick-off meeting and background data collection, informal discussions were held with the study participants in order to obtain additional concepts that they would like to see employed within the study. A number of ideas were generated and included the following:

- Soccer pitches to attract high profile tournaments;
- Ball diamonds;
- Parking and concession facilities;
- Expansion of the existing tree nursery;
- Re-routing of surface water to augment infiltration and attenuate downstream flows; and
- Re-routing and expansion of the existing cycling and pedestrian paths to take advantage of the education component of the study.

Two (2) site plans were generated to illustrate the study scope items and to generate further discussion. A copy of the concept plans can be found in Appendix I.

On March 2, 2010, the City of Yorkton held a workshop at the Gallagher Centre in Yorkton. The objective of the workshop was to review the existing site plan options and generate additional ideas for purposes of refining the scope of the study. In general, the meeting resulted in identification of the following components and associated benefits:

- Backwash water sedimentation ponds to meet water quality objectives;
- Wetlands for additional treatment and an area for waterfowl nesting;
- Fish pond to attract visitors to the park and illustrate water quality;
- Use of treated wastewater for irrigation of soccer pitches, tree nursery and community gardens;
- Opportunity to educate and promote wastewater reuse within the community;
- Small carbon footprint due to the natural treatment concept;
- Reduction of the hydraulic loading in the sanitary sewer collection system and at the wastewater treatment plant;
- Recharge of the local aquifer(s);
- Increased biodiversity; and
- Reduced Total Suspended Solids (TSS) discharged into the Yorkton Creek.

A copy of the workshop meeting minutes can be found in Appendix B.
Following the March 2, 2010 meeting, the City retained the services of Crosby Hanna and Associates to work with Associated Engineering to incorporate the public recreational components of the study with the engineered wastewater reuse facilities and to summarize the study with an overall area Master Plan. The City wanted to ensure that the resulting site was functional for both wastewater treatment and public recreation and education and accurately documented for future development.

Before the workshop, there was considerable work completed on the overall concept with the site limited to Logan Greens (as previously defined). During the March 2, 2010 stakeholder meeting the Ministry of Environment (MOE) commented that artificial recharge in the eastern limits of the site may be too close to the existing water production wells which may result in those wells having to be considered groundwater under the direct influence of surface water (GUDI). If infiltration/artificial recharge was to be utilized within the limits of Logan Greens, detailed surface water quality and hydrogeological data would be required in efforts to substantiate a non-GUDI well status.

Due to the desire of the study participants to include storm water treatment and infiltration as part of the overall study, it became evident that the study team had to look beyond the existing Logan Green site limits to incorporate artificial recharge into the overall master plan. Moving offsite to the east was the only option which removed the need to re-pump the effluent. It was suspected by BHL that the groundwater flow gradient was from the east to west allowing the “reuse” component of the study to be retained; however, additional hydrogeological work was required to prove this theory.

The study team noted that there was an existing large diameter culvert located underneath Hwy 9 that conveyed storm water east of Logan Greens to natural wetlands. East of the natural wetlands was a large drainage ditch that was constructed in the 1980s to convey significant storm water discharging from a large basin south of the City to the Yorkton Creek. The study team agreed it was in the best interest of the study to move the artificial recharge area east of Logan Greens. This provided a significant distance between the recharge area and the nearest production well, reducing the risk of GUDI. The revised effluent route would also add existing wetlands to the flow path, providing additional treatment of both the backwash wastewater and the storm water from the surrounding area. From this decision, the study team worked to develop two preliminary master plans options.
7.2 Option I

The first option that was explored using the expanded study area involved a series of cascading ponds within the Logan Greens area. As the water would exit the Logan Greens area it would enter into the existing drainage course east of Hwy 9. Refer to drawing CP-4 located in Appendix H.

This concept was to provide a natural overall wet park concept. However, following discussions with the study team, it was felt that this concept was not worth pursuing for the following reasons:

- Vast land mass that it would encompass would take away opportunities for other park uses (ie. walking paths);
- Stagnant water creating significant mosquito control challenges;
- Excessive loss of natural prairie grass; and
- Significant earthworks required to shape the ponds causing construction budget problems.

7.3 Options II

The study team directed AE and Crosby Hanna to simplify the Logan Green area development concept by using more of a linear wetlands approach to convey the water east across the site. A linear channel concept would provide the following benefits over the Option I:

- Minimize the use of existing land mass providing more opportunities for other park uses;
- Increase the velocity of the water as it migrates east across the site which should reduce the breeding grounds for mosquitos;
- Minimize the loss of natural prairie grass; and
- Minimize the earthworks volumes and thus keep the construction budget to a minimum.

Following a number of drawing submissions and associated refinements, the study team accepted the concept as illustrated in the preliminary Master Plan drawings located in Appendix I.

7.4 Community Open House

A community open house took place on Tuesday, June 7, 2011. The objective of the open house was to gauge public support for the study concept and obtain constructive feedback from the public regarding possible changes to the master plan as presented. Representatives from the City of Yorkton Environmental Services Department, the Assiniboine Watershed Stewardship Association, Associated Engineering and Crosby Hanna and Associates were in attendance discuss the study and to answer questions from residents.

There were approximately 20 people who attended the Open House. All comments that were received were positive and in general support of the study. There were no requested changes to the Master Plan.
7.5 City of Yorkton Council Approval

City Council formally approved the construction of the earthworks phase of the Master Plan on June 27, 2011.

8 Capital Cost Estimates

The following conceptual capital cost estimate was established to assist the City of Yorkton with implementing the scope of work identified in the master plan. The cost estimates below are shown in 2011 dollars.

- Sedimentation Ponds: $150,000
- Linear Wetlands: $250,000
- Fish Pond: $250,000
- Storm Water Detention Ponds: $400,000
- Soccer Pitches: $500,000
- Walking/Bike Paths: $100,000
- Interpretive Signage: $50,000
- Contingency: $300,000
- Engineering and Project Management: $300,000

Total: $2,300,000

9 Conclusions and Recommendations

The study has been formally endorsed by many residents and representatives of organizations within the City of Yorkton. It has also been approved by City Council.

The earthworks for the construction of the sedimentation ponds, linear wetlands, fish pond and soccer pitches were approved by the MOE on July 25, 2011. A copy of the MOE Approval to Construct can be found in Appendix D.

Construction of the earthworks began in August 2011 and completion is scheduled for the summer of 2012. A copy of the earthworks construction drawings can be found in Appendix J.
Implementation of the remaining components of the study in a phased approach is recommended. This approach will facilitate sequential construction requirements, maximize local contractor involvement and spread out capital cash flow over a greater period of time. The remaining components include:

- Completion of earthworks for the sedimentation ponds, linear wetlands, fish pond and rough grading for the soccer pitches;
- Completion of the soccer pitches (irrigation, grass seeding, fencing, washrooms, etc.);
- Installation of walking and bike paths;
- Planting of trees, shrubs and grass; and
- Interpretive signage

10 Closure

We wish to thank all of the study participants for providing valuable direction and guidance to the study team. A special thanks to the Assiniboine Watershed Stewardship Association and the City of Yorkton staff for their tireless efforts, innovation and leadership that was provided from the beginning to the completion of the study.

We would also like to acknowledge the funding contribution by the Government of Canada through the Green Municipal Fund as administered through the Federation of Canadian Municipalities. Without this funding this study would not have been possible.
City of Yorkton
Water Treatment Plant
Wastewater Reuse Feasibility Study

ASSOCIATION OF PROFESSIONAL ENGINEERS
AND GEO SCIENTISTS OF SASKATCHEWAN
CERTIFICATE OF AUTHORIZATION
ASSOCIATED ENGINEERING (SASK.) LTD.
NUMBER
C116

Permission to Consult Held By:

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QUALITY MANAGEMENT SIGN-OFF

Signature: \\
Date: Dec 13/11

PROFESSIONAL ENGINEER
SASKATCHEWAN
D.B. ANHOLT
MEMBER 06468
11-12-13
YR. MON. DAY
Appendix A – Process Flow Diagram
CITY OF YORKTON
WATER TREATMENT PLANT
WASTEWATER REUSE FEASIBILITY STUDY

WELL SUPPLY
AERATOR
RAPID MIXER
POTASSIUM PERMANGANATE
CHLORINE
PRE-DISINFECTION
FORCED DRAFT BLOWER
POTASSIUM PERMANGANATE
CHLORINE
PRE-DISINFECTION
UPFLOW ROUGHING FILTER (URF)
RAPID MIXER
FLOCCULATOR
AIR WASH
BACKWASH
AIR WASH
BACKWASH
SUPPLEMENTAL CHLORINE
TO HWY 15 PUMP STATION
SUPPLEMENTAL CHLORINE
TO DISTRIBUTION
TO HWY 10
PUMP STATION
TO DISTRIBUTION

PROJECT No. 2007-4219
DATE: 11/12/06
APPROVED: D. ANHOLT
SCALE: N.T.S.
DWG. No. FIGURE-XXX

CITY OF YORKTON
WATER TREATMENT PLANT
WASTEWATER REUSE FEASIBILITY STUDY
Appendix B - Meeting Minutes

- April 12, 2007
- March 2, 2010
- October 20, 2010
- October 20, 2010 – Meeting 7
- May 18, 2011 – Meeting 2
These minutes are considered to be complete and correct. Please advise the writer within one week of any errors or omissions, otherwise these minutes will be considered to be an accurate record of the discussions.

1 OBJECTIVE

1.1 The objectives of this meeting are to confirm the scope of the project and list of project team members.

2 SCOPE OF PROJECT

2.1 The scope of the project consists of a feasibility study to investigate the reuse of process wastewater discharged from the Queen Street WTP by artificially recharging the Logan West Aquifer.

2.2 There were ten (10) tasks that were defined in the project funding submission. These tasks are as follows:

- Project Initiation Meeting (today’s meeting)
- Study Criteria
- Site Topography and Drainage Issues
- Detailed Hydrogeological Assessment
- Stakeholder Meeting
- LEED Suitability Assessment
- Develop and Analyze Design Options
- Cost Estimates and Comparisons
- Feasibility Report
- Project Management

2.3 AE to provide a Project Execution Plan (PEP) using the above noted tasks as the outline. The PEP will serve as the plan for the execution of the project but will be an evolving document as the project develops. Action By: AE.
3 PROJECT TEAM

3.1 The project team consists of the following:
   - City of Yorkton (COY)
   - Assiniboine Watershed Stewardship Association (AWSA)
   - Ducks Unlimited (DU).
   - Saskatchewan Watershed Authority (SWA)
   - Saskatchewan Ministry of Environment (MOE)
   - Yorkton Wildlife Federation (YWF), representing SaskWildlife Federation
   - Beckie Hydrogeologists (BHL)
   - GE Ground Engineering Ltd. (GE)
   - Crosby Hanna and Associates (CHA)
   - Associated Engineering (AE)

3.2 AE is the prime consultant responsible for coordinating other consultants and associated budgets.

3.3 All consultants to submit invoices directly to the COY for payment.

3.4 CHL will not be required until the layout of all park facilities has been completed to at least the draft stage. Once the concept plan has been developed and agreed upon by all stakeholders, AE to provide CHL with the plan to complete the planting layout and specify the irrigation requirements for the various areas. CHL should also provide design assistance with pond design to ensure that the ponds are natural looking versus the typical engineered looking cells.

3.5 The project team should give consideration to retain the services of a sports field specialist and horticulturist when ready for that level of detailed input.

3.6 Neither an Environmental Screening (ES) nor an Environmental Impact Assessment (EIA) is part of this feasibility study. Depending on the results of this study an ES or EIA maybe required.

4 PRELIMINARY CONCEPT PLAN

4.1 A preliminary concept was developed during the meeting to facilitate discussion amongst all team members. The intent of the plan is simply to establish meaningful discussion as to what the COY, BHL and AE are envisioning for the water re-use components. Refer to the attached site plan.

4.2 The preliminary concept plan consists of two separate lined settling ponds located immediately north of the Queen Street WTP. The intent of the settling ponds is to receive the process wastewater from the
WTP and provide sufficient detention time to allow the iron, manganese, arsenic and other oxidized minerals to be settled out (clarified).

4.3 Additional detention time and perhaps a number of detention ponds maybe required to settle out the oxidized minerals, including arsenic. Bench scale testing of the backwash wastewater will help determine how much time and number of ponds will be required. AE to provide the COY with a testing procedure for backwash wastewater analysis. **Action By: AE.**

4.4 Following the clarification process, the wastewater would then flow by gravity through a constructed meandering stream and a series of wetland ponds.

4.5 The intent of the wetlands ponds is three fold: 1) provide further clarification of the wastewater; 2) offer a natural habitat for duck nesting and 3) present a natural park setting.

4.6 DU will be required to provide design input on the number, size, configuration, etc. for the wetland ponds. AE and DU to work closely together on water quality issues.

4.7 Following the last wetland pond, the effluent would then enter into an infiltration pond. The infiltration pond would penetrate the Logan West Aquifer and be sized in floor area and depth to accommodate the effluent flow rate. AE to work with BHL and GE to determine an approximate floor size area required to accommodate the volume of effluent. **Action By: AE, BHL and GE.**

4.8 BHL suggested that the infiltration pond should be located as close to well LW10 as possible in efforts to utilize well LW10 as an interceptor well. The intent would be to use well LW10 as a source of irrigation water for the park area and by doing so would draw recharge water towards the well leaving the two proposed test wells to be utilized as raw water production wells (ie. better water quality for the WTP).

4.9 The locations for the proposed settling ponds and wetland ponds will be provided by AE and DU based on the topography and duck nesting requirements.

4.10 The preliminary concept plan to be used to facilitate discussion amongst the project team in order to establish the study criteria.

4.11 The concept plan will be refined over the development of the project. There maybe a couple of concepts (maximum three) that will result in options for capital and operational cost analysis.

5 **STUDY CRITERIA**

5.1 The design average and maximum day capacity of the Queen Street WTP is 13,000 and 33,000 m³/day respectively.
5.2 Assuming a waste stream volume of 10%, it is anticipated that an average day water volume will not be sufficient for irrigation purposes or to maintain the pond levels at aesthetically pleasing or functional wetland levels. Therefore, it may be necessary to supplement the levels by pumping water into the ponds from existing well LW10 and/or by diverting local storm water drainage into the ponds.

5.3 This diversion could also provide additional benefits to the City with respect to the management of their storm water.

6 HYDROGEOLOGICAL ASSESSMENT

6.1 The original GMF grant application included a hydrogeological assessment (Task 4) with a budget of $150,000.

6.2 The hydrogeologic scope of work was to be refined following confirmation of the project and associated budget. In general, the scope of work would consist of the following:

6.2.1 Installation of approximately eight (8) permanent 50 mm diameter piezometers to confirm the water quality, the groundwater flow direction/gradient and the potential for groundwater mounding (increased pressure) in the Logan West Aquifer in response to the proposed injection of treated effluent.

6.2.2 These piezometers will also be used to monitor the effect of the proposed injection on the long term water quality of the aquifer and of Yorkton Creek. Some or all of these piezometers would be equipped with electronic data loggers.

6.2.3 Construct two (2), 200 mm diameter test wells on the north side of the WTP. Once the wells have been constructed and fitted with submersible pumps and pitless units, and powered from the Queen Street WTP, the wells should be pump tested for a minimum of 30 days

6.2.4 It is envisioned that the test well water will be utilized in the WTP for potable water production. This allows the water to be treated and used in the distribution system versus discharged to the ditch and wasted. It also allows the water to be transported off-site to eliminate the possibility of recirculation of the discharge water back into the aquifer.

6.2.5 The City’s minimum day demand far exceeds the anticipated production rate of these wells; thus, continuous operation of these wells should be possible.

6.2.6 The WTP has also been designed to allow for continuous operation even during backwash of various filters. Therefore, unless there is mechanical failure of the pumping or treatment system, a continuous 30 day pump test should be possible.
6.2.7 The data from the pump tests will be used to confirm the characteristics and production/injection capacity of the developed aquifer system and to determine the most effective method of treated effluent injection (i.e. ponds, injection wells, natural infiltration, etc.).

6.3 Based on existing hydrogeological data for the Logan West aquifer it is envisioned that the two proposed test wells should be able to produce a continuous supply of 12.5 l/s (165 igpm). This production rate should be sufficient to adequately assess the aquifer because the aquifer is only licensed by SWA to produce this volume of water.

6.4 The installation of the proposed eight (8) piezometers and the extended pumping test on the new well(s) should be completed following stakeholder consultation and confirmation of the final pond(s) orientation. This assumes that the Queen Street WTP will be operational to treat the water and power the two (2) test wells.

6.5 The test wells should be of sufficient distance away from WTP to allow for servicing by a rig.

6.6 Flow metering of the pump test well water will be accomplished utilizing the meter located inside the WTP.

7 STAKEHOLDER MEETING

7.1 It was agreed that one or two concept drawings must be prepared in advance of the stakeholder meeting in efforts to provide for meaningful discussion.

7.2 The intent of the meeting is to obtain input from all stakeholders. Once this input is obtained, a revised site plan(s) can developed.

8 SCHEDULE

8.1 Task 1: Project Initiation Meeting. This was the project initiation meeting, held Thursday, April 12, 2007.

8.2 Task 2: Study Criteria. This task can start now and should be completed prior to the Stakeholder Meeting(s).

8.3 Task 3: Site Topography and Drainage. This task should be completed during the summer when weather conditions are conducive to survey work.

8.4 Task 4: Hydrogeological Assessment.

8.4.1 The test wells and piezometers should be constructed in the summer when weather conditions are suitable for this type of work.
8.4.2 The actual pump test work cannot proceed until the WTP is operational, which is expected to be sometime in 2009.

8.4.3 The placement of the piezometers should take place following the stakeholder meeting(s) and confirmation of the proposed footprint for the wastewater reuse facility.

8.5 Task 5: Stakeholder Meeting: Following the completion of tasks 2 and 3 this meeting can be scheduled.

8.6 Tasks 6 to 9. The schedule for these tasks will be developed once the above tasks are closer to completion.

Respectfully Submitted,

Darren Anholt, P.Eng.
Project Manager

DA/kf
Water Reuse Study Meeting Notes
Meeting 1
Tuesday, March 2, 2010 at 1:30 p.m.
Wellington West Room, 2nd Floor, Gallagher Centre, Yorkton, SK

Attendance

Present: Michael Buchholzer, City of Yorkton (COY)
        Glenda Holmes, City of Yorkton (COY)
        Darcy McLeod, City of Yorkton (COY)
        Brian Dudar, City of Yorkton (COY)
        Harry Kerr, City of Yorkton (COY)
        Trent Mandzuk, City of Yorkton (COY)
        Theodore Trotz, City of Yorkton (COY)
        James Kluk, City of Yorkton (COY)
        Darren Anholt, Associated Engineering (AE)
        Mike Famulak, Beckie Hydrogeologists Ltd. (BHL)
        Jesse Nielsen, Assiniboine Water Stewardship Association (AWSA)
        Bland Brown, NRC-Centre for Sustainable Infrastructure Research (NRC)
        Doug Brook, Ducks Unlimited Canada (DUC)
        Jason Puckett, Saskatchewan Watershed Authority (SWA)
        Joe Zarowny, Ministry of Environment (MOE)
        Ries Mansuy, Ministry of Environment (MOE)
        Ryan Evans, Ministry of Environment (MOE)
        Donald Cannon, Yorkton Wildlife Association (YWF)
        Adam Fetsch, Yorkton Soccer Association (YSA)
        Chuck Tysowski, Yorkton Soccer Association (YSA)
        Sheila Hryniuk, Yorkton Active Transportation Collaborative (YATC)

Absent: Aron Hershmiller, Assiniboine Water Stewardship Association (AWSA)
        Syed Ahmad, City of Yorkton (COY)
        Trevor Plews, Ducks Unlimited Canada (DUC)
        David Hubble, National Research Council (NRC)
        John Fahlman, Saskatchewan Watershed Authority (SWA)
        Kei Lo, Saskatchewan Watershed Authority (SWA)
        Louise Belanger, Yorkton Active Transportation Collaborative (YATC)

Recording: Val Fatteicher, City of Yorkton (COY)
1. Introductions

- Michael (COY) – Welcomed participants. He will be providing introduction and background on water reuse study at the beginning of the meeting, Mike Famulak (BHL) will provide the Hydrogeological Report, and Darren Anholt (AE) will close with the Wastewater Analysis and Logan Green Concepts. This meeting for informational purposes, future meeting to allow for brainstorming and discussion.
- Round table introductions and attendance sheet circulated for completion.

2. Project Overview: Michael Buchholzer, City of Yorkton

- Michael (COY) – Design data was not available but we have a vision of what we’d like to see. Conceptual only and open to change. Would like open discussion and input. Prior to 1990, the City of Yorkton could not sustain their use, insufficient ground water. Looked at other concepts such as pumping water from Lake of the Prairies to maintain our requirements. Groundwater geology study provided by Beckie Hydrogeologists found that the groundwater would sustain this growth. Prior to the design of the water treatments plants, the City needed to establish a Water Treatment Master Plan. Concept developed of utilizing one plant on Logan Green. This practice will divert all raw water to one plant rather than 3 or 4 plants. In 2005, construction commenced with the reservoir followed by the water treatment plant structure and looking at opening in May or June, 2010. The lengthy construction timeline was partially due to the required funding for this project. Initially applied to MRIF, with their agreement to provide revenue of 1/3 federal dollars, 1/3 provincial and 1/3 municipal. However the application was capped at one million dollars but with phase in of project would allow for one million for each phase. Applications for additional funding provided for grants of twelve million dollars.

Part of the design criteria involved handling of the backwash water. Presently disposing through sanitary sewer, except for one plant where there is a holding pond in the summer months and evaporation is utilized. This would mean that all water would have to run through entire sanitary sewer collection system to get to the wastewater treatment plant plus cost associated with treating the process wastewater. Looked for green concept. Discussion with Doug Brook (DUC) back in 2005 regarding marsh life and irrigation onto recreation fields. Found there was potential for funding to complete a feasibility study. In 2006 applied for FCM – GMF grant, and received their approval to proceed. Outcome will be a feasibility study. Looking for an award winning project with community involvement, marshlands, environment for wildlife, walking path, bike path, waterfall system, public education/awareness and recreation fields. Create a tourist attraction with strictly a water reuse project. Active participants in this process are the City of Yorkton, Yorkton Soccer Association as fields could be soccer pitches, Yorkton Active Transportation for establishing bike and walking paths, Ducks Unlimited for marshlands, Wildlife Federation Ministry of Environment, Communities of Tomorrow, NRC for funding source and technical assistance, Beckie Hydrogeologists for ground hydrogeology, Crosby Hannah and Associates for area design, Associated Engineering for project engineering, Assiniboine Watershed Stewardship for project coordination.

- Jessie (AWSA) – Quick overview of what their organization does and why they are involved. They are a non-profit organization with core funding from Sask Watershed Authority. Other groups located throughout the province. Have a 12 member board of directors with members from the City of Yorkton, City of Melville, six towns, 3 villages
and surrounding rural municipalities. Their primary goals involve source water protection, where water comes from, groundwater and also to promote and ensure safe source water. Green up operations to ensure safe drinking water while working with Ducks Unlimited, Ministry of Agriculture, Ministry of Environment, City of Yorkton, and agriculture producers to determine what is in our stormwater. Endorse green up operations with wetland restoration and placing wetlands on municipal well decommissioning sites, also various fish projects partnered with Sask Wildlife. Copy of brochure with website address provides more information. Aron Hershmiller unable to attend today but please forward comments or questions to either Aron or Jessie and they will assist.

3. Participant Roles: Michael Buchholzer, City of Yorkton

- Michael (COY) – Round table discussion from each participant and their contributing role for this project.
- Bland Brown (NRC) – Focus on innovation and research. Aspect of this project in unknown zone. NRC would be interested in looking at. Communities of Tomorrow are a funding support with an opportunity for funding to be provided.
- Joe Zarowny (MOE) – Their role is to ensure the City is compliant within their permit requirements.
- Ries Mansuy (MOE) – Will require secondary permit to existing for backwash application.
- Darren Anholt (AE) – Project management and engineering required to compile project findings and to provide submission to the Ministry of Environment for permit to Construct and Operate Works
- Ryan Evans (MOE) – Discharge is from site, so would be MOE and not SWA. Waste stream is from a permitted site.
- Jason Puckett (SWA) – Involved in projects and partnerships, and permitting with MOE. Working with Ducks Unlimited and Assiniboine Watershed Stewardship with respect to wetland restoration. Able to assist with the vegetation aspect, upland vegetation and species selection.
- Doug Brook (DU) – Role is protecting or restoring wetlands, but expertise could be useful in sustaining vegetation. Very interested in the education value of wetland protection.
- Donald Cannon (YWF) – Previous experience with fishpond at JC beach or using dugout by DU quancet but presents a safety issue. Actively looking for area for fishpond, ideal area with changing huts and concession huts. Have not had an opportunity to discuss the concept with their executive. Would provide great opportunity for kids to catch and release as well as educational.
- Mike Famulak (BHL) – Will provide hydrogeological services to confirm aquifer limitations from withdraw to artificial recharge of treated process wastewater.
- Donald (YWF) – Unsure at this time. Could have someone from head office come in at next meeting or consult with and report back.
- James Kluk (COY) – He was past president of Wildlife Federation. Fish couldn’t winter at Hopkins Lake.
- Jessie Nielsen (AWSA) – Could put in aeration, or maybe convert to a skating pond in the winter.
- Donald Cannon (YWF) – Would just put fish in the pond in spring.
• Jason Puckett (SWA) – Would there be a constant discharge into pond? If there is discharge can put oxygen in there, but would also be an issue of public safety. Russell and Roblin, have fish ponds.
• Donald Cannon (YWF) – Melville has just set up a fish pond. Could contribute some of the funding for the project.
• Adam Fetsch (YSA) – Have been looking for new fields, west of the area proposed currently. Have to move to Yorkdale. Working on trying to grow the sport, numbers are down. Lost space behind the parkland mall. YSA has put money towards fields, has $10,000 dollars of funding available. City will generate income through economic spinoff. Are there still plans for the City Cemetery to be developed in this area?
• Darcy McLeod (COY) – Presently conducting review of existing cemetery. Area is registered right now as cemetery property. City Council wants review of whether we should be in the cemetery business. Future is unsure.
• Adam Fetsch (YSA) – Parking is always an issue.
• Michael Buchholzer (COY) – Crosby Hannah will come up with ideas to separate this area from the area proposed for the cemetery.
• Sheila Hryniuk (YATC) – Active Transportation wants to ensure the plan for cycling goes through, both for recreation point of view as well as commuters. Increase ability to use system, the pathways are there, can move around from site to site without too much difficulty. Would create a recreation destination with soccer pitches. Also wetland education piece to attract school groups. The ability to navigate location by cycles or by walking is important to the community.
• Michael Buchholzer (COY) – Is the cycling plan established?
• Sheila Hryniuk (YATC) – Path is already there but there are concerns with hidden locations in path, tight corners that are difficult for cyclers, still have components that can be looked at making path easily accessible.
• Trent Mandzuk (COY) – Public Works concerns could be the possibility of having a stormwater discharge from other areas to this area to help wetlands. Some drainage concerns further to north, if some of the southwest corner or southern area could be diverted would be beneficial.
• Michael Buchholzer (COY) – Have some outfalls into Logan Flats right now.
• Darcy McLeod (COY) – Leisure Services would be the connection to get general community support, as well as interested in education aspect and physical activity, making it accessible to general population.
• Michael Buchholzer (COY) – Could host an open house for community.
• Darren Anholt (AE) – Outside of day to day coordination, we would take the individual concepts and put them onto paper and look at integrating them. Pull together as a feasibility report to satisfy the City as well as the funding agent to obtain money for project.
• Michael Buchholzer (COY) – Get the finished design together, with wastewater to certain point and water to certain point so the area is protected. Would like to have at least two concepts to choose from.

4. Project Site Overview: Michael Buchholzer, City of Yorkton & Darren Anholt, Associated Engineering
• Darren Anholt (AE) – Site overview of area zoning – Parks and recreation, because of aquifer underlying areas makes environmentally sensitive. Water treatment plant main focus. Coordinate plan so as not to landlock the WTP for future expansion. Reserve the
land to the west for future use, equally on the east side by reservoir for potable water storage requirements. Boxed areas shown on map indicating this. Michael mentioned plans for water softening and demineralization, identify area by WTP for this purpose to the south. That’s the detail of this concept as we move forward. Referred to as Logan Flats, gently sloping to the southeast sector and ends up in Yorkton Creek and layout of concept with water flowing from west to east. Have soil conditions for the site that were encountered during geotechnical work for reservoir and water treatment plant. Three to four meters of clay material, sand, yields well to infiltration.

- Michael Buchholzer (COY) – Clarify that we can run plant discharge water to wastewater treatment plant right now, not sending to Logan Flats.
- Darren Anholt (AE) - NE corner reference to Well #10, and 2A. Well 1A are all in service at this point supplying potable water. Also Logan West 1 and Logan West 2, two primary wells placed in aquifer allowing BHL to adequately assess the aquifer and add long term production wells. Tree nursery on North central part of plan, Yorkdale School and bike path existing but not easily seen on plan.
- Adam Fetsch (YSA) – Concrete rubble left around by trees. What was the area used for before?
- Theodore Trotz (COY) – Area had been used as a disposal site for concrete previously.
- Michael Buchholzer (COY) – Will have that cleaned up. Did not encounter any concrete in area where piezometers were placed or during test drilling.
- Sheila Hrynuik (YATC) – Adam referring to area as a possible heritage site?
- Adam Fetsch (YSA) – Was it used as a primitive landing spot?
- Darcy McLeod (COY) – Will talk to Terri Prince, the City’s Heritage Researcher, to see what information exists on the site.

5. Hydrogeological Report: Mike Famulak – Beckie Hydrogeologists Ltd.
- Mike Famulak (BHL) – They have been the groundwater consultants for the City of Yorkton. Since 1997 all work has gone into production of the map distributed. They have established a good understanding of aquifers around the city, both for current and future demands for the City’s water supply. Aquifer that applies to this project known as the Bredenbury Aquifer as shown on the map. City has 5 water wells on that aquifer, only two being used now, with others put in place. LW1 and LW2, new plant running those wells will run 24-7, going to provide base flow and pressure release around reservoir. Aquifer is used rarely, old 1 pumping into WTP 4 plant. Like to be able to take water out annually. Right now operating with 16 water wells from 5 aquifers. Will come to one common plant, discharge water from that plant will be used for this green project. From hydrogeological perspective as a protection process will allow clear water to come off top of ponds to infiltration ponds for whatever uses and infiltrate back into ponds.
- Jessie Nielson (AWSA) – What is the aquifer depth?
- Mike Famulak (BHL) – 20 meters with clay layer. Will have to excavate to expose. Ponds north of treatment plant will have to be drained. Not allowing infiltration, conceptual now, looking at different ideas to make it work. Once have more detailed conceptual plan, will go in and do some drilling and have some points. Don’t want to start drilling piezometers yet. Once done will do pumping tests on two new wells, try to come up with a sustainable capacity. Want to put that water through the treatment plant, make sure up and running and send it into distribution.
- Ries Mansuy (MOE) – Will any wells be abandoned?
Mike Famulak (BHL) – Wells 1 and 2 to be abandoned. Well 10 may be reserved for supplementary irrigation to soccer pitches. Questions?

6. Wastewater Analysis: Darren Anholt, Associated Engineering
- Darren Anholt (AE) - The WTP is designed to remove iron and manganese, with the backwash water in the 5% range, maybe as high as 10%, concentrating on removing chemicals. Test sample from existing plant, iron/manganese/arsenic have oxidized. Results from analysis: Iron 100 mg/l, manganese – 70 mg/l, arsenic 160 ug/l, higher than Ministry of Environment limits. Glenda (COY) did decant sampling over various times and was able to get iron down to 0.7, manganese to 0.6 and arsenic to 3.7 ug/l.

Coffee Break - 2:50 pm

Reconvene – 3:15 pm


- Darren Anholt (AE) – Site plan provided is a starting point. Concept of settling ponds for backwash, wetlands for some form of advanced water treatment, multiple ponds, storm water management, infiltration, interceptor wells, tree nursery, soccer pitches, public washrooms, cycling and walking paths, interpretive centers, park aesthetics, create environmental area with the residents backing the park. Residents are used to having wide open green concept, will keep in mind as we go through process. Are there any other points or issues to document? Keep in mind that the water has to end up in the southeast corner and water has to discharge on the existing southeast side of the water treatment plant.

8. Discussion: All Participants

- Michael Buchholzer (COY) – As a City, feel it is an important aspect to consider, have not conducted a study on the current system. Can go to sanitary system but what is the effect of this. We would like this project to be initiated. Also have problems with groundwater runoff, and could divert from other areas of the city to over here.
- Trent Mandzuk (COY) – What quantity do you estimate for backwash water?
- Darren Anholt (AE) – When plant is commissioned this summer will be in order of 5% of actual consumption. Estimated 6 million liters on an average day, allow 5% and then for future design of the water treatment plant is essentially double that. If city goes to demineralization, the backwash water concentrate would be in order of 30%.
- Mike Famulak (BHL) – With current use you get about 50 gallons per minute on average day.
- Ryan Evans (MOE) – How deep would the pond be? Deep enough so it wouldn’t freeze? Will it be discharged all winter?
- Mike Famulak (BHL) – One issue, how you will keep it going. Probably want it shallower so you don’t touch the aquifer.
- Michael Buchholzer (COY) – How deep is the pond in Melville?
- Donald Cannon (YWF) – Don’t know. Site is visible from the highway. Not looking for huge pond. Should be wheelchair accessible. Concept of round pond with three foot fence as a barrier.
- Michael Buchholzer (COY) – Liability issue?
- Donald Cannon (YWF) – Likely but Melville able to proceed. Would have to go back to them to get information. Would recommend putting in fish in spring and take them out in fall.
- Michael Buchholzer (COY) – We should be looking at adequate size of ponds, what do we need for infiltration.
- Mike Famulak (BHL) – Small 6.5 square meters.
- Darren Anholt (AE) – 20 square meter pond would give us 20 minutes of settling time. Significantly oversized for what we need over time. Talked about winter time for what we need for infiltration, need control structures to maintain adequate levels, have 3-4 water meter depth, infiltrate into aquifer. Looked at onsite storage, but that wouldn’t be an aesthetically looking structure. Keep with something that operates the same throughout the year.
- Michael Buchholzer (COY) – Sized for total storage throughout the year?
- Darren Anholt (AE) – Looked at filling up the area with lines.
- Mike Famulak (BHL) – Pretty large pond to store for 4 months.
- Michael Buchholzer (COY) – Thinking of going to sanitary in winter?
- Darren Anholt (AE) – Adequate sedimentation through gravity settling to introduce to aquifer throughout the winter. Thoughts to put in mechanical treatment system. Have experience to know it would work but not the mandate for this project at this time. Maybe if this doesn’t turn out. Confident with numbers provided, that can introduce back to the infiltration system.
- Jason Puckett (SWA) – How much sewage do we discharge a minute? If takes 50 gallons per minute, how much of it would be this wastewater?
- Michael Buchholzer (COY) – 6300 gallons discharge at the wastewater plant. Unsure because this plant is not online.
- Darren Anholt (AE) – Will be less than 5% of the total water, but will not know for sure until we get plant online. Should generate less backwash water.
- Jason Puckett (SWA) – Question how much that would help the sewage requirements downstream when you pull that 50 gallons out, how does that change the sewage release?
- Michael Buchholzer (COY) – Good point. We have no detention time with existing plants. Some detention time at Park Street WTP, nothing at West Broadway or Hwy 10 East WTP’s.
- Darren Anholt (AE) – When plant is at maximum capacity, estimated that we couldn’t detain it for any more than 24 hours as it would basically max the path to the sanitary sewer system. Estimate based on 30 million liters per day.
- Michael Buchholzer (COY) – When reach that type of capacity will have to develop to the south. At same time, energy used to move water by that route, possibly add lift station.
- Darren Anholt (AE) – Question for Bland (NRC) and Doug (DU), and Donald (YWF) – Do you have any data on wetland plans with regards to salt uptake/tolerance, would like to see what information you have, in a wetland atmosphere? If demineralization is introduced, what is effect? What would this concentration do to vegetation?
- Bland Brown (NRC) – Do these chemical compounds have any effect on wildlife?
- Darren Anholt (AE) – Backwash wastewater intent would be taken back at a level acceptable but when demineralization introduced then changes, not oxidized.
- Jason Puckett (SWA) – May cause problems if have to change the way the city treats water in 10 years.
• Darcy McLeod (COY) – Have to be very good at communicating this, find some secondary benefits for the community. If fish ponds will work but essentially about the backwash system.
• Donald Cannon (YWF) – Will not be able to take fish away, more of a catch and release. Chemical analysis would say if fit for consumption.
• Darcy McLeod (COY) – Had fish stocked at JC beach, not feasible location because they couldn’t winter. Message must communicate that may not be that way forever.
• Donald Cannon (YWF) – More for kids or wheelchair accessible for those that can’t go fishing elsewhere. Not intended for consumption.
• Jessie Nielsen (AWSA) – Have meeting next Tuesday. Kengsheng (SWA) to have more information. Fishpond was an option. Have seen what’s in that storm water, not sure if there will be healthy fish.
• Darren Anholt (AE) – Something we could do with surface water? Could look at integrating with sedimentation.
• Jessie Nielsen (AWSA) – Not direct feed but series of ponds.
• Darren Anholt (AE) – City of Regina has done a series of studies on wetland pond treatment.
• Jessie Nielsen (AWSA) – Address issues, have funding available for wetland creation.
• Darren Anholt (AE) – Previously one of the concerns, volume of water from backwash to maintain an adequate flow. Might not have much water left for infiltration.
• Mike Famulak (BHL) – Will have some water quality information next week.
• Jessie Nielsen (AWSA) – Started sampling last April until beginning of October. Four sampling dates.
• Darren Anholt (AE) – With regards to duck ponds, size requirements are something to think about.
• Doug Brook (DUC) – No concern with size but depth. Cannot be less than 3 feet.
• Darren Anholt (AE) – Deeper in centre but overall between 2-4 feet.
• Ries Mansuy (MOE) – Mosquitoes an issue?
• Brian Dudar (COY) – Not usually in deeper water, 6 inches or less, if moving not an issue, only when stagnant, sitting water. Design with ponds will allow for recreation activities, education, fish pond at end, opportunity to bring people to recreate. Amenities with benches, like interpretive centre. No other facilities like this to gain knowledge?
• Ries Mansuy (MOE) – Not familiar with any other backwash collection wetlands.
• Darren Anholt (AE) – Not in this particular application.
• Doug Brook (DUC) – Preliminary drawing shows very good, wanted to see.
• Darren Anholt (AE) – Able to give to wetlands sector for their perspective, take and work with it, would that be something they would rather have their designers handle?
• Doug Brook (DUC) – Would be surprised if they could fit this into their current schedule. General design 2-4 foot depth, no steep banks, gradual slope, after 3 foot range get different kinds of vegetation. The flatter the better.
• Darren Anholt (AE) – Other questions with regards to soccer pitches and parking issues?
• Chuck Tysowski (YSA) – Parking always an issue. Pitches look good.
• Darren Anholt (AE) – 3 soccer pitches adequate?
• Chuck Tysowski (YSA) – Yes, senior soccer pitches. Parking requires better flow of traffic. Other locations have one entrance and one exit. Pitches are on city property, vehicles driving too fast, have to monitor that for liability. Could control with service road but have had issues.
• Michael Buchholzer (COY) – Installation of speed bumps of some kind?
Darren Anholt (AE) – Any idea on number of parking spaces required?
Chuck Tysowski (YSA) – Due to age groups and ability to play all age groups, start at 6 pm. Estimate 100 players an hour.
Darcy McLeod (COY) – Are soccer pitches facing right direction?
Chuck Tysowski (YSA) – North-south preferred.
Michael Buchholzer (COY) – A lot of pitches have burms around them to stop access into the field.
Chuck Tysowski (YSA) – Have had to deal with vehicles driving across the pitches and then they are repairing the damage. Concept opens up option of competitive soccer for senior or possibly youth levels. Working with governing body for corporate sponsorship. Have discussed possibility of an indoor facility. Could be for multiple uses like football, lacrosse, walking or running tracks. Cost for turf at approximately $100,000 to $250,000 per field.
Darren Anholt (AE) – Any area expansion needed for the tree nursery?
Brian Dudar (COY) – Would go with more of a grass tilled area. Have discussed replacing the stock that was there. Lots of room there.
Darren Anholt (AE) – Any benefit to approaching PFRA with regards to being part of this team and adding more of an educational aspect on this project.
Brian Dudar (COY) – Problem with growing seedlings in that they need so much looking after in the first year of growth.
Harry Kerr (COY) – What would be the quality of the irrigation water? Any added chemicals? Especially for the soccer pitches?
Mike Famulak (BHL) – At this point we’re not sure if the irrigation will come from ponds or Well 10. That would be fine for any type of irrigation. Are we going to traditional or go to membrane treatment. If membrane treatment, then irrigation may not be suitable. Well 10 is set aside for interception and also for a source of irrigation.
Harry Kerr (COY) – What are ponds going to be lined with?
Darren Anholt (AE) – Synthetic liners using insituclay material would be used for the settling ponds.
Michael Buchholzer (COY) – Can you provide data on water quality required for irrigation?
Harry Kerr (COY) – Yes.
Mike Famulak (BHL) – Any concern with temperature?
Harry Kerry (COY) - No, but possible accumulation of salts, etc.
Mike Famulak (BHL) – Cover is more of a silt, clay rich material.
Ries Mansuy (MOE) – Using backwash, operational requirements with perimeters unknown as there are not a lot of existing. If irrigation water is coming from the plant would need a separate permit to operate that. If Well 10 then not an issue.
Mike Famulak (BHL) – Well 10 preferred option. When was it last active?
Glenda Holmes (COY) – Not sure.
Jessie Nielsen (AWSA) – Settling ponds going to be wetland mediation, aesthetically, synthetic liners with nothing around it won’t look good. May be important to try and incorporate, making a pristine area, better to have clay liner.
Darren Anholt (AE) - Initial settling ponds elevated, quite a gentle sloping piece of land. Better to have ponds coming at grade rather than coming off existing ground and burmed up.
Joe Zarowny (MOE) – A lot of area for a six hole par three golf course for kids.
• Darcy McLeod (COY) – Could consider but there would be maintenance and possible supervision issues.
• Michael Buchholzer (COY) – Create all the ponds even though oversized, if not being used turn into grasslands. If the sides are shallow, wouldn’t notice it when walking around it and still creating the fish pond.
• Darren Anholt (AE) – How far should cattails be submerged?
• Doug Brook (DUC) – As long as they are under 3 feet of water.
• Jessie Nielsen (AWSA) – Have an oversized area that accommodates future water capacities. Most stormwater retention ponds are just areas of grass and water for a short period of time during the year.
• Doug Brook (DUC) – Need to go through a natural dry cycle – one growing season – one summer – every 7 to 10 years.
• Darren Anholt (AE) – Look at opportunity to bypass ponds. Is there any demand for market gardens?
• Brian Dudar (COY) – Existing gardens shown on black areas on map. Sell them on a north south direction, east west side has really good soil, along poplars. All 21 gardens are sold. They are a long way from nowhere, no water supply either.
• Michael Buchholzer (COY) – Any more comments? Potentially have committee with recreational plan, another with design. Take discussions from today, digest it, summarize any questions and submit to Jessie. Who will attend next meeting if we have another workshop?
• Darren Anholt (AE) – Once this groundwork is established, agree to working concepts and utilize the landscape architect to alleviate and assist with site aesthetics.
• Michael Buchholzer (COY) – These ideas will be provided to Crosby Hannah for input and then we can have another meeting. Forward any information you have to Jessie.
• Ries Mansuy (MOE) – We have direct contact with the City, not AWSA.
• Michael Buchholzer (COY) – Beneficial to have at the table for input to know what can or can’t be done. Any related matters from Ministry of Environment can be sent to me.
• Brian Dudar (COY) – Access to the WTP would be separate than these other areas?
• Michael Buchholzer (COY) – Want to keep isolated due to security issues. Will be surveillance by camera.

9. Next Meeting: To be announced.

10. Adjournment - 4:45 pm
Water Reuse Study
Soccer Pitches Planning Committee Meeting
Wednesday, October 20, 2010 at 10:30 a.m.
Meeting Room A, City Hall, Yorkton, SK

Attendance

Present:  Michael Buchholzer, City of Yorkton (COY)
          Brian Dudar, Community Development Parks & Recreation (COY)
          Fran Brimacombe, City of Yorkton (COY)
          Adam Fetsch, Yorkton Soccer Association (YSA)
          Aron Hershmilller, Assiniboine Water Stewardship Association (AWSA)
          Jesse Nielson, Assiniboine Water Stewardship Association (AWSA)
          Chuck Tysowski, Yorkton Soccer Association (YSA)
          Rob Crosby, Crosby Hannah & Associates (CHA)
          William Hrycan, Crosby Hannah & Associates (CHA)

Absent:  Darcy McLeod, City of Yorkton (COY)
         Darren Anholt, Associated Engineering (AE)

Recording:  Val Fatteicher, City of Yorkton (COY)

1. Introductions
   - Round table introductions.

2. Soccer Pitches – Layout, Design, Location
   - Rob – Developed plan based on meeting notes and on air photo, setting the
development standard and then see how it evolves. Visited actual site for
the first time today, may need to make some adjustments. William will
explain the details of the plan displayed.
   - William – (Refer to left side of plan) Plan for six fields – 96 x 120, 64m x
100m still able to shift/expand.
   - Adam – 64m required for men’s soccer.
   - Chuck – in order to host provincials must have a minimum of 4 fields.
Would rather see four senior pitches to get those competitions here as well
as four junior pitches for ages 4 through 12.
   - William – parking area indicated in grey.
   - Adam – north/south line – dashed line is off limits?
• Brian – proposed plan to abandon that cemetery location.
• Rob – allowance for 150 stalls, may have to incorporate overflow on grassed area.
• Chuck – working with a firm to design an indoor facility that would house one or two fields and also working on possible grants.
• Rob – is there a sense of size for the facility, maybe a diagram of where doors or common areas are? Could work with this layout.
• Fran – existing/proposed location for cemetery site, previous plan as a subdivision development.
• Brian – 20 acres to the south for cemetery. May be used to maximize parking, concessions, bathrooms, etc.
• Fran – would also have to talk to Sask. Highways due to access off the highway.
• Chuck – all access off of Yorkdale site now.
• Fran – if cemetery use changes, service road could be developed. Work with existing approach to WTP, and extend.
• Rob – gravel road set up for cemetery?
• Brian – yes, going to council for end of the year. Decision to vacate. Council asked for some alternate locations.
• Fran – not sure what future plan for development of this area is, would have to talk to David Putz (City Manager), or see what Gord Shaw’s (Director of Planning & Engineering) recommendation is? Can initiate that discussion.
• Chuck – Could also incorporate multiuse, football, lacrosse, etc.
• Michael – Whether it’s a big block for future expansion, water and sewer there already, parking established.
• Chuck – no washrooms right now. 4-5 yr project. Have to accommodate or bring in portables. Regina site is good example of what they are looking for.
• Rob – Parcel to west need some direction whether able to integrate. Need information on size of multipurpose facility. 6 full size and 4 smaller ones. Changing community gardens?
• Brian – one in NE corner only, had nursery established. Would be removal of trees to the east, expansion to gardens. Two to the west have been abandoned (along dashed line).
• Rob – (circled in red) Critical for orientation of soccer fields.
• Adam – grow trees between fields to create boundary.
• Chuck – allow for bleachers?
• Adam – Similar to Regina’s, on the Ring Road off Mount Pleasant Park, two big pitches, back to back. Well put together. Chain link fencing for traffic control?
• Brian – damage to turf. Need to protect.
• Michael – noise control for residents to the north. May see complaints when going to open house.
• Rob – Fair distance to residences right now.
• Michael – another concern to protect gardens.
• Aron – north end of soccer pitch, what distance?
• Rob – about 150 m to the residences
• Brian – how far to gardens?
• Rob – right now one pitch right on top, will have to move around. Chain link at ends?
• Adam – Have in Regina, assists in traffic control, for admission collection and to keep balls in.
• Rob – noticed some private use, residents using for back property access.
• Brian – provide access off Tupper Avenue, sell them a key to access. If cemetery development doesn’t go forward and develops into housing will not have access from the west anymore. Have to watch the south side. Get in by WTP.
• Rob – gate open at foot of Tupper Avenue for access through Gladstone.
• Michael – safety issue for parking along the west side? Concerns?
• Jesse – compound would be gone then?
• Brian – abandon whole thing. City uses now.
• Jesse – room to put parking along west side.
• Adam – could put a lot of vehicles there, highway too busy.
• Chuck – want to get multiuse facility, based on a lot of private sponsorship and grants.
• Michael – would be good to identify an area on the plan, to show future planning/intent.
• Brian – access road/service road now, would need more access for their staff, but not open to public. Have tried to protect that road. Garden access now. Try to incorporate right now.
• Chuck – having six pitches right now
• Adam – 40-50 yds right now, between pitches, lots of room. Orientation good right now, north and south.

Adam – left meeting 11:15 am

• Rob – lighting for night?
• Chuck – no, not a big fan for night games. If looking for night games look for indoor facility. In ten years maybe put lights in or put in but not turn on.
• Rob – show them on the plan at least.
Chuck – early in the season gets dark quicker. Lighting along parking areas would be good. Trail lighting? Allow people to walk through at night.

Rob – doesn’t look like the kind of pathway system to be lit. Maybe lit to a certain point. Area is too natural.

Rob – would resist unless residents wanted it.

Michael – did not put lights on back of WTP to keep it natural for the residents. Just minimal lights to use at night when necessary. Big concern to keep atmosphere. Keep lighting low.

Rob – can make it lower with landscaping. Need space for equipment boxes, player benches?

Chuck – Benches yes. Equipment brought in.

Rob – nets and corner posts with coaches to have access to.

Chuck – come down after game play. Lining machine, indoor storage for paint when it’s colder.

Rob – how big of storage?

Chuck – Some equipment stored in heated storage to preserve. On site storage wouldn’t have to be that large. Coaches have equipment, bring with them. Permanent players benches would be better, but would not have to be at all pitches. Portable takes away the ability for them to get wrecked. Two pitches with permanent, the rest could be portable.

Michael – storage may need two concepts. Cold storage and bathrooms incorporated later on.

Rob – if multipurpose facility then fine, but if not then?

Chuck – players come changed now, portable toilets. Building could house bathroom/changeroom and showers? City would determine who would maintain building.

Brian – For baseball have half building for concession and half for bathrooms. Need to put in 300-400 ft space to accommodate. Seasonal/temporary could be moved later? Not sure for what other use, admin/office space?

Michael – building will be phased approach. Fields being created but building would have to be brought into management team to review. Bring in as a conceptual design.

Fran – left meeting at 11:30 am

Rob – Building to have some function, soccer, wastewater reuse, and some formal education all important factors. Have to orientate into that. Irrigation would be important.

Brian – need to redesign trail when WTP and soccer areas get established.
• Rob – significance of name Logan Green?
• Brian – check with Terri Prince (City Historian).
• Rob – existing sign that lists donors and has a logo. Protect everything north of the trail. Residents protect and cut the grass there.
• Brian – told when they bought the properties there that that area was theirs.
• Rob – any issues when WTP built there?
• Michael – now a utility area, protecting what’s there. Not sure what residents reaction will be?
• Brian – maybe a buffer of trees? Or better that it’s open, still give them a lot of privacy, row planting.
• Rob – things that could be done to improve. Memorial tree park, granite and tindle walls.
• Brian – tree nursery. People have asked to plant trees in memory of someone.
• Rob - Would want to protect that little quadrant. Still quite a bit of space there. Now that they have visually seen site will have to adjust on paper, keep modifying until it’s worked out.
• Chuck – played on Yorkdale 30 years ago. Working on project with the schools, more push towards soccer. Core users 4 to 12.
• Aron – irrigation for fields still talking about ponds or well?
• Michael – will have to look at water quality issue.
• Aron – Keng (Sk Watershed) wants to comment on meeting this pm.
• Michael – if Beckie brought in then they could be brought in. Attended first meeting. Rather than interpreting, have Beckie Hydrogeologists do correspondence.
• Chuck – still have $10,000 to invest. Staying on Yorkdale, but looking at future.
• Rob – this plan will be the master plan, much more refined indication of how the planting program will work.
• Chuck – biggest area is parking right now. No barriers to stop vehicles.
• Rob – get controlled and defined.
• Michael – also work on highway’s permission to access.

Next Meeting: To be announced.

Adjournment - Noon
Attendance

Present:  
Michael Buchholzer, City of Yorkton (COY)  
Fran Brimacombe, City of Yorkton (COY)  
Trent Mandzuk, City of Yorkton (COY)  
Darren Anholt, Associated Engineering (AE)  
Aron Hershmiller, Assiniboine Water Stewardship Association (AWSA)  
Jesse Nielsen, Assiniboine Water Stewardship Association (AWSA)  
Rob Crosby, Crosby Hannah & Associates (CHA)  
William Hrycan, Crosby Hannah & Associates (CHA)  
Mike Famulak, Beckie Hydrogeologists (BHL)  
Doug Brook, Ducks Unlimited Canada (DUC)  

Absent:  
Darcy McLeod, City of Yorkton (COY)  

Recording:  
Val Fatteicher, City of Yorkton (COY)  

1. Introductions
   - Round table introductions.  
   - Michael – 2nd meeting, 1st with Soccer Association this morning. Review the preliminary design.

2. Design Criteria and Layout - Settling ponds/wetland ponds /fish pond
   - Darren – Following first meeting, an opportunity to talk about what wanted in project. Aron compiled requests that evolved from various groups, they are documented on this drawing. Intent of compilation on drawing was to sit down with Crosby Hannah to achieve what all interest groups wanted to see. Look at treatment system, come up with concept system. DUC may challenge concept but first stab at trying to develop understanding of the area, fish ponds and infiltration ponds and storm sewer system. Go through flow diagram, illustrating concept. At top trying to illustrate, phase 1 of treatment coming off of filtration system of WTP, use gravity sedimentation, two gravity ponds, cleaning sedimentation use one or other depending on what being cleaned. Ponds are sized in the order of 30 days at maximum flow, from sedimentation ponds city collected data from backwash water, should be at 99% level just by gravity itself.
Freewater flow, vegetative growth, freestanding water. See the plants, the flow is happening below the surface of the actual ground material. Polish into the fish pond and then into the infiltration pond. That’s the current concept right now. Have wastewater treatment specialist looking at sizes. Some operational issues to look at in winter. Storm water system, intercepting some of the water coming down Queen Street on the north side of ditch, attenuating gravity settlement and again into infiltration system. In future, made provisions in WTP to utilize membrane treatment for demineralization, reject water would be high in hardness, salt, divert to another series of settlement ponds and again into fish ponds and infiltration ponds. Establish phase 1, implement until such time is required to proceed.

- Rob – About 10 days ago, looked at AE drawing and reviewed. Call concept schematic. Use engineering drawing and try to fit into the landscape. Gave them sense of what system looks like. Look at different blocks and critical elevations. Take material excavated and build soccer fields. Listing on bottom from AE, summary of meeting in March/wish list, all trying to achieve. Distill down to goals and objectives. Schematic drawing now, get into realistic form. Study area, may want to include in plan. Was future cemetery, partly used for other purposes, may house multipurpose facility. Having that parcel of land may change our thinking. Hand out draft goals and objectives to all members, to see what we are trying to do. Distills what we knew over a week ago. Read and see if on track. After seeing site, thinking has evolved some. Any comments on the goals and objectives?
- Doug – to accommodate active and passive recreation and leisure, does it also accommodate educational purposes?
- Rob – add into fourth bullet or second from last. Will expand on that, good point.
- Jesse – what exactly is this wastewater? Backwash water/wastewater, what is it?
- Michael – wastewater not going to work. Talked about before, just treating the backwash water. Backwash water, natural occurring arsenic, residual treatment water.
- Darren – remaining minerals stay in their soluble form and flow through the filters. Not elevating those parameters.
- Michael – hard to say how much arsenic could be settling out in our detention tanks. Will evolve differently in this system from our old system, more retention time.
- Darren – within an hour, 95% of iron and manganese settling out, already in its solid form.
- Michael – filter out now, haul iron and manganese to wpcp now.
- Darren – looking at 10% of backwash treatment train, double that 20% would be in membrane residuals treatment stream.
- Aron – evaporation?
- Darren – not at that level yet. Tried to establish worst case scenario to give Crosby Hannah the broadest scale. Wetland specialist going through and revise as necessary.
- Michael - Capacity of detention tanks?
- Darren – two backwashes.
- Michael – product going out will change quite dramatically. Will settle out but with more frequent backwashes will change. Water quality going to first pond could be quite good on startup. High demand with LDM and JRI, should be peaked right now unless someone else comes in. Backwash once every day or every second day, minimum 24
hours and then cycle. Won’t have all the filters at the start. Will be automatic system that could go on all night. At bottom of tank get cleaned out and then go to the landfill. Clean tank maybe once or twice a year, backwash detention tank. Worried about water quality going into the first pond.

- Mike – backwash water will change, not consistent.
- Darren – decant off settling ponds consistent in terms of water quality. Buffering zone.
- Doug – specialist determining the quality of the water to allow vegetation to grow, or fish?
- Darren – have had discussions, in terms of what backwash water contains after settling up to one hour. Speculating, basically would be what it is coming out of the well, coming off the settling ponds, any settling in terms of oxidizing would be in the wetlands system. What do we expect to be loading. His concerns are nutrients, to feed the wetlands? One came in about two weeks ago where they are using wetlands for the same purpose doing here, in Canada, just came out in an environmental science magazine. Not the first, with this concept. One issue, another more of a concern how to deal with winter operations, hopefully can address that. Subsurface flow fine when frost free, but during winter backwash? Beginning of project, worst case scenario shut down. No answer at this point.

Fran – arrived at 1:50 pm

- Darren – 100 imperial gallons with conventional treatment, based on design flow rate of the water treatment plant on average day, 13,000,000 liters/day, half of that would be anticipated.
- Rob – if treatment train not functioning, what happens with backwash?
- Darren – look at combination, redirect to sanitary system, put through collection and send to wastewater plant out of the city. Have enough sedimentation through wetlands to have enough capture of any sedimentations and allow us to discharge to the aquifer or store it on site. Make bigger storage chambers.
- Michael – preference to go all year, try to stay on the flats, did not model on the sanitary system. Can throttle down and put through, everyone will be sensitized due to July 1st storm. Even if a layering effect, mid November still no freezing. Beginning of January more likely.
- Trent – what is the ratio?
- Michael – sometimes three times now, put out 6000 cubic meters at WTP and 18,000 at WPCP. Plus the energy to treat it alone.
- Trent – significant and costly for treating wastewater.
- Darren – saving would be seen if deminerization goes in and this wetland project. Some data out there, some saline treatment plants out there.
- Michael – deminerization would be on backburner, other things taking priority.
- Trent – if effective, apply to storm water, instead of pumping through plants.
- Fran – looking at west drainage study, to divert water to two holding ponds to get here?
- Michael – that’s what looking for the more water the better.
- Fran – AE doing drainage study.
• Darren – in terms of layout, best guess at two top trains in that area and build what we can, not based on any anticipated storm water runoff at this point. What we can divert in and what cannot be bypassed. Talked about how much effort, look beyond, deviating what grant had us looking into, backwash water not storm water.
• Michael – could look at the dilution of the water, may need both to make it work.
• William – water pumped up to top of wetlands, not traditional, may need to add to make it work.
• Mike – if water quality issues can change the direction of the ground water flows to keep it moving out of those areas. Haven’t thought of winter operations, or maybe goes back into the system.
• Darren – had to remind our research team, traditionally going to the client and telling them it will work, basically a research project. Make best effort, all of us need to keep in mind it’s leading edge and no textbook reference to go on. That’s why able to secure grant funding. Have made initial application to insert for some follow up monitoring dollars. To look at system over a year or two years, 30,000 dollars available for monitoring funds.
• Jesse – storm water wouldn’t be effective with fish. From what Keng (SWA) knows, would build up enough contaminants.
• Rob – how critical is the fish in fishpond?
• Michael – important for Wildlife.
• Jesse – does have the capacity to handle storm water, from what area taking it in the city?
• Michael – Logan Crescent dumps into there.
• Fran – could take from the roundabout area
• Trent – could help silver heights
• Darren – as a group here, need to focus on when we need to have this implemented, a year from today, need to have a facility constructed, money used to construct will be funded under another program, which runs out in March 31, 2012. That means we need to have this feasibility study done this winter. Need to appease the federal government to get 50 cents on dollar back to city. If we want to utilize both grants. Probably going to be the hardest to convince, go with good assumptions and do the best we can and monitor.
• Mike – Watershed Authority has non-interest on this, all to Ministry of Environment. Confirmation from groundwater specialist at Sask Water to Ministry of Environment because it’s post treatment. Adaptive study until we know how it responds, testing and research project.
• Darren – 200 day (six months) storage facility would require a storage pond of 250 m x 250 m by 3 m deep.
• Mike – only need that to be half due to two ponds.
• Michael – one for treatment, one for demineralization.
• Mike – total storage for total volume
• Aron – design now, based on six month storage?
• Darren – no, looked at because that’s what GMF calls it, feasibility study. Come up with a couple of layouts, due a matrix evaluation including financial and regulatory. Don’t want to see more than two options to evaluate.
• Michael – could have two designs for report but when open house only one option.
Mike – maybe better to get regulatory input now to see which direction to push forward in.

William – after discussion less sure of what has been done now. Design took form from information at that time. High points and sloping down to fish ponds to aquifer recharge area. Scheme idea to something natural looking, something uniform to ideally a natural wetland. Structure leading down to filtration system. Look like a grassy field. Envisioned pedestrian bike trail. Tupper identified as cycle path as well as other connecting streets. Like the organic feel of existing path. Overall path structure is good. Main interpretive walk, with parking being brought into the area, and wetlands looking like they are serving different functions. Key features identified, maintain existing vegetation, keep trees where can and replace with habitat, create grasslands and wetlands. Education key, water treatment process, biodiversity need to be addressed. Doesn’t show the character of the site. Dark green areas, treed areas will be modified somehow. Identified the northern belt where the path exists, lots of mature trees, landowners have taken care of and claimed, keep as existing. Overview of structure, open for change. Circles are settling ponds. Bands of alternating water and vegetation, force it to spread out through the vegetation, theme of industrial to somewhat organic to very organic. Flows into vegetation green area and then fish ponds.

Darren – concern with infiltration pond, freezing and protecting the pond underneath.

Mike – thought could artificially assist with infiltration pond. About 4 m below grade can introduce for infiltration area. Pond size should be 65 meters.

Darren – almost pointing us toward storage to take advantage of storm water in this system.

Michael – don’t want deep storage, safety with public, don’t want to fence it.

Darren – if open in winter, have to be at a depth range to reduce liability.

Mike – 3 meters to maintain storage.

Rob – 10 to 1 sideslope

Mike – maybe primary waste management ponds (settling ponds) have to be fenced.

William – put a lid on them?

Michael – if settling ponds were close to the WTP and contain them, then looks like part of the process.

Mike – by putting treatment ponds within the confines of the treatment plant, what about storage ponds.

Aron – what about fish ponds?

Michael – not fenced in Melville. 20 feet in Melville, ledged. Liability issue for city versus wildlife.

William – public communication is key.

Trent – left at 3:24 pm

Michael – storm water retention pond study. North of Smith on Dracup.

Darren – as part of feasibility study, reserve space for it in case we need it, as a backstop for winter to get us through.

Rob – where in that treatment train would it be?

Darren – after the settling ponds.
• William – can the settling ponds work with a layer of ice on them?
• Darren – yes, frozen over.
• William – underground pipes from ponds to sedimentation.
• Darren – settling ponds would be the highest in elevation. Ideally, 2 meters above existing grade.
• Michael – main area to blend in with the landscape of WTP
• William – WTP elevation quite high, might smooth the whole area out. Need 2% gravity.
• Darren – 0.5% adequate, 1 meter grade to the water at the east end. Can I get some feedback of sideslopes of 10 to 1 or 20 to 1 big difference. Is there enough room at 10 to 1? 4 to 1 ditch slope would be typical highway slope, 5 to 1 for highway median, as shallow as 6 to 1 easy to maintain. Somewhere between 6 and 10, if maintaining the grounds look at 6.
• Rob – prefer to have no steeper than 1 to 4, like a hwy ditch.
• Darren – burm no steeper than 3 to 1.
• Michael – WTP?
• Darren – 6 to 1.
• Michael – 6 to 1 okay then for slope.
• Fran – looking at 5 to 1 for Dracup pond.
• Jesse – settling ponds to be round?
• William – made them round due to shape of WTP, going from square to round, then into natural looking landscape.
• Jesse – would like to see natural looking shapes.
• Darren – established criteria and plant material, should have something to Rob by end of next week.
• Doug – Ducks utilizes Robert Cadlich as a reference.
• Darren – Should have what we come up with for wetland design evaluated.
• Michael – may not be able to offer info if hasn’t worked on. Ask him to comment on it, best judgement.
• Doug – will talk to their research team.
• Rob – grant funding for this project, anything that outlines the process, are their interim deliverables to supply?
• Darren – haven’t actually supplied deliverables, just status reports to get some funding.
• Doug – when look at information to forward?
• Darren – as early as next week.
• William – would like to meet with Arcadio (AE).
• Darren – enough interest in using storm water, integrating into the wetland system, from the north west corner.
• Fran – from city’s perspective, would be beneficial.
• Jesse – would have some funding available for that.

• Darren – feedback on storage – stormwater or backwash water? Size? Where to stop physically? Equivalent square area would be? In a series of two or three storage facilities.
• Micheal – need to deal with regulatory if necessary.
Darren – series of sedimentation ponds and then some for storage. When decanting get better quality water just from settling, primary purpose would be storage. Not building a lake just a series of neat little ponds.

Rob – some storage could be underground, couldn’t it?

Mike – they would have to be lined.

Darren – data from backwash water, close to raw water. Like Michael said going to get some sedimentation in the concrete chamber. That’s why filters work, building bigger flock.

William – is master plan part of the feasibility study? Before report written?

Rob/Darren – yes.

Rob – lots of ways of doing, come up with plan then write report.

Darren – storage? Implement in footprint for next round of review/comment.

Rob – if don’t then go into sanitary.

Michael – storm water study will tell us if we can, if it will accept the flow. Work in conjunction. Even though dollar value will address storm water, the scope of the project became bigger due to additional storm water issue.

Jesse – are fishponds feasible?

William – doesn’t have anything to do with, could be storage ponds instead.

Mike – intent to line all the ponds to eliminate the natural infiltration?

Darren – would encourage any natural infiltration.

Mike – look at changing the sizes, smaller for infiltration and larger for storm water capacity. Primary purpose for backwash water treatment. Even with no rains or storm water still doing what intended.

William – fish ponds part of the grant?

Michael – wildlife gave a letter of support for the grant.

Darren – storm water up in the north west, 200 days storage at 8 liters per second for conventional. Can reserve area for demineralization treatment. Future wetlands, given number of unknowns.

Michael – smaller concept for storage treatment.

Darren - If hydraulic cells can be lowered by fall and build it up, or pump it down. Risk if early frost fall, no water moving through, better leave in two 30’s plus equivalent 180 (pond size). Will look at 10 to 1 slopes to 6 to 1 slopes, will save a lot of area.

Michael – need some flow information. (Darren will get from Jason (AE) – from SW corner).

Michael – Not sure if fish ponds will work.

Rob – too early to set next time for meeting.

Michael – have to meet with Ministry of Environment when we have a plan. Can’t go too far ahead without their approval.

Darren - go to MOE permitting, show stamped drawings and they will comment.

Michael – might say is part of our permitting. Part of permit to operate. We have permit to construct. Depends how they look at concept. Might have to monitor effluent. If they say anything about recharge may refer to watershed authority.

Aron – once plan is drawn up and council reviewed, have open house.

Michael – will not show plan right now, will wait to show management team. Show that it will help manage the storm water plan.
- Fran – Council just awarded Storm Water Drainage Study project on Monday. Jason Horner (AE) just starting.
- Darren – earliest to meet with Arcadio would be next Monday. Would like him to get the concept of what we are thinking.
- William – useful to have a sketch.
- Darren – yes and then sit down to discuss. Available on Monday?
- Rob – will check, late morning and after,
- William – ok.
- Aron – another meeting in December?
- Rob – need to progress, hit public first week of December or January?
- Rob – another meeting before year end.
- Michael – have another with entire group, may not need soccer association that round.
- Rob – will need their concept plan of multipurpose facility and plan for that subdivision.

Next Meeting: To be announced.

Adjournment – 5:06 pm
## Logan Green Water Reuse Project – Stakeholder Meeting

**MAY 18, 2011 1:15 P.M.**

**RAVINE ROOM, GALLAGHER CENTRE, YORKTON, SK**

<table>
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<tr>
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<tr>
<td>Michael Buchholzer, City of Yorkton (COY)</td>
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<td>James Kluk, City of Yorkton (COY)</td>
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<td>Glenda Holmes, City of Yorkton (COY)</td>
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<td>Brian Dудar, City of Yorkton (COY)</td>
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<td>Trent Mandzuk, City of Yorkton (COY)</td>
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<td>Darren Anholt, Associated Engineering (AE)</td>
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<td>Shengtao Weng, Associated Engineering (AE)</td>
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<td>Aron Hershmiller, Assiniboine Water Stewardship Association (AWSA)</td>
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<td>Jesse Nielsen, Assiniboine Water Stewardship Association (AWSA)</td>
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<td>William Hrycan, Crosby Hannah &amp; Associates (CHA)</td>
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<td>Mike Famulak, Beckie Hydrogeologists (BHL)</td>
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<td>Tim Adelman, Ground Engineering (GE)</td>
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<td>Ries Mansuy, Ministry of Environment (MOE)</td>
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<td>Jason Puckett, Sask Watershed Authority (SWA)</td>
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<td>Adam Matichuk, Sask Wildlife Federation (SWF)</td>
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<td>Adam Fetsch, Yorkton Soccer Association (YSA)</td>
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<td>Carl Achtemchuk, City Resident</td>
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<td>Louise Belanger, Sunrise Health Region (SHR)</td>
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<td>Lauren Reiger, Sunrise Health Region (SHR)</td>
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<tr>
<td>Darcy McLeod, City of Yorkton (COY)</td>
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<td>Fran Brimacombe, City of Yorkton (COY)</td>
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<td>Doug Brook, Ducks Unlimited Canada (DUC)</td>
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<td>Ryan Evans, Ministry of Environment (MOE)</td>
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<td>Chuck Tysowski, Yorkton Soccer Association (YSA)</td>
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<td>Sheila Hryniuk, Yorkton Active Transportation Collaborative (YATC)</td>
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**Discussion on Agenda Topics**

Since last stakeholder meeting, design concepts have been incorporated into the preliminary master plan drawings circulated to the attendees at today’s meeting.
Discussion on Agenda Topics (continued)

Drawings to be presented and discussed:

1) Site Plan: Backwash sedimentation ponds, storm water pond, wetlands and infiltration pond (prepared by Crosby Hanna)
2) Site Plan: Backwash sedimentation ponds, storm water ponds with seasonal surface discharge (prepared by Crosby Hanna)
3) Site Plan: Backwash sedimentation ponds and linear wetlands (prepared by Crosby Hanna)
4) Sections: Sedimentation and Effluent Ponds and Linear Wetland System (prepared by AE)
5) Site Plan: Soccer Pitches (prepared by Crosby Hanna)
6) Sections: Soccer Pitches (initial section prepared by AE and finished by Crosby Hanna)

- Settling ponds will be designed to handle backwash wastewater only. Retain existing pathway system as much as possible. Drainage directed to culvert on east side of property. Drainage from soccer pitches directed south, to Queen Street ditch.

- Soccer pitch area will also incorporate area for proposed future soccer facility. Maintain access to soccer pitches from Gladstone Avenue. Permanent benches to be placed along main field 3. Parking located on north side near Gladstone access. Discussed placement of kiosk and washroom facility location. Suitable location would be northeast corner near field 4 as it is close to the pathway system. Construction of berms alongside soccer fields.

- Parking was also created for the community garden sites on the north side of the oval designated for bus turnaround. Crosby Hanna to look at design for existing community garden area.

- Overall site layout divided into 5 sections. Urban park/gardens/tree nursery and tree plantings (area 1); soccer centre (area 2); native parkland, area to the east, natural grasslands and trees (area 3); WTP and settling ponds (area 4); and last functioning linear wetlands and fishpond system (area 5). Introduce picnic or day use areas, with access off of Queen Street. Path structure maintained with grass and mown paths.
Adam Fetsch (YSA) left meeting 2:30 pm.

- Discussion on fish pond construction and location proposed.
- Funding opportunities exist relating to interpretive/education site and promoting active living through trail system. Other funding sources may be available.

Louise Belanger & Lauren Reiger (SHR) left meeting at 3:05 pm.

- Associated Engineering will meet with City and Ground Engineering representatives to work on technical details relating to soil conditions.
- Concept will be presented to the Environmental Committee which submits their minutes to City Council. After open house is held, initial earthwork can go to tender.
- Any other inquiries from stakeholders will be dealt with on an individual basis.
- Discussion on site safety, including fencing and lighting options.

Meeting adjourned.
Appendix C - Literature Review Results
As you walk along a meandering wood chip path in West Elgin, Ontario, you can’t help but be impressed by the natural beauty of the place. An array of native plant species of all shapes and sizes adorns the perimeter of two large, interconnected ponds and the adjacent wetland. It’s a rural setting, complete with resident wildlife, including ducks, birds, fish, amphibians and small woodland creatures.

What is not evident is that this scenic backdrop serves a dual purpose. In addition to being a place of natural tranquility for wildlife and the community, these ponds are also an integral part of a recently completed $16.9 million water treatment plant.

For decades, most communities in Canada have used a common method to clean the ‘backwash’ or ‘process water’ that is cast off as a byproduct of the water treatment process. This backwash, which is loaded with suspended solids (silt, algae, etc.) and process chemicals (alum, polymers, chlorine, etc.) is typically stored in large clarifying tanks. It is sometimes further treated with chemicals, then the suspended solids are filtered or allowed to settle out. Remaining chemicals, such as chlorine, are then removed so the water can be returned to the original source.

West Elgin is one of the first in Canada to employ large wetland retention ponds to do the work of the clarifying tanks and chemicals. There are no chemicals added and no ongoing maintenance costs. And, once this polishing process is complete, most of the naturally-treated water simply exfiltrates back to the groundwater table.

In an age when many environmentally-friendly innovations tend to lean toward the overly complex, West Elgin’s retention ponds represent a decidedly simple, almost nostalgic approach. And, in an era when it seems increasingly difficult to please even some of the people some of the time, the community’s latest green initiative is receiving positive attention from a wide range of stakeholder groups, including politicians, environmentalists, students, ratepayers, water industry experts and the media.

By opting for retention ponds, rather than a traditional backwash water treatment system, the community was able to save hundreds of thousands of dollars in capital expenditures. As part of the water treatment process.

“Because the West Elgin facility is a membrane facility, and there is an extremely low amount of chemicals used with these types of plants,” said Elvio Zaghi, of Stantec, “we had the wetlands pond alternative available to us. So we proposed this alternative to the community. Once the key players realized what they would be able to achieve with this approach, everyone was extremely supportive of the idea of incorporating these ponds as part of the new facility.”

Mindful of the larger significance these ponds would hold for West Elgin, Stantec made a special point of engaging the community in every phase of the
Water Treatment

project. One of the first organizations involved was the West Elgin Nature Club, a local group founded in 1946. It played an active role in helping design the landscaping plan for the ponds, the layout of the wetland, where the paths should be located, etc.

The group also helped by recommending (and helping to plant) many of the native plant species currently growing in and around the ponds. A number of students from the local high-school helped with the planting process.

Before construction, Stantec undertook extensive, year-long hydrogeological testing in the area to observe water movement patterns. The new water treatment plant was being built on an entirely new site and the property the municipality purchased contained a provincially significant wetland. Whatever was to be built on the site could not negatively impact the wetland, or the natural setting of the area.

Incorporating retention ponds that exfiltrated the plant process water actually helped maintain the high groundwater levels in the wetland area, ensuring that the natural wetland nearby will last for generations to come.

Key features of the project include:
• The water treatment and retention ponds have been online since April 2009.

Incorporating retention ponds that exfiltrated the plant process water actually helped maintain the high groundwater levels in the wetland area, ensuring that the natural wetland nearby will last for generations to come.

• System was designed for the 20 year daily flow of 12,160 m³/d.
• 90% of the cost of the new water treatment facility was paid for by the Canada-Ontario Municipal Rural Infrastructure Fund, a partnership between the Government of Canada, the Government of Ontario, and the Association of Municipalities of Ontario.
• Wetland retention ponds were built to a depth of three metres, to allow fish and plants to survive the harsh winters.
• Discharge water from the retention ponds meets Ontario Ministry of the Environment guidelines.
• The water supply system was also one of the first ten systems in the province to achieve Drinking Water Quality Management Standard (DWQMS) accreditation.
• The water system provides water to the neighbouring municipalities of Dutton-Dunwich, Southwest Middlesex, Newbury, and the community of Bothwell in Chatham-Kent.

The retention ponds were built for a little over $150,000, whereas a conventional process water treatment system was estimated at $1,000,000. Also, involving citizen groups not only provided great community support, but using volunteers reduced landscaping costs.

Andy Valickis and Holly Wirth are with the Ontario Clean Water Agency, which provided management services for this project. For more information, E-mail: avalickis@ocwa.com

Photo’s by Erin Valickis

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Appendix D - Regulatory Requirements

- SWA Correspondence
- Surface Water Quality Objectives
- MOE- Permit to Construct
Darren Anholt - RE: City of Yorkton - Water Re-Use Study

From: Cas Rogal <Cas.Rogal@swa.ca>
To: Mike Famulak <famulak@sasktel.net>, Don Newcombe <DON.NEWCOMBE@swa.ca>
Date: 9/30/2010 4:19 PM
Subject: RE: City of Yorkton - Water Re-Use Study
CC: 'Michael Buchholzer' <mbuchholzer@yorkton.ca>, 'Darren Anholt' <anholtd@ae.ca>

Gentlemen, it is my understanding the water supply for this park is a waste stream from the Yorkton water treatment plant and as such, is regulated by Sask Environment. No approval or allocation will be forthcoming from the groundwater division of SWA for this project.

Cas Rogal, P.Geo.
Co-Ordinator, Ground Water Approvals
Saskatchewan Watershed Authority
111 Fairford Street East
Moose Jaw, SK S6H 7X9
Ph: (306) 694-3149
Fax: (306) 694-3944
e-mail: cas.rogal@swa.ca

From: Mike Famulak [mailto:famulak@sasktel.net]
Sent: September 30, 2010 3:43 PM
To: Don Newcombe; Cas Rogal
Cc: 'Michael Buchholzer'; 'Darren Anholt'
Subject: City of Yorkton - Water Re-Use Study

Cas and Don:

The City of Yorkton is currently undertaking a conceptual study to determine if backwash water from their new Queen Street water treatment plant can be re-used to create an environmentally friendly (green) park in the Logan Greens area adjacent to the plant. The objective would be to create a series of inter-connected surface water ponds which could facilitate advanced water treatment, the creation of marshlands, storm water management and the supply of irrigation water for the proposed park area and soccer pitches.

As per our telephone conversation(s) on September 29, 2010, it is my understanding that if this project were to proceed, it would not have to be approved by the surface water division or by the groundwater division of the Saskatchewan Watershed Authority (SWA) and that all applications for regulatory approval(s) are to be submitted to Saskatchewan Environment. Please confirm by return email if this is correct.

Thanks,

Mike S. Famulak, P. Geo.
Beckie Hydrogeologists Ltd.
Consulting Engineers and Geoscientists
381 Park Street, Regina, SK, S4N 5B2
Office (306) 721-0846
Fax 721-7729, Cellular 536-1625
Foreword
The Surface Water Quality Objectives (EPB 356, July 2006) were adopted and modified from the Canadian Environmental Quality Guidelines (CCME, 1999). Since the CCME is currently revising their protocols for the derivation of water quality guidelines these objectives are now being published as an 'Interim Edition'.

Any comments, inquiries, or suggestions regarding the content of this document may be directed to:

Drinking Water Quality Section  
Saskatchewan Environment  
3211 Albert Street  
REGINA SK S4S 5W6  
Telephone: (306) 787-6517  
Fax: (306) 787-0197

A copy of this document is available for downloading at the following web address:  

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1.0 Introduction

This document replaces the publication *Surface Water Quality Objectives* (MB #110, August 1997) and its earlier printings and editions.

Water quality objectives are developed to provide basic scientific information about the effects of water quality variables on potential water uses such as recreation, agriculture, industrial and municipal water supplies, and aquatic life. The objectives are important tools which, when used in a framework of provincial and federal environmental assessment, risk management, and the application of best available treatment technology, support the management, protection and enhancement of the surface water resources of the province. Those charged with developing objectives (federal, provincial and territorial governments, as well as water management agencies such as the Prairie Provinces Water Board) must decide what uses are to be protected, obtain the necessary information, formulate the objectives, and present them for approval to the appropriate jurisdiction. Ongoing, periodic revisions to the surface water quality objectives are necessary to ensure that new scientific findings are routinely incorporated and that emerging approaches to enhanced environmental protection are considered. In recent years, much new scientific information has emerged that warrants consideration.

Water quality objectives have been established for Saskatchewan surface waterbodies as part of Saskatchewan Environment’s (SE) mandate to manage, enhance and protect this province’s natural and environmental resources including air, water and soil. One of the first major steps in the development of water quality objectives in this province was the publication of *Water Quality Criteria* by the Saskatchewan Water Resources Commission in 1970. *Water Quality Objectives* (1975) was essentially a reprint of the 1970 document with some minor revisions. The criteria in these early publications were the main values used to evaluate water quality until 1987, when the Canadian Council of Resource and Environment Ministers (CCREM) released the *Canadian Water Quality Guidelines* (CCREM, 1987). The Saskatchewan objectives were subsequently revised and updated in 1988 based largely on the information provided in the CCREM document and were published as *Surface Water Quality Objectives* (WQ 110 - November 1988). The document *Surface Water Quality Objectives* (MB#110, August 1997) was a reprint of the 1988 booklet and was changed mainly with respect to updating the names, addresses and telephone numbers of agency contacts.

In April 1996, the Deputy Minister’s Committee of the Canadian Council of Ministers of the Environment (CCME) gave its approval for the Water Quality Guidelines Task Group to work towards assembling an integrated *Canadian Environmental Quality Guidelines* document to be presented to the Ministers. The resulting document was published in 1999 and builds on the highly successful release of the *Canadian Water Quality Guidelines* in 1987, which provided national environmental quality guidelines for a number of water resource uses. The 1999 publication is the most comprehensive compendium of its kind in Canada and the world - including a wide range of environmental quality and human health guidelines for water, soil, sediment, tissue and air - and is the basis for the current version of the Saskatchewan objectives.

The *Surface Water Quality Objectives* will be revised on a continual basis in the future as new scientific information emerges and as further experience is gained in applying the objectives.

2.0 Approaches to Guideline Derivation

The *Surface Water Quality Objectives* are numerical concentrations or narrative statements that have no legal standing, but instead serve as a guide for issuing permits, licenses and orders, and as a means of supporting and maintaining designated water uses. While the objectives take into consideration that healthy aquatic ecosystems can tolerate some stress and can recover, where water bodies are considered to be of exceptional value it is a generally accepted policy that degradation of the existing water quality should always be avoided.
For the 2006 version of the *Surface Water Quality Objectives – Interim Edition*, the province has decided to directly adopt the generic CCME Guidelines for the protection of aquatic life, agricultural and recreational uses for all watersheds in the province unless the following criteria arise:

1. the generic guideline for a substance is lower than the upper limit of background data – there are some waterbodies in Saskatchewan where natural or background levels of certain constituents regularly exceed the existing objectives. For example, natural levels of sodium in the Carrot River often exceed the guideline for irrigation. In situations like this, basin- or watershed-specific objectives may be developed on a case-by-case basis; or,

2. the toxicity of a substance is dependent on a receptor (e.g. brown trout) or environmental factor (e.g. water hardness, pH, etc.) that would not typically be found in Saskatchewan.

If one of the these conditions exists, and sufficient water quality data is available for the watershed, then the province will review the generic objectives using procedures outlined in the CCME document *Guidance on the Site-Specific Application of Water Quality Guidelines in Canada: Procedures for Deriving Numerical Water Quality Objectives* (2003). The ‘Background Concentration Procedure’ recommends using the mean value obtained for a specific parameter and then adding two standard deviations to obtain the upper limit for that parameter. If the upper limit is greater than the generic objective, then a site- or watershed-specific objective should be developed.

There are many instances where the natural water quality of a lake or river does not meet some of the objectives. In these cases, the objectives obviously will not apply. It should be noted, however, that where the natural existing quality is inferior to desirable objectives, it would be unwise to permit further deterioration by unlimited or uncontrolled introduction of pollutants. Naturally occurring circumstances are not taken into account in these “objectives” and due consideration must be given where applicable (e.g. spring runoff effect on colour and odour; ice and snow cover effect on dissolved oxygen; and, rainfall influences on bacteria levels in surface waters).

### 3.0 Objectives for Effluent Discharges

#### 3.1 General Objectives

The following basic objectives are applicable to all waters receiving effluents, including the mixing zones adjacent to effluent outfalls (see Section 3.2) in the context that municipal, industrial, agricultural and other discharges should be:

- free from substances in concentrations or combinations which are acutely toxic or may be harmful to human, animal or aquatic life;
- free from substances that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl;
- free from debris, oil, grease, scum or other materials in amounts sufficient to be noticeable in the receiving water;
- free from colour, turbidity or odour-producing materials that would adversely affect aquatic life or waterfowl, significantly alter the natural colour of the receiving water, or directly or through interaction among themselves or with chemicals used in water treatment, result in undesirable taste or odour in treated water;
- free from nutrients in concentrations that create nuisance growths of aquatic weeds or algae or that results in an unacceptable degree of eutrophication of the receiving water; and,
- in addition to the above objectives, effluent discharged to surface waters should not utilize more than 30 percent of the assimilation capacity of the receiving waterbody when discharged via means of a diffused outfall, or more than 10 percent when discharged via a point source outfall. These design objectives should be utilized during the planning stages of projects involving effluent discharges. For purposes of determining the available assimilation capacity of a receiving waterbody, a flow rate equal to or less than the average seven-day low flow which occurs once in ten years (e.g. 7Q10), at the outfall area, generally should be used.
3.2 Guidelines for Effluent Mixing Zones
A mixing zone is a transitional area within a waterbody in which an effluent discharge is gradually assimilated into the receiving water. At the outer edge of the mixing zone the water quality should not be appreciably different from the water quality prior to the discharge of the effluent. The size of the mixing zone will be influenced by the difference in water quality between the effluent and the receiving waterbody and the volume of effluent relative to the receiving waterbody.

The effluent mixing zone guidelines are intended for application to larger surface waterbodies. However, they also have limited application to some intermittent streams and small lakes that have sufficient flow or volume of water, at least seasonally, to adequately assimilate periodic discharges of treated wastewater effluent.

The guidelines should be applied by proponents during the planning and design stages of new developments involving effluent discharge(s) or changes in the flows/volumes of water available for effluent assimilation, and for current dischargers where alterations of the existing wastewater treatment or disposal system are proposed. These guidelines prescribe the general characteristics that mixing zones should or should not possess.

Specific Effluent Mixing Zone Guidelines
- the mixing zone should be as small as practicable and should not be of such size or shape as to cause or contribute to the impairment of existing or likely water uses;
- the existing General Objectives for Effluent Discharges (Section 3.1) should be achieved at all sites within the limited use zone;
- the limited use zone in streams and rivers should be apportioned no more than 25 percent of the cross-sectional area or volume of flow, nor more than one-third of the river width at any transect in the receiving water during all flow regimes which equal or exceed the 7Q10 flow for the area. Surface water quality objectives applicable to the area must be achieved at all points along a transect at a distance downstream of the effluent outfall to be determined on a case-by-case basis;
- in lakes and other surface impoundments, surface water quality objectives applicable to that waterbody must be achieved at all points beyond a radius of 100 metres from the effluent outfall. The volume of limited use zones in lakes should not exceed 10 percent of that part of the receiving waters available for mixing;
- the mixing zone should be designed to allow an adequate zone of passage for the movement or drift of all stages of aquatic life; specific portions of a cross-section of flow or volume may be arbitrarily allocated for this purpose;
- mixing zones should not interfere with the migratory routes, natural movements, survival, reproduction, growth, or increase the vulnerability to predation, of any representative aquatic species, or endangered species;
- mixing zones should not interfere with fish spawning and nursery areas;
- when two or more mixing zones are in close proximity, they should be so defined that a continuous passageway for aquatic life is available;
- when two or more mixing zones overlap the combination of the effluent plumes should not result in unacceptable synergistic or antagonistic effects on aquatic life or other water uses downstream of the mixing zone(s);
- mixing zones should not cause an irreversible organism response or attract fish or other organisms and thereby increase their exposure period within the zone;
- the 96 hr LC₅₀ toxicity criteria, for indigenous fish species and other important aquatic species should not be exceeded at any point in the mixing zones;
- mixing zones should not result in contamination of natural sediments so as to cause or contribute to excursions of the water quality objectives outside the mixing zone;
- mixing zones should not intersect domestic water supply intakes, bathing areas or other sensitive designated use areas;
- specific numerical water quality objectives may be established by the Department for such variables or constituents thought to be of significance within the effluent mixing zone; and,
• defining the effluent mixing zone may need to be done on a case-by-case basis, in consultation with the Department, particularly where effluent is discharged into smaller waterbodies (i.e. streams and small lakes).

4.0 Surface Water Quality Objectives

The specific objectives presented below provide a means for evaluation of water quality conditions except in areas of a waterbody in close proximity to wastewater outfalls. In the vicinity of outfalls a “zone of passage” of satisfactory quality must be considered for aquatic biota travel. In waters of superior quality, impairment to the objective levels will not be acceptable.

4.1 Aquatic Life

Objectives for protecting the quality of the habitat of aquatic organisms are often more stringent than those applicable to other water uses. These objectives (Table 4.1) will afford a reasonable degree of protection of fish and other aquatic life at all stages of development. Because of the relatively stringent values for various constituents these objectives will also likely afford protection to wildlife, which rely upon surface water for drinking water and for their source of food supply.

Since the release of Canadian Water Quality Guidelines (CCREM, 1987), it has been recognized that water quality objectives for some persistent, bioaccumulative substances such as PCBs, toxaphene and DDT have a high level of scientific uncertainty and limited practical management value, and are therefore no longer recommended. For these substances, it may be more appropriate to use the respective tissue residue objectives and/or sediment quality objectives.

Table 4.1 Surface Water Quality Objectives for the Protection of Aquatic Life (modified from CCME 1999)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Objective*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>5 - 100</td>
<td>See Note 1</td>
</tr>
<tr>
<td>Ammonia (in mg/L)</td>
<td>--</td>
<td>See Table 4.1.1</td>
</tr>
<tr>
<td>Arsenic</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Bromoxynil</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.017 – 0.10</td>
<td>See Note 2</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>0.0035</td>
<td></td>
</tr>
<tr>
<td>Chromium VI</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>2 - 4</td>
<td>See Note 3</td>
</tr>
<tr>
<td>Cyanide</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Dicamba</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Diclofop-methyl</td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td>Dimethoate</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>1 to 7</td>
<td>See Note 4</td>
</tr>
<tr>
<td>Lindane</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Mercury (inorganic)</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>25 - 150</td>
<td>See Note 5</td>
</tr>
<tr>
<td>Oxygen, Dissolved (in mg/L)</td>
<td>5.5 - 9.5</td>
<td>See Note 6</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Phenols (mono- and dihydric)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Phenoxy Herbicides (2,4-D)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Picloram</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Silver 0.1
Temperature Narrative Statement See Note 7
Triallate 0.24
Trifluralin 0.20
Uranium 15 See Note 8
Zinc 30
*All values in micrograms per litre (ug/L) unless otherwise indicated

Note 1:  Aluminum Objective: 5 ug/L at pH <6.5, Ca <4 mg/L and DOC <2 mg/L; 100 ug/L at pH ≥ 6.5, Ca ≥ 4 mg/L and DOC ≥ 2 mg/L.
Note 2:  Cadmium Objective: 0.017 ug/L where hardness is 0 - 48.5 mg/L; 0.032 ug/L where hardness is 48.5 - 97; 0.058 where hardness is 97 - 194; 0.10 ug/L where hardness is >194.
Note 3:  Copper Objective: 2 ug/L where hardness is 0 - 120 mg/L; 3 ug/L where hardness is 120 - 180 mg/L; 4 ug/L where hardness is >180 mg/L.
Note 4:  Lead Objective: 1 ug/L where hardness is 0 - 60 mg/L; 2 ug/L where hardness is 60 - 120 mg/L; 4 ug/L where hardness is 120 - 180 mg/L; 7 ug/L where hardness is >180 mg/L.
Note 5:  Nickel Objective: 25 ug/L where hardness is 0 - 60 mg/L; 65 ug/L where hardness is 60 - 120 mg/L; 110 ug/L where hardness is 120 - 180 mg/L; 150 ug/L where hardness is >180 mg/L.
Note 6:  Dissolved Oxygen Objective: 6.0 mg/L for warm-water biota in early life stages; 5.5 mg/L for warm-water biota in other life stages; 9.5 mg/L for cold-water biota in early life stages; 6.5 mg/L for cold-water biota in other life stages.
Note 7:  Temperature Objective: Thermal additions should not alter thermal stratification or turnover dates, exceed maximum weekly average temperatures, nor exceed maximum short-term temperatures.
Note 8:  The objective was developed by the Industrial, Uranium and Hardrock Mining Unit of Saskatchewan Environment.

Table 4.1.1  Surface Water Quality Objectives for Total Ammonia for the Protection of Aquatic Life* (from CCME 1999)

<table>
<thead>
<tr>
<th>Temp °C</th>
<th>6.0</th>
<th>6.5</th>
<th>7.0</th>
<th>7.5</th>
<th>8.0</th>
<th>8.5</th>
<th>9.0</th>
<th>9.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>231</td>
<td>73.0</td>
<td>23.1</td>
<td>7.32</td>
<td>2.33</td>
<td>0.749</td>
<td>0.250</td>
<td>0.042</td>
</tr>
<tr>
<td>5</td>
<td>153</td>
<td>48.3</td>
<td>15.3</td>
<td>4.84</td>
<td>1.54</td>
<td>0.502</td>
<td>0.172</td>
<td>0.034</td>
</tr>
<tr>
<td>10</td>
<td>102</td>
<td>32.4</td>
<td>10.3</td>
<td>3.26</td>
<td>1.04</td>
<td>0.343</td>
<td>0.121</td>
<td>0.029</td>
</tr>
<tr>
<td>15</td>
<td>69.7</td>
<td>22.0</td>
<td>6.98</td>
<td>2.22</td>
<td>0.715</td>
<td>0.239</td>
<td>0.089</td>
<td>0.026</td>
</tr>
<tr>
<td>20</td>
<td>48.0</td>
<td>15.2</td>
<td>4.82</td>
<td>1.54</td>
<td>0.499</td>
<td>0.171</td>
<td>0.067</td>
<td>0.024</td>
</tr>
<tr>
<td>25</td>
<td>33.5</td>
<td>10.6</td>
<td>3.37</td>
<td>1.08</td>
<td>0.354</td>
<td>0.125</td>
<td>0.053</td>
<td>0.022</td>
</tr>
<tr>
<td>30</td>
<td>23.7</td>
<td>7.50</td>
<td>2.39</td>
<td>0.767</td>
<td>0.256</td>
<td>0.094</td>
<td>0.043</td>
<td>0.021</td>
</tr>
</tbody>
</table>

* in mg/L

Note:  The toxicity of ammonia relates primarily to the unionized form (NH₃).  The concentration of unionized ammonia present in water increases with pH and temperature.  The above values represent total ammonia-nitrogen concentrations (at various temperatures and pH levels) above which accompanying NH₃ concentrations may be harmful to aquatic life.

4.2  Agricultural Uses

Surface water quality objectives for agricultural uses are shown in Table 4.2.  Users of these objectives, such as resource managers and farmers, are reminded that these values are recommended concentration limits of contaminants in irrigation and livestock water; above these limits, possible harm to crops and livestock may result.

As far as irrigation is concerned, the two major factors to be considered when determining water’s suitability for that use are salinity (measured by electrical conductivity or the concentration of Total Dissolved Solids) and the Sodium Adsorption Ratio or SAR.  A plant’s salt sensitivity is a function of many conditions including type of salt, conditions in the soil, water quality and climate.  High SAR levels, meaning excess sodium relative to calcium and magnesium, can negatively impact soil structure by dispersing clay aggregates thus reducing soil permeability and aeration.  Since different soils and plant species vary considerably in the quality of water each may tolerate, irrigators are advised to contact the Irrigation Development Branch, Saskatchewan Agriculture and Food in Outlook, Saskatchewan.

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(telephone 306-867-5528) for guidance regarding site-specific irrigation and cultural practices that would be best suited to the soil types and quality of waters available to them.

Livestock, depending upon the species, stage of development, quality of diet and rearing conditions, have different requirements and tolerances to various levels of constituents in waters supplied to them for consumption. The objectives presented in Table 4.2 are intended to afford protection to most livestock species as well as to the consumers of products derived from these livestock. Higher concentrations of constituents addressed in these objectives may be tolerated by some livestock species or by adult animals conditioned to such levels. For instance, higher salt concentrations than the objective level for TDS of 3000 mg/L may be tolerated by some livestock species. In such situations where the quality of water available for livestock watering does not meet the objectives livestock producers are advised to contact their local veterinarian for advice.

### Table 4.2 Surface Water Quality Objectives for Agricultural Uses* (CCME 1999)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Irrigation</th>
<th>Livestock</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>5000</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>100</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Beryllium</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Blue-green algae</td>
<td>--</td>
<td>Avoid heavy growth</td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>500 - 6000</td>
<td>5000</td>
<td>See Note 1</td>
</tr>
<tr>
<td>Bromoxynil</td>
<td>0.33</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>5.1</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Chloride (mg/L)</td>
<td>100 - 700</td>
<td>--</td>
<td>See Note 2</td>
</tr>
<tr>
<td>Chromium VI</td>
<td>8</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Cobalt</td>
<td>50</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Coliforms, fecal (E.coli)</td>
<td>100 per 100mL</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Coliforms, total</td>
<td>1000 per 100mL</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>200 - 1000</td>
<td>500 - 5000</td>
<td>See Note 3</td>
</tr>
<tr>
<td>Dicamba</td>
<td>0.006</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>Diclofop-methyl</td>
<td>0.18</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Fluoride (mg/L)</td>
<td>1</td>
<td>1 - 2</td>
<td>See Note 4</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>--</td>
<td>280</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>5000</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>200</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Lindane</td>
<td>--</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Lithium</td>
<td>2500</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>200</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>--</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Molybdenum</td>
<td>10 - 50</td>
<td>500</td>
<td>See Note 5</td>
</tr>
<tr>
<td>Nickel</td>
<td>200</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Nitrate + Nitrite (mg/L)</td>
<td>--</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Phenol</td>
<td>--</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Phenoxy herbicides (2,4-D)</td>
<td>--</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Picloram</td>
<td>--</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>20 - 50</td>
<td>50</td>
<td>See Note 6</td>
</tr>
<tr>
<td>Sulphate (mg/L)</td>
<td>--</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>500 - 3500</td>
<td>3000</td>
<td>See Note 7</td>
</tr>
<tr>
<td>Triallate</td>
<td>--</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>Trifluralin</td>
<td>--</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Uranium</td>
<td>10</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Vanadium</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>1000 - 5000</td>
<td>50,000</td>
<td>See Note 8</td>
</tr>
</tbody>
</table>

*all values in micrograms per litre (ug/L) unless otherwise indicated.

**Note1:** Boron Objective: 500 ug/L for blackberries; 500 - 1000 ug/L for peaches, cherries, plums, grapes, cowpeas, onions, garlic, sweet potatoes, wheat, barley, sunflowers, mung beans, sesame, lupins, strawberries, Jerusalem artichokes, kidney beans,
lima beans: 1000 - 2000 ug/L for red peppers, peas, carrots, radishes, potatoes, cucumbers; 2000 - 4000 ug/L for lettuce, cabbage, celery, turnips, Kentucky bluegrass, oats, corn, artichokes, tobacco, mustard, clover, squash, muskmelons; 4000 - 6000 ug/L for sorghum, tomatoes, alfalfa, purple vetch, parsley, red beets, sugar beets; 6000 ug/L for asparagus.

Note 2: Chloride Objective: 1) Foliar damage: 100 - 178 mg/L for almond apricots, plums; 178 - 355 mg/L for grapes, peppers, potatoes, tomatoes; 355 - 710 mg/L for alfalfa, barley, corn, cucumbers; >710 mg/L for cauliflower, cotton, safflower, sesame, sorghum, sugar beets, sunflowers. 2) Rootstocks: 180 - 600 mg/L for stone fruit (peaches, plums, etc.); 710 - 900 mg/L for grapes. 3) Cultivars: 110 - 180 mg/L for strawberries; 230 - 460 mg/L for grapes; 250 mg/L for boysenberries, blackberries, raspberries.

Note 3: Copper Objective: 1) Crops: 200 ug/L for cereals; 1000 ug/L tolerant crops. 2) Livestock: 500 ug/L for sheep; 1000 ug/L for cattle; 5000 ug/L for swine and poultry.

Note 4: Fluoride Objective: 1.0 mg/L if feed contains fluoride.

Note 5: Molybdenum Objective: 50 ug/L for short-term use on acidic soils

Note 6: Selenium Objective: 20 ug/L for continuous use; 50 ug/L for intermittent use.

Note 7: Total Dissolved Solids Objective: 500 mg/L for strawberries, raspberries, beans, and carrots; 500- 800 mg/L for boysenberries, currants, blackberries, gooseneeseberries, plums, grapes, apricots, peaches, pears, cherries, apples, onions, parsnips, radishes, peas, pumpkins, lettuce, peppers, muskmelons, sweet potatoes, sweet corn, tomatoes, celery, cabbage, kohlrabi, cauliflower, cowpeas, broad beans, flax, sunflowers, corn; 800 - 1500 mg/L for spinach, cantaloupe, cucumbers, tomatoes, squash, Brussels sprouts, broccoli, turnips, smooth brome, alfalfa, big trefoil, beardless wild rye, vetch, timothy, crested wheat grass: 1500 - 2500 mg/L for beets, zucchini, rape, sorghum, oat hay, wheat hay, mountain brome, tall fescue, sweet clover, reed canary grass, birds foot trefoil, perennial ryegrass; 3500 mg/L for asparagus, soybeans, safflower, oats, rye, wheat, sugar beets, barley, barley hay, tall wheat grass.

Note 8: Zinc objective: 1000 ug/L when soil pH < 6.5; 5000 ug/L when soil pH > 6.5

4.3 Recreation and Aesthetics

Recreational water refers to surface waters that are used primarily for activities in which the user comes into frequent direct contact with the water, either as part of the activity or incidental to the activity. Examples include swimming, water skiing, bathing and wading. Secondary recreational uses include boating, fishing and canoeing, which generally have less frequent body contact with water.

The objectives shown in Table 4.3 deal mainly with potential health hazards related primarily to recreational water use, but also relate to aesthetics and nuisance conditions. They should afford reasonable protection of water users from waterborne disease and maintain desirable aesthetic conditions in the waterbody.

Although the use of surface waters for personal drinking water supply is not addressed in this document, recreational water users are cautioned not to consume surface waters without prior disinfection (e.g. boiling, chlorination). Even waters that appear to be pristine may contain naturally occurring disease-causing microorganisms.

Table 4.3 Surface Water Quality Objectives for Recreation and Aesthetics (modified from CCME 1999)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em></td>
<td>The geometric mean of at least five samples taken during a period not to exceed 30 days should not exceed 2000 <em>E. coli</em> per litre. Resampling should be performed when any sample exceeds 4000 <em>E. coli</em> per litre.</td>
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<tr>
<td>Blue-green algae</td>
<td>Limits have not been specified. Health Canada is in the process of developing a numerical objective for microcystin, an algal toxin. Water with blue-green surface scum should be avoided because of reduced clarity and possible presence of toxins.</td>
</tr>
<tr>
<td>Temperature</td>
<td>The thermal characteristics of water should not cause an appreciable increase or decrease in the deep body temperature of bathers and swimmers</td>
</tr>
<tr>
<td>Clarity</td>
<td>The water should be sufficiently clear that a Secchi disc is visible at a minimum of 1.2 metres.</td>
</tr>
<tr>
<td>Turbidity</td>
<td>A limit of 50 Nephelometric Turbidity Units (NTU) is suggested.</td>
</tr>
</tbody>
</table>
| Oil and grease | Oil or petrochemicals should not be present in concentrations that:  
• can be detected as a visible film, sheen, or discoloration on the surface;  
• can be detected by odour; or  
• can form deposits on shorelines and bottom deposits that are detectable by sight and odour. |
Aquatic plants | Bathers should avoid areas with rooted or floating plants; very dense growths could affect other activities such as boating and fishing.
---|---
Aesthetics | All water should be free from:
• materials that will settle to form objectionable deposits;
• floating debris, oil, scum, and other matter;
• substances producing objectionable colour, odour, taste, or turbidity; and
• substances and conditions or combinations thereof in concentrations that produce undesirable aquatic life.

5.0 Saskatchewan Water Quality Index

An integral part of any environmental monitoring program is the reporting of results to both water managers and the general public. This poses a particular problem in the case of water quality monitoring because of the complexity associated with analyzing a large number of measured variables. One solution to this problem is to reduce the multivariate nature of water quality data by employing an index that will mathematically combine all water quality measures and provide a general and readily understood description of water. An index is a useful tool for describing the state of the water column, and for ranking the suitability of water for use by humans, livestock, crops, aquatic life, etc.

Saskatchewan has adopted its version of the Water Quality Index (WQI) from the Canadian Water Quality Index (CWQI), recently developed by the CCME Water Quality Index Technical Subcommittee. In addition to rating the suitability of provincial waterbodies for their potential uses, the Index will be used in Saskatchewan as a performance measure to gauge progress towards the goal of ensuring that watersheds are protected, natural purification and protection processes are maximized, and potential for contamination is minimized.

The WQI formula incorporates three elements: scope – the number of variables that do not meet the Saskatchewan Surface Water Quality Objectives; frequency – the number of times these objectives are not met; and, amplitude – the amount by which the objectives are not met. The WQI produces a number between 100 (best water quality) and 0 (worst water quality). The resulting Index categories, that is, Excellent (95 – 100), Good (80 – 94), Fair (65 – 79), Marginal (45 – 64) and Poor (0 – 44), can be used to assess water quality relative to its desirable state and to provide insight into the degree to which water quality is affected by human activity.

Instructions for calculating the WQI for a specific waterbody are available in the Canadian Water Quality Index User’s Manual (CCME, 2001).

6.0 Potable Water Supply

The maintenance of good quality drinking water can be achieved both by protecting the raw water supply and by water treatment. It is possible to protect the raw water supply by means of pollution control measures that prevent undesirable constituents from entering the raw water and by good watershed management practices. A wide range of treatment technologies is available by means of which it is possible to produce acceptable drinking water from most raw water sources.

The surface water quality objectives presented in Sections 4.1 to 4.3 above will assist in the protection of waters to be withdrawn and treated as a potable supply.

Treatment processes for drinking water should be selected to provide potable and aesthetically acceptable water to the users. For waterworks serving the public, the treated water quality should meet the current Saskatchewan Municipal Drinking Water Quality Objectives. Untreated water should not be used for potable purposes.

Pharmaceuticals and personal care products in potable water are an emerging concern, however, little data exists in any country on their presence in treated drinking water. The Department will be working
with its provincial and federal counterparts to address these issues. Minimizing the impact of these compounds depends on proper usage and disposal of the products, proper source water protection through watershed management and provision of proper treatment and distribution systems for drinking water supplies.

7.0 Algae and Other Aquatic Nuisances

"Aquatic nuisances" are those aquatic plants and animals that are present in sufficient numbers to pose problems for people or animals using a particular waterbody or its surrounding environment. Recreational water uses, for example, may be limited by the presence of swimmers’ itch, excessive weed growth or algae blooms. One of the most common aquatic nuisances in Saskatchewan surface waters is algae. Algae are tiny plants, most of which are microscopic in size. Although an important component of aquatic ecosystems, certain algae when overabundant can foul beaches and cause water to have an unpleasant colour, taste or odour. Also high densities of blue-green algae that occurs under bloom conditions in surface waters may result in sickness or death among livestock or pets that drink such water.

Various control measures to reduce or eliminate such nuisances as algae, aquatic weeds, leeches, swimmers’ itch, and biting insects, are possible. However, aquatic nuisance control activities must be carried out in a manner that will not jeopardize public safety and/or aquatic or terrestrial fauna and flora. Prior to conducting such control activities approval must be obtained from Saskatchewan Environment.

The subject of aquatic nuisance identification, control measures, use of chemical/mechanical control, and approval requirements is described in detail in the publication, A Guide to Aquatic Nuisances and Their Control (Saskatchewan Environment and Resource Management, reprinted 1998).

8.0 References


www.SaskH20.ca
July 25, 2011

Michael Buchholzer, Waterworks Manager
City of Yorkton
60 Park Street
Yorkton SK S3N 2W3

Dear Mr. Buchholzer:

**Permit to Construct – Water Treatment Plant Waste Residuals Treatment & Disposal**

The Saskatchewan Ministry of Environment wishes to thank the City of Yorkton for the "Application for Permit to Construct, Extend or Alter Existing Works". Enclosed is a Permit to Construct under *The Environmental Management and Protection Act 2002* (EMPA) issued to the City of Yorkton for construction of waterworks in SW-35-25-4-W2 connecting to existing waterworks, namely the installation of two new sedimentation ponds for treatment of the water treatment plant process wastewater connected in series to provide 6 days detention time at 1.65 MLD, followed by a linear wetland, and another holding pond, then is released through another series of natural wetlands with flow towards the east eventually reaching Yorkton Creek in SE-31-25-03-W2.

It is important to public safety that you read and understand all of this covering letter, the attached permit and guideline documents. It is a condition of this permit that a copy of this cover letter and permit must be given to the person(s) supervising those performing the construction work, such as the contractor or employee. Please ensure your relevant employees and contractors read and understand the content and conditions of this letter and permit.

The construction of the approved works for the City of Yorkton is to be completed in accordance with information provided to the Saskatchewan Ministry of Environment; "Application for Permit to Construct, Extend, or Alter Existing Works" dated July 7th, 2011, the report titled "Contract Documents City of Yorkton Queen St. Water Treatment Plant Contract 9: Process Wastewater Treatment System", and the project drawings titled "Water System Expansion Queen Street WTP Contract 12: Process Wastewater Treatment System" prepared by Associated Engineering, and other application correspondence and information which were received by the Saskatchewan Ministry of Environment between July 6, 2011 and July 22, 2011.

The City of Yorkton must comply with the conditions listed on the permit.

1. **QA / QC on Lagoon Liners**

   The clay liner shall be constructed under supervision and approval of the Engineering Consultant. A minimum of one sample shall be taken from each cell and testing for
hydraulic conductivity of the liner. Documentation on QA/QC performed on the liner shall be made available at the request of Ministry of Environment.

2. Downstream Monitoring and Impact

The application information did not include an assessment of the potential impacts to the Yorkton Creek or downstream users or water bodies. Yorkton needs to monitor effluent quality of this discharge to the environment and periodically assess impacts which may lead to future mitigation requirements.

3. Land Access and Control

This permit does not grant any permission to the Permittee or others to enter or build on land that is not owned or controlled by the Permittee. All land access and control agreements, easements, etc. need to be acquired by the Permittee prior to the commencement of any construction. Please ensure that land access and control is acquired for both the construction and ongoing maintenance of the installed works.

Also land control, easements and/or agreements for overland discharge of wastewater across properties not owned by the Permittee may be required. The Permittee shall ensure they have permission to discharge water across downstream lands to accommodate this additional flow until the water reaches Yorkton Creek in SE-31-25-03-W2.

4. Stormwater Infrastructure

At this time the Ministry of Environment does not require permitting of the construction or operation of municipal stormwater infrastructure under The Environmental Management and Protection Act, 2002 or The Water Regulations, 2002 similar to what is required for drinking water and sanitary sewer infrastructure. For your information and use the ministry has published Stormwater Guidelines which include best practices and good recommendations. These are available online at http://www.saskhh2o.ca/DWBinder/EPB322StormwaterGuidelines.pdf.

Another separate application for a Permit to Operate the system is not required as the existing operating permit will be amended as needed by the Saskatchewan Ministry of Environment to include any new representative monitoring of the new system.

Please contact your Environmental Project Officer prior to commencing construction. After construction, you must also submit “as-constructed” drawings of the permitted works to your Environmental Project Officer listed here.
Joe Zarowny  
Saskatchewan Ministry of Environment  
120 Smith Street  
YORKTON SK S3N 3V3  
Telephone: (306) 786-1425  
Fax: (306) 786-5716  

Every permittee of a waterworks or sewage works and every employee, agent or contractor engaged by a permittee shall immediately report to the Environmental Project Officer, Mr. Joe Zarowny at the Yorkton office at 306-786-1425 or the Saskatchewan Ministry of Environment Spill Control Centre at 1-800-667-7525 any known or anticipated upset condition, bypass condition or events that could adversely affect a waterworks, a sewage works, the environment, or the public.

Please note that our review was not a detailed engineering review of the application rather our review pertained only to those items which could be related to the protection of public health and the environment. Therefore, please ensure that the project adheres to appropriate good engineering practices and complies with EMPA, The Water Regulations 2002, “A Guide to Waterworks Design”, and “Guidelines for Sewage Works Design”.

This project may require permits from other agencies or regulators before construction may commence. The Ministry of Environment’s issuance of a Permit to Construct indicates that a project meets the requirements set out in The Environmental Management and Protection Act, 2002; The Water Regulations, 2002; and the applicable Ministry of Environment guidelines. The issuance of a Permit to Construct does not guarantee that other regulators will approve the proposed project.

If you have any questions, please contact me at 787-1016.

Yours sincerely,

[Signature]

Ben Lichtenwald, MSEnvE, P.Eng.,  
Senior Approvals Engineer  
Municipal Branch

cc: Shengtao Weng, Associated Engineering, Saskatoon  
Gilbert Comres, Sr.PHI, Sunrise Health Region #5  
Joe Zarowny, Ministry of Environment, Yorkton

Enclosure
To: City of Yorkton (Permittee).

PURSUANT to section 23(1)(a)(i) of The Environmental Management and Protection Act, 2002, a permit for construction of waterworks in SW-35-25-4-W2 connecting to existing waterworks, namely the installation of two new sedimentation ponds for treatment of the water treatment plant process wastewater connected in series to provide 6 days detention time at 1.65 MLD, followed by a linear wetland, and another holding pond, then is released through another series of natural wetlands with flow towards the east eventually reaching Yorkton Creek in SE-31-25-03-W2, is issued in accordance with the attached Terms and Conditions.

This Permit takes effect on the 25th day of July, 2011.

This Permit expires on the 25th day of July, 2013, unless cancelled or suspended before that date.

Issued:

[Signature]

Minister of the Environment
per
Ben Lichtenwald, MSEnV, P. Eng.,
Senior Approvals Engineer
Environmental Protection Services Section
Municipal Branch
Saskatchewan Ministry of Environment
Acting for and on Behalf of the Minister
of the Environment
Terms and Conditions

Section One: Definitions
1.1 All words and phrases have the same definitions as set out in The Environmental Management and Protection Act, 2002, and The Water Regulations, 2002, as the case may be.

1.2 In this Permit:
   (a) “Act” means The Environmental Management and Protection Act, 2002;
   (b) “Regulations” means The Water Regulations, 2002;
   (c) “Minister” means the Minister of Environment for the Province of Saskatchewan;
   (d) “Approvals Engineer” refers to the Approvals Engineer or Drinking Water Engineer of the Municipal Branch of the Ministry of Environment of the Government of Saskatchewan; and
   (e) “Environmental Project Officer” refers to the Environmental Project Officer for the corresponding geographical administration area of the Municipal Branch of the Ministry of Environment of the Government of Saskatchewan.

Section Two: Effective Date and Expiry
2.1 This Permit takes effect on the date shown on the Permit.

2.2 The Permittee shall complete construction of the works in accordance with the Permit by the date shown on the Permit.

2.3 If the Permittee is unable to complete the construction by the expiry date shown on the Permit, the Permittee shall advise the Approvals Engineer in writing, not less than thirty (30) days prior to the Permit expiry date, stating the reasons for non completion and requesting an extension of the Permit.

Section Three: Construction
3.1 The construction of the approved works for the City of Yorkton is to be completed in accordance with information provided to the Saskatchewan Ministry of Environment; “Application for Permit to Construct, Extend, or Alter Existing Works” dated July 7th, 2011, the report titled “Contract Documents City of Yorkton Queen St. Water Treatment Plant Contract 9: Process Wastewater Treatment System”, and the project drawings titled “Water System Expansion Queen Street WTP Contract 12: Process Wastewater Treatment System” prepared by Associated Engineering, and other application correspondence and information which were received by the Saskatchewan Ministry of Environment between July 6, 2011 and July 22, 2011.

3.2 A copy of this cover letter and permit must be given to the person(s) supervising those performing the construction work, such as the contractor or employee.

3.3 The clay liner shall be constructed under supervision and approval of the Engineering Consultant. A minimum of one sample shall be taken from each cell and testing for hydraulic conductivity of the liner. Documentation on QA / QC performed on the liner shall be made available at the request of Ministry of Environment.

3.4 All land access and control agreements, easements, etc. need to be acquired by the Permittee prior to the commencement of any construction.

3.5 No changes or deviations shall be made to the Plan without the prior consent of the Minister and any proposed change or deviation shall be submitted in writing to the Approvals Engineer for approval.
3.6 Prior to commencing construction, the Permittee shall notify the Environmental Project Officer.

3.7 Upon completion of construction, the Permittee shall:
(a) notify the Environmental Project Officer; and
(b) submit "as-constructed" drawings to the Environmental Project Officer; and
(c) submit operation and maintenance manuals for new treatment works to the Environmental Project Officer.

Section Four: General

4.1 This Permit is not an authorization or approval to operate the works.

4.2 The Permittee shall not operate the works without first obtaining a permit to do so in accordance with the Act and Regulations.

4.3 This approval is subject to cancellation, alteration, or suspension as provided by Act.

4.4 Where any notice or reporting is required to be given by the Permittee, it shall be provided to:

(a) in the case of the Approvals Engineer:
Saskatchewan Ministry of Environment
Municipal Branch
3211 Albert Street 4th Floor
REGINA SK S4S 5W6
Telephone (306) 787-6504
Fax: (306) 787-0197

(b) in the case of the Environmental Project Officer:
Saskatchewan Ministry of Environment
Municipal Branch
120 Smith Street
YORKTON SK S3N 3V3
Telephone: (306) 786-1425
Fax: (306) 786-5716
Appendix E - Process Wastewater Quality

- WTP Pilot Plant Quality
- Sedimentation Time Charts
City of Yorkton
Water Treatment Plant
Wastewater Reuse Feasibility Study
(February, 2006)

WTP No. 4

Detention Time (Minutes)
- Total Suspended Solids (TSS)

West Broadway WTP

Detention Time (Minutes)
- Total Suspended Solids (TSS)
City of Yorkton
Water Treatment Plant
Wastewater Reuse Feasibility Study
(December, 2009)

WTP No. 4

Residual Concentration (mg/L)

Detention Time (Minutes)

Fe
Mn

West Broadway WTP

Residual Concentration (mg/L)

Detention Time (Minutes)

Fe
Mn
## City of Yorkton
### Water Treatment Plant Wastewater Reuse Feasibility Study
#### Process Wastewater Quality Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Process Wastewater from Uplow Roughing Filter After 30 hrs Detention</th>
<th>Process Wastewater from Greensand Filter After 30 hrs Detention</th>
<th>Saskatchewan Ministry of Environment: Surface Water Quality Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicarbonate</td>
<td>mg/L</td>
<td>442</td>
<td>443</td>
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<td>Chloride</td>
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<td>31</td>
<td>33</td>
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<td>Hydroxide</td>
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<td>&lt;1</td>
<td>&lt;1</td>
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<td>P. alkalinity</td>
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<td>&lt;1</td>
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<td>pH</td>
<td></td>
<td>8.05</td>
<td>8.01</td>
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<td>Specific conductivity</td>
<td>uS/cm</td>
<td>1030</td>
<td>1060</td>
<td>-</td>
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<tr>
<td>Sum of ions</td>
<td>mg/L</td>
<td>887</td>
<td>895</td>
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<td>Total alkalinity</td>
<td>mg/L</td>
<td>362</td>
<td>363</td>
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<tr>
<td>Total hardness</td>
<td>mg/L</td>
<td>505</td>
<td>522</td>
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<td>Nitrate</td>
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<td>&lt;0.04</td>
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<td>Organic carbon</td>
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<td>Total dissolved solids</td>
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<td>Calcium</td>
<td>mg/L</td>
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<td>Magnesium</td>
<td>mg/L</td>
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<td>Potassium</td>
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<td>Sodium</td>
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<td>Sulfate</td>
<td>mg/L</td>
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<td>Aluminum</td>
<td>mg/L</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
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<td>Arsenic</td>
<td>ug/L</td>
<td>2.2</td>
<td>2.0</td>
<td>5</td>
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<tr>
<td>Barium</td>
<td>mg/L</td>
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<td>0.020</td>
<td>-</td>
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<td>Boron</td>
<td>mg/L</td>
<td>0.12</td>
<td>0.12</td>
<td>-</td>
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<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>&lt;0.00001</td>
<td>&lt;0.00001</td>
<td>0.000017 - 0.0001</td>
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<tr>
<td>Chromium</td>
<td>mg/L</td>
<td>&lt;0.0005</td>
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<td>0.001</td>
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<tr>
<td>Copper</td>
<td>mg/L</td>
<td>0.0003</td>
<td>0.0002</td>
<td>0.002 - 0.004</td>
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<tr>
<td>Iron</td>
<td>mg/L</td>
<td>0.13</td>
<td>0.14</td>
<td>0.3</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.001 - 0.007</td>
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<td>Manganese</td>
<td>mg/L</td>
<td>0.021</td>
<td>0.044</td>
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<td>Selenium</td>
<td>mg/L</td>
<td>0.0004</td>
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<td>Uranium</td>
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<td>Zinc</td>
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<td>0.0065</td>
<td>&lt;0.0005</td>
<td>0.03</td>
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</table>
Appendix F - Location And Site Plans

- City of Yorkton Zoning District Map
- Location Plan
- General Site Plan
- Topographical Site Plan
- Existing Infrastructure
See attached map titled "Schedule Z–1 – City of Yorkton Zoning Districts Map."

Amended By

TITLE: GEOTECHNICAL INVESTIGATION
LOGAN GREEN WASTEWATER REUSE PROJECT
PROPOSED SEDIMENTATION PONDS
YORKTON, SASKATCHEWAN

CLIENT: CITY OF YORKTON

FILE NO: GE-0447 DATE: DECEMBER 8, 2011
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December 8, 2011

City of Yorkton
c/o Associated Engineering (Sask.) Ltd.
1 – 2225 Northridge Drive
SASKATOON, Saskatchewan
S7L 6X6

ATTENTION: MR. DARREN ANHOLT, P. ENG.

Dear Sir:

SUBJECT: GEOTECHNICAL INVESTIGATION
LOGAN GREEN WASTEWATER REUSE PROJECT
PROPOSED SEDIMENTATION PONDS
YORKTON, SASKATCHEWAN

1.0 INTRODUCTION

This report presents the results of a site specific subsurface soils investigation and geotechnical analysis carried out at the site of the proposed Logan Green Wastewater Reuse Project to be constructed in the City of Yorkton, Saskatchewan. It is understood that the project includes construction of two (2) backwash wastewater sedimentation ponds, storm water ponds, linear wetlands and an effluent pond possibly stocked with fish. The objectives of this investigation were to provide the following information:

.1 To define the subsurface soil stratigraphy and engineering properties of the insitu soils.

.2 To provide design recommendations for design and construction of the sedimentation pond liner.

.3 To determine the suitability of excavated materials for use as backfill and provide compaction recommendations.
.4 To comment on possible excavation and construction problems related to pond construction with particular reference to groundwater conditions and if appropriate, groundwater control.

.5 To provide recommendations on pertinent geotechnical issues identified during the subsurface investigation.

Authorization to proceed with this work was received in your e-mail dated May 11, 2011.

2.0 DESCRIPTION OF THE SITE

The study area shown in Figure 1 is located to the north and east of the existing Queen Street Water Treatment Plant (WTP) in the City of Yorkton, Saskatchewan. The site is bounded by Queen Street to the south, Highway No. 9 to the east and residential housing to the north. The property consists of undeveloped grassland and bush. The topography is best described as a hummocky, poorly drained, till plain with undrained depressions and sloughs. The site was quite wet at the time of our investigation and the low areas of the site were not accessible for the drilling rig. Ground surface elevations vary up to 3.8 metres between the test hole locations.

3.0 FIELD AND LABORATORY INVESTIGATION

The subsurface conditions were investigated by drilling 16 test borings at the locations shown on Drawing No. GE-0447-1. The test borings were drilled on May 18, 19 and 20, 2011 using a truck-mounted, CME-75 digger equipped with a 150 mm diameter continuous flight auger. The test holes were terminated at depths ranging from 4.6 to 12.2 metres below existing grade.

Representative disturbed auger samples were recovered from the test borings at selected intervals and were taken to our laboratory for analysis. Each soil sample was visually examined to determine its textural classification and natural moisture content tests were performed on each soil sample. In addition, Atterberg Limits, grain size analyses, sulphate content and Standard Proctor density tests were performed on selected soil samples. Two
FIGURE 1
LOCATION OF STUDY AREA
(2) hydraulic conductivity tests were conducted on remolded composite samples of the surficial soil. Details of the soil profile, samples taken, laboratory test results and stratigraphic interpretations of the subsoils are presented on Drawing Nos. GE-0447-5 to -36, inclusive.

Each test hole location and ground surface elevation was surveyed and marked in the field by representatives of Associated Engineering (Sask.) Ltd. prior to drilling the test holes.

4.0 GEOTECHNICAL ANALYSIS

4.1 Stratigraphy

The drilling information indicates that the surficial topsoil is partially underlain by a silty clay stratigraphic unit which extends to depths ranging from 0.45 to 1.8 metres below grade. The surficial clay unit was not encountered in Test Holes 205, 208, 210, 211, 213, 214 and 215. The clay is generally moist, firm in consistency and laminated with interbedded layers of silt and organic layers. Atterberg Limits tests indicate that the clay is medium plastic with an average Liquid Limit of 41% and an average Plasticity Index of 24%.

The topsoil and/or clay units are underlain by an oxidized till stratigraphic unit. The till extends to depths ranging from 2.1 to 4.3 metres below existing grade. The till is a heterogeneous mixture of clay, silt, sand and gravel with occasional silt and clay lenses, cobblestones and boulders. Atterberg Limits tests indicate that the till is medium plastic with an average Liquid Limit of 35% and an average Plasticity Index of 22%.

In Test Holes 202, 215 and 216, the till unit is underlain by a lower silty clay unit which extends to depths of 10.0, 4.1 and 3.6 metres below existing grade, respectively. The Lower Clay is silty, moist and very stiff to hard in consistency. Atterberg Limits tests indicate that the Lower Clay is medium to highly plastic with a Liquid Limit in the order of 49% and a Plasticity Index in the order of 33%.
In Test Holes 214, 215 and 216 the till and/or lower clay units are underlain by a thin silt layer which extends to depths ranging from 3.0 to 4.9 metres. The silt is sandy, moist to very moist and loose.

The till, clay and silt units are underlain by an oxidized sand stratigraphic unit which extends to the maximum depth penetrated in test holes (12.2 metres). The gradation of the sand varies from fine grained to medium grained as shown on Drawing Nos. GE-0447-23 to -25, inclusive. The sand is relatively clean and cohesionless.

4.2 **Groundwater**

The surficial clay, silt and till units encountered at this site are moist and cohesive. The underlying sand unit is an unconfined aquifer. The sand unit is saturated below depths ranging from 3.0 to 6.6 metres below grade. During periods of heavy rainfall or spring run off, the water table could be even higher. Standpipe piezometers were installed in Test Holes 202, 203, 204, 205 and 212. The piezometric data is summarized in Table 1, below.

<table>
<thead>
<tr>
<th>PIEZOMETER NO.</th>
<th>DATE MEASURED</th>
<th>GROUNDWATER LEVEL FROM TOP OF PIPE (m)</th>
<th>GROUNDWATER LEVEL BELOW GRADE (m)</th>
<th>PIEZOMETRIC SURFACE ELEVATION (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH 202</td>
<td>May 18, 2011</td>
<td>9.94</td>
<td>8.98</td>
<td>498.0</td>
</tr>
<tr>
<td>TH 203</td>
<td>May 18, 2011</td>
<td>6.63</td>
<td>5.54</td>
<td>500.67</td>
</tr>
<tr>
<td>TH 204</td>
<td>May 18, 2011</td>
<td>7.67</td>
<td>6.63</td>
<td>500.76</td>
</tr>
<tr>
<td>TH 205</td>
<td>May 18, 2011</td>
<td>5.77</td>
<td>4.72</td>
<td>500.63</td>
</tr>
<tr>
<td>TH 212</td>
<td>May 19, 2011</td>
<td>5.92</td>
<td>4.92</td>
<td>499.65</td>
</tr>
</tbody>
</table>

5.0 **DESIGN RECOMMENDATIONS**

5.1 **Backwash Wastewater Sedimentation Ponds**

Two (2) hydraulic conductivity tests were conducted on composite samples of the remolded till soil to determine its suitability for use in constructing the pond liners. In addition, grain size analyses were performed on samples of clay and till soils recovered from the test holes. The test results are summarized in Table 2, below.
## TABLE 2

### GRADATION ANALYSIS OF CLAY AND TILL SOILS

<table>
<thead>
<tr>
<th>PARTICLE SIZE</th>
<th>TH 201 Composite Sample 0.9 – 2.4 metres</th>
<th>TH 206 Composite Sample 0.9 – 1.8 metres</th>
<th>TH 206 Composite Sample 0.3 – 1.8 metres</th>
<th>TH 207 Composite Sample 0.3 – 1.8 metres</th>
<th>TH 209 Composite Till Sample TH’s 202, 204, 207 &amp; 208</th>
<th>Composite Till Sample TH’s 203, 205, 206 &amp; 209</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENT (%)</td>
<td>CONTENT (%)</td>
<td>CONTENT (%)</td>
<td>CONTENT (%)</td>
<td>CONTENT (%)</td>
<td>CONTENT (%)</td>
<td>CONTENT (%)</td>
</tr>
<tr>
<td>Gravel</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Sand</td>
<td>34</td>
<td>10</td>
<td>26</td>
<td>3</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Silt</td>
<td>27</td>
<td>47</td>
<td>32</td>
<td>44</td>
<td>42</td>
<td>27</td>
</tr>
<tr>
<td>Clay</td>
<td>34</td>
<td>43</td>
<td>37</td>
<td>53</td>
<td>54</td>
<td>34</td>
</tr>
<tr>
<td>Classification</td>
<td>Till</td>
<td>Clayey Silt</td>
<td>Till</td>
<td>Silty Clay</td>
<td>Silty Clay</td>
<td>Till</td>
</tr>
</tbody>
</table>

Generally, a soil which contains at least 20 to 25 percent clay-sized particles is suitable for constructing a compacted earth liner. The grain size analyses show that the surficial till unit at this site is relatively uniform with 34 to 37 percent clay-sized particles. The silty clay unit is more variable with 43 to 54 percent clay-sized particles.

Saskatchewan Ministry of Environment guidelines suggest that the seepage velocity from a wastewater facility not exceed 150 mm per year. The guidelines also recommend that an on-site permeability of 10 times the laboratory value be used to calculate seepage losses. Generally, a lining system equivalent to 600 mm with an average hydraulic conductivity of $1 \times 10^{-7}$ cm/s is adequate. The hydraulic conductivity test results on composite samples of till soils from Test Holes 202, 204, 207 and 208 (west sedimentation pond) as well as Test Holes 203, 205, 206 and 209 (east sedimentation pond) are summarized in Table 3 and are shown on Drawing Nos. GE-0447-35 and -36.

## TABLE 3

### SUMMARY OF HYDRAULIC CONDUCTIVITY TEST RESULTS

<table>
<thead>
<tr>
<th>TEST HOLE NO.</th>
<th>STANDARD PROCTOR DENSITY (t/m³)</th>
<th>MOLDING DENSITY (t/m³)</th>
<th>RELATIVE COMPACTION (%)</th>
<th>MOLDING MOISTURE CONTENT (%)</th>
<th>ELAPSED TIME (min)</th>
<th>HYDRAULIC CONDUCTIVITY (cm/s)</th>
<th>SOIL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite Test Holes 202, 204, 207 and 208</td>
<td>1.840</td>
<td>1.842</td>
<td>100.1</td>
<td>14.2</td>
<td>18234</td>
<td>$3.46 \times 10^9$</td>
<td>Till</td>
</tr>
<tr>
<td>Composite Test Holes 203, 205, 206 and 209</td>
<td>1.653</td>
<td>1.649</td>
<td>99.8</td>
<td>19.6</td>
<td>33102</td>
<td>$4.16 \times 10^9$</td>
<td>Till</td>
</tr>
</tbody>
</table>
Based on the above hydraulic conductivity test results, the till soils at this site are suitable for use as an earth liner for the backwash wastewater sedimentation ponds.

**5.1.1 Backwash Wastewater Sedimentation Pond Liner**

The objective during construction of the proposed sedimentation ponds is to provide the most impermeable lining possible in order that infiltration into the subsoils is minimized. It should be a relatively straightforward construction procedure to construct a compacted earth liner in the sedimentation ponds utilizing the on-site till soil. Consequently, a compacted earth liner should be very economical. A total liner thickness of 600 mm is recommended to minimize seepage losses, based on the hydraulic conductivity test results. The following construction procedures are recommended:

.1 All surficial topsoil, organic matter and localized sandy soils should be stripped from the designated pond areas and should not be used for liner or dyke construction.

.2 Localized wet, soft areas may be encountered at the base of the pond excavation. These areas should be over-excavated to a depth of 300 mm and filled with till material compacted to a minimum of 95% Standard Proctor density.

.3 The base of the ponds should be scarified and pulvimixed to a depth of 150 mm to construct the bottom lift of the earth liner. This should break the insitu material into the smallest size possible and break down the natural desiccation cracks and fissures. The remaining three (3) lifts should be 150 mm in thickness for a total compacted liner thickness of 600 mm.

.4 The till liner should be compacted to a minimum of 100 percent Standard Proctor Maximum dry density using a vibratory padfoot or heavy sheepsfoot type roller. Moisture conditioning of the liner material may be required during construction to achieve the specified compaction.

.5 It is recommended that 150 mm of sandy cover material be placed over the finished liner to protect the liner from desiccation, erosion or other biological destructive forces. Only light compaction of the cover material is required. The ponds should be filled with water as soon as possible after construction has been completed.
Variations in the subsoil conditions at the site may occur between test hole locations. Localized, more permeable sand lenses are not desirable in the pond lining system. For this reason, it is recommended that the preparation of the earth liner should be supervised during construction by experienced geotechnical personnel.

5.1.2 Containment Dykes

Specific recommendations for the design and construction of the containment dykes are provided below:

1. Subgrade preparation should consist of the removal of all surficial topsoil and scarifying the subgrade soils under the dykes to a depth of 200 mm. The scarified soil should then be recompacted to a minimum of 97% Standard Proctor density.

2. The liner should extend all the way from the floor of the sedimentation ponds up the inside face of the dyke. A containment dyke constructed out of the till would constitute part of the seepage control barrier to minimize lateral flow of water.

3. The embankment fill for construction of the dykes should be uniformly compacted to a minimum of 97 percent Standard Proctor density. The material used should be placed in lifts of 200 mm, approximately.

4. Saskatchewan Ministry of Environment guidelines recommend that the interior side slopes of the dykes should not be flatter than one (1) vertical to six (6) horizontal or steeper than one (1) vertical to three (3) horizontal. The top of earth dykes should be at least three (3) metres wide to permit access to vehicles.

5. Erosive forces to be considered for earth slopes of containment ponds are wave and wind effects. If wind and wave action may be extreme, then riprap or some other suitable means of slope protection should be considered.
5.1.3 Compaction Control

Proper compaction specifications and compaction quality control during construction of any fill areas should be a high priority. To achieve the specified density, uncompacted lift thicknesses for all earth fill areas should be a maximum of 200 mm, approximately.

6.0 EXCAVATION CONSIDERATIONS

During construction, any surficial sand or permeable sand lenses encountered during excavation, should be stripped from the site and stockpiled for use as cover material or for constructing the access road. Cobblestones and boulders (>150 mm in diameter) should be removed from material used to construct the pond liner.

Excavations at this site will be in the surficial silty clay and till units. Conventional excavation procedures should therefore be applicable to the soils at this site. Occupational Health and Safety Regulations require that any trench or excavation in which persons must work must be cut back at least one (1) horizontal to one (1) vertical or a temporary shoring system must be used to support the sides of the excavation.

7.0 OTHER

.1 In the event that changes are made in the design, location or nature of the project, the conclusions and recommendations included in this report would not be deemed valid unless the changes in the project were reviewed by our firm. Modification to this report would then be made if necessary.

.2 In is anticipated that the backwash water may contain high concentrations of salts which will aggressively attack concrete. Therefore, we recommend HS (Type 50) Sulphate Resistant cement be used for all concrete in contact with the backwash water.
3. Variations in the subsoil conditions at the site may occur between test hole locations. Localized, more permeable sand lenses are not desirable in the fill materials and for this reason it is emphasized that the preparation of the earth liner should be inspected during construction by experienced geotechnical personnel.

4. This report has been prepared for the City of Yorkton and is intended for the specific application to the design and construction of the proposed Logan Green Wastewater Reuse Project to be constructed at the Queen Street WTP in the City of Yorkton, Saskatchewan. The analysis and recommendations are based in part on the data obtained from the test hole logs. The boundaries between soil strata have been established at bore hole locations. Between the boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error. Contractors bidding on the project works are particularly advised against reviewing the report without realising the limitations of the subsurface information. It is recommended that Contractors should make such tests, inspections and other on-site investigations as is considered necessary to satisfy themselves as to the nature of the conditions to be encountered.

8.0 CLOSURE

We trust this report is satisfactory for your purposes. If you have any questions or require additional information, please contact our office.

Yours very truly
Ground Engineering Consultants Ltd.


Reviewed By: Tim Adelman, P. Eng., P. Geol.
### CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

**ASTM Designation:** D 2487 - 66 AND D 2488 - 69  
(Unified Soil Classification System)

<table>
<thead>
<tr>
<th>Major Divisions</th>
<th>Group Symbols</th>
<th>Typical Names</th>
<th>Classification Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse-grained soils</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 50% retained on No. 200 sieve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gravels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% or more of coarse fraction retained on No. 4 sieve</td>
<td>Clean gravels</td>
<td>GW</td>
<td>Well-graded gravels and gravel-sand mixtures, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GP</td>
<td>Poorly graded gravels and gravel-sand mixtures, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GM</td>
<td>Silty gravels, gravel-sand-silt mixtures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GC</td>
<td>Clayey gravels, gravel-sand-clay mixtures</td>
</tr>
<tr>
<td><strong>Sands</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 50% of coarse fraction passes No. 4 sieve</td>
<td>Clean sands</td>
<td>SW</td>
<td>Well-graded sands and gravelly sands, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SP</td>
<td>Poorly graded sands and gravelly sands, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SM</td>
<td>Silty sands, sand-silt mixtures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC</td>
<td>Clayey sands, sand-clay mixtures</td>
</tr>
</tbody>
</table>

| **Fine-grained soils** |              |               |                         |
| 50% or more passes No. 200 sieve |              |               |                         |
| **Silt and clays** |              |               |                         |
| Liquid limit 5% or less | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands | ML | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty and clayey clays, lean clays |
|              |              | CL | Organic silts and organic silty clays of low plasticity | Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols |
|              |              | OL | Organic silts and organic silt clay of medium plasticity | Equation of A-line: $P_i = 0.73(\text{LL} - 20)$ |
| **Silt and clays** |              |               |                         |
| Liquid limit greater than 5% | Inorganic clays of high plasticity, fat clays | MH | Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts |
|              |              | CH | Organic clays of high plasticity | Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols |
|              |              | OH | Organic clays of medium to high plasticity | Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols |
| **Highly organic soils** |              |               |                         |
|              |              | Pt | Peat, muck and other highly organic soils |                         |

---

*Based on the material passing the 75mm (3in) sieve.*

**PLASTICITY CHART**

- **CL**
- **ML**
- **OL**
- **MH**
- **CH**
- **OH and ML**

---

**GE-0447-2**
### SYMBOLS AND TERMS USED IN THE REPORT

<table>
<thead>
<tr>
<th>CLAY</th>
<th>SILT</th>
<th>SAND</th>
<th>GRAVEL</th>
<th>ORGANIC</th>
<th>PEAT</th>
<th>TILL</th>
<th>SHALE</th>
<th>FILL</th>
</tr>
</thead>
</table>

The symbols may be combined to denote various soil combinations, the predominating soil being heavier.

### RELATIVE PROPORTIONS

<table>
<thead>
<tr>
<th>TERM</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>0 - 5%</td>
</tr>
<tr>
<td>A Little</td>
<td>5 - 15%</td>
</tr>
<tr>
<td>Some</td>
<td>15 - 30%</td>
</tr>
<tr>
<td>With</td>
<td>30 - 50%</td>
</tr>
</tbody>
</table>

### ASTM CLASSIFICATION BY PARTICLE SIZE

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>&gt; 300 mm</td>
</tr>
<tr>
<td>Cobble</td>
<td>300 mm - 75 mm</td>
</tr>
<tr>
<td>Gravel</td>
<td>75 mm - 4.75 mm</td>
</tr>
<tr>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>coarse</td>
<td>4.75 mm - 2 mm</td>
</tr>
<tr>
<td>medium</td>
<td>2 mm - 0.025 mm</td>
</tr>
<tr>
<td>fine</td>
<td>0.025 mm - 0.0025 mm</td>
</tr>
<tr>
<td>Silt</td>
<td>0.0025 mm - 0.005 mm</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt; 0.005 mm</td>
</tr>
</tbody>
</table>

### DENSITY OF SANDS AND GRAVELS

<table>
<thead>
<tr>
<th>DESCRIPTIVE TERM</th>
<th>RELATIVE DENSITY 1</th>
<th>N VALUE STANDARD 2 PENETRATION TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very loose</td>
<td>0 - 15%</td>
<td>0 - 4 Blows per 300mm</td>
</tr>
<tr>
<td>Loose</td>
<td>15 - 35%</td>
<td>4 - 10 Blows per 300mm</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>35 - 65%</td>
<td>10 - 30 Blows per 300mm</td>
</tr>
<tr>
<td>Dense</td>
<td>65 - 85%</td>
<td>30 - 50 Blows per 300mm</td>
</tr>
<tr>
<td>Very Dense</td>
<td>85 - 100%</td>
<td>&gt; 50 Blows per 300mm</td>
</tr>
</tbody>
</table>

### CONSISTENCY OF CLAYS AND SILTS

<table>
<thead>
<tr>
<th>DESCRIPTIVE TERM</th>
<th>UNDRAINED SHEAR STRENGTH (kPa)</th>
<th>N VALUE STANDARD 2 PENETRATION TEST</th>
<th>FIELD IDENTIFICATION (ASTM D 2488-84)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>&lt;12</td>
<td>&lt; 2 Blows per 300mm</td>
<td>Thumb will penetrate soil more than 25 mm</td>
</tr>
<tr>
<td>Soft</td>
<td>12 - 25</td>
<td>2 - 4 Blows per 300mm</td>
<td>Thumb will penetrate soil about 25 mm</td>
</tr>
<tr>
<td>Firm</td>
<td>25 - 50</td>
<td>4 - 8 Blows per 300mm</td>
<td>Thumb will indent soil about 6 mm</td>
</tr>
<tr>
<td>Stiff</td>
<td>50 - 100</td>
<td>6 - 15 Blows per 300mm</td>
<td>Thumb will indent, but only with great effort (CFEM)</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>100 - 200</td>
<td>15 - 30 Blows per 300mm</td>
<td>Readily indented by thumbnail (CFEM)</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt;200</td>
<td>&gt; 30 Blows per 300mm</td>
<td>Thumb will not indent soil but readily indented with thumbnail</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Relative Density determined by standard laboratory tests.
2. N Value - Blows/300mm of a 620N hammer falling 762mm on a 50mm O.D. Split Spoon.
**SYMBOLS AND TERMS USED IN THE REPORT (continued)**

**GROUNDWATER**
- Water level measured in the bores at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soil, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious waterbearing soil are present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.
- Water level determined by piezometer installation - in all soils the levels can be considered reliable groundwater levels.

**DESCRIPTIVE SOIL TERMS**
- **WELL GRADED**: Having wide range of grain sizes and substantial amounts of all intermediate sizes.
- **POORLY GRADED**: Predominantly of one grain size.
- **SLICKENSIDES**: Refers to a clay that has planes that are slick and gossy in appearance; slickensides are caused by shear movements.
- **SENSITIVE**: Exhibiting loss of strength on remolding.
- **FISSURED**: Containing cracks, usually attributable to shrinkage. Fissured clays are sometimes described as having a nubbly structure.
- **STRATIFIED**: Containing layers of different soil types.
- **ORGANIC**: Containing organic matter; may be decomposed or fibrous.
- **PEAT**: A fibrous mass of organic matter in various stages of decomposition. Generally dark brown to black in color and of spongy consistancy.
- **BEDROCK**: Preglacial material.
- **DRIFT**: Material deposited directly by glaciers or glacial melt-water.
- **ALLUVIAL**: Soils that have been deposited from suspension from moving water.
- **LACUSTRINE**: Soils that have been deposited from suspension in fresh water lakes.

**DRILLING AND SAMPLING TERMS**
- **C.S.**: Continuous Sampling
- **Sy**: 75mm Thin Wall Tube Sample
- **Sy (2)**: 50mm Thin Wall Tube Sample
- **SPT (SS)**: 50mm O.D. Split Spoon Sample
- **BLOWS 300mm**
- **Bag**: Disturbed Bag Sample
- **No.**: Sample Identification Number
- **Piezometer Tip**: Slope Indicator
- **SPG**: Observed Seepage

**LABORATORY TEST SYMBOLS**
- **Symbol**: Moisture Content - Percent of Dry Weight
- ****: Plastic and Liquid Limit determined in accordance with ASTM D-423 and D-424
- ****: Dry Density - $t/m^3$
- ****: Shear Strength - As determined by Unconfined Compression Test
- ****: Shear Strength - As determined by Field Vane
- ****: Shear Strength - As determined by Pocket Penetrometer Test
- **%\(SO_4\)**: Water Soluble Sulphates - Percent of Dry Weight
- **M.A.**: Grain Size Analysis

GE-0447-4
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes, the boundaries are interpolated and may be subject to considerable error.
SECTION 'B-B'
SCALE: HOR. 1:1500
VERT. 1:100

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes, the boundaries are interpolated and may be subject to considerable error.
### SOIL DESCRIPTION

**TOPSOIL**

- **150mm**
  - 6.0in
  - Clay - silty
    - laminated with silt and organic layers
    - moist, soft to firm
    - oxidized
    - olive brown (2.5Y 4/4)

- **910mm**
  - 3.0ft
  - Till - silty, clayey
    - moist, stiff to very stiff
    - oxidized, iron and manganese stains
    - salt crystals
    - dark grayish brown (2.5Y 4/2)

- **2.5m**
  - 8.5ft
  - Sand - fine grained, silty
    - moist, wet below 3.6 metres
    - oxidized
    - olive brown (2.5Y 4/4) to light brownish gray (2.5Y 6/2)

**END OF HOLE**

- **12.2m**
- **40.0ft**

**NOTES:**

1. Test hole was excavated on April 18, 2011 using a 150 mm dia. continuous flight auger to a depth of 6.1 metres.
   Test hole was redrilled on May 18, 2011 to a depth of 12.2 metres.
2. Seepage and sloughing was noted below a depth of 3.6 metres during drilling.
3. No groundwater accumulation was noted 22.0 hours after completion of drilling.
   Test hole had sloughed to 3.2 metres.
4. Test hole was backfilled to surface.

---

*GROUND ENGINEERING LTD.*

Regina, Saskatchewan

*LOGGED BY: RY*  
*REVIEWED BY: PW*  
*COMPLETE: 11/05/18*
SOIL DESCRIPTION

TOPSOIL
100mm
CLAY — silty
- laminated with silt and organic layers
- moist, soft to firm
- oxidized
- olive brown (2.5Y 4/4)

TILL — silty, clayey
- moist, stiff to very stiff
- oxidized, iron and manganese stains
- salt crystals
- dark greyish brown (2.5Y 4/2)

CLAY — silty
- moist, very stiff to hard
- unoxidized below 8.7 metres
- very silty, stiff below 8.7 metres
- reddish brown (5YR 4/4) to dark grey (5YR 4/1)

SAND — fine grained, silty
- wet
- oxidized
- dark greyish brown (2.5Y 4/2)

12.2m END OF HOLE

NOTES:
1. The test hole was excavated on May 18, 2011 using a 150 mm dia. continuous flight auger.
2. Piezometer was installed.

GROUND ENGINEERING LTD.
Regina, Saskatchewan

LOGGED BY: RY
REVIEWED BY: PW
Fig. No: GE-0447-8

COMPLETION DEPTH: 12.2 m
COMPLETE: 11/05/18
SOIL DESCRIPTION

TOPSOIL
- 100mm
- Clay - silty
  - laminated with silt and organic layers
  - moist, soft to firm
  - oxidized
  - olive brown (2.5Y 4/4)

1.8m
- Till - silty, clayey
  - moist, stiff to hard
  - oxidized, iron and manganese stains
  - salt crystals
  - dark greyish brown (2.5Y 4/2)

3.3m
- Sand - fine grained, silty
  - moist, wet below 5.2 metres
  - oxidized
  - dark greyish brown (2.5Y 4/2)

7.6m END OF HOLE 25.0 ft

NOTES:
1. Test hole was excavated on May 18, 2011 using a 150 mm dia. continuous flight auger.
2. Piezometer was installed.
# Soil Description

**Topsoil**
- 125mm
- Silty
  - Laminated with silt and organic layers
  - Moist, soft to firm
  - Oxidized
  - Olive brown (2.5Y 4/4)

**Till**
- 1.68m
- Silty, clayey
  - Moist, stiff to very stiff
  - Oxidized, iron and manganese stains
  - Salt crystals
  - Dark grayish brown (2.5Y 4/2)

**Sand**
- 3.6m
- Fine grained, silty
  - Moist
  - Wet, medium to coarse grained below 6.6 meters
  - Oxidized
  - Dark grayish brown (2.5Y 4/2)

**End of Hole**
- 9.1m

**Notes:**
1. Test hole was excavated on May 18, 2011 using a 150 mm dia. continuous flight auger.
2. Piezometer was installed.
SOIL DESCRIPTION

TOPSOIL
125mm
- silty, clayey
- moist, stiff to very stiff
- oxidized, iron and manganese stains
- salt crystals
- dark greyish brown (2.5Y 4/2)

TILL
- moist, stiff to very stiff
- oxidized, iron and manganese stains
- salt crystals
- dark greyish brown (2.5Y 4/2)

SAND
- medium to coarse grained, silty
- moist
- wet below 4.9 metres
- oxidized
- dark greyish brown (2.5Y 4/2)

NOTES:
1. Test hole was excavated on May 18, 2011
   using a 150 mm dia. continuous flight auger.
2. Piezometer was installed.
SOIL DESCRIPTION

TOPSOIL

150mm

CLAY - silty
- laminated with silt and organic layers
- moist, firm
- oxidized
- alive brown (2.5Y 4/4)

910mm

TILL - silty, clayey
- moist, very stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

3.2m

SAND - fine grained, silty
- moist
- wet, medium to coarse grained below 5.5 metres
- oxidized
- dark grayish brown (2.5Y 4/2)

7.6m END OF HOLE 25.0ft

NOTES:
1. Test hole was excavated on May 18, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted 16.0 hours after completion of drilling Test hole had sloughed to 5.5 metres.
3. Test hole was backfilled to surface.
SOIL DESCRIPTION

TOPSOIL
200mm
CLAY - silty
- laminated with silt and organic layers
- moist, soft to firm
- oxidized
- olive brown (2.5Y 4/4)

1.8m
TILL - silty, clayey
- moist, very stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

2.7m
SAND - fine grained, silty
- moist
- wet, medium to coarse grained below 5.2 metres
- oxidized
- dark grayish brown (2.5Y 4/2)

6.1m END OF HOLE 20.0ft

NOTES:
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 5.6 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
**SOIL DESCRIPTION**

**TOPSOIL**
150mm
- 6.0in
- silty, clayey
- moist, stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

**TILL**
- moist, stiff to hard
- silty clay
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

**SAND**
- fine grained, silty
- moist
- wet, medium to coarse grained below
- 6.1 metres
- oxidized
- dark grayish brown (2.5Y 4/2)

**NOTES:**
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 6.1 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.

---

**GROUND ENGINEERING LTD.**
Regina, Saskatchewan
SOIL DESCRIPTION

TOPSOIL

150mm
- silty
  - laminated with silt and organic layers
  - moist, soft to firm
  - oxidized
  - olive brown (2.5Y 4/4)

1.8m
- silty, clayey
  - moist, stiff to hard
  - oxidized, iron and manganese stains
  - salt crystals
  - dark grayish brown (2.5Y 4/2)

2.6m
- fine grained, silty
  - moist
  - wet, medium to coarse grained below 4.9 metres
  - oxidized
  - dark grayish brown (2.5Y 4/2)

6.1m END OF HOLE 20.0ft

NOTES:
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. Water level was measured at a depth of 4.3 metres, immediately after completion of drilling. Test hole sloughed to 4.9 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
SOIL DESCRIPTION

T O P S O I L
1.00m
- silty, clayey
- moist, stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

2.4m
S A N D
- fine grained, silty
- moist
- wet, medium to coarse grained below
  4.3 metres
- oxidized
- dark grayish brown (2.5Y 4/2)

6.1m
E N D O F H O L E

NOTES:
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. Water level was measured at a depth of 4.4 metres, immediately after completion of drilling. Test hole sloughed to 4.5 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
SOIL DESCRIPTION

TOPSOIL
125mm
- silty, clayey
- moist, stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

2.7m
SAND
- fine grained, silty
- moist
- wet, medium to coarse grained below 4.1 metres
- gravelly below 9.4 metres
- oxidized
- dark grayish brown (2.5Y 4/2)

12.2m END OF HOLE
40.0ft

NOTES:
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 4.1 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
SOIL DESCRIPTION

TOPSOIL
200mm - silty
  - laminated with silt and organic layers
  - moist, soft to firm
  - oxidized
  - olive brown (2.5Y 4/4)

1.8m - silty, clayey
  - moist, stiff to hard
  - oxidized, iron and manganese stains
  - salt crystals
  - dark grayish brown (2.5Y 4/2)

4.3m - SAND - fine grained, silty
  - moist
  - well, medium to coarse grained below 4.9 metres
  - oxidized
  - dark grayish brown (2.5Y 4/2)

12.2m - END OF HOLE

NOTES:
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. Piezometer was installed.
SOIL DESCRIPTION

TOPSOIL

- 125mm, 5.0in

- Till: silty, clayey
  - moist, stiff to hard
  - oxidized, iron and manganese stains
  - salt crystals
  - dark grayish brown (2.5Y 4/2)

- 2.7m, 9.0ft

- Sand: medium to coarse grained, clayey
  - till lenses
  - moist
  - oxidized
  - dark grayish brown (2.5Y 4/2)

- 4.6m, END OF HOLE, 15.0ft

NOTES:

1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.

2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 3.5 metres.

3. Test hole was backfilled to surface immediately after completion of drilling.
SOIL DESCRIPTION

TOPSOIL
200mm
- silty, clayey
- moist, stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

TILL
- moist to very moist, loose
- olive brown (2.5Y 4/4)

SAND
- fine grained, silty
- wet
- oxidized
- dark grayish brown (2.5Y 4/2)

END OF HOLE
4.6m

NOTES:
1. Test hole was excavated on May 19, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 3.5 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
SOIL DESCRIPTION

TOPSOIL
200mm - silty, clayey
- moist, stiff to hard
- oxidized, iron and manganese stains
- cobblestones at 3.4 metres
- salt crystals
- dark grayish brown (2.5Y 4/2)

TILL - moist, stiff to hard
- oxidized, iron and manganese stains
- cobblestones at 3.4 metres
- salt crystals
- dark grayish brown (2.5Y 4/2)

3.5m - CLAY - silty
- moist, very stiff to hard
- oxidized
- reddish brown (5YR 4/4)

4.1m - SILT - sandy
- moist to very moist, loose
- olive brown (2.5Y 4/4)

4.9m - SAND - fine grained, silty
- wet
- oxidized
- gravelly below 11.3 metres
- dark grayish brown (2.5Y 4/2)

12.2m - END OF HOLE

NOTES:
1. Test hole was excavated on May 20, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 4.1 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
TOPSOIL
200mm  8.0in
CLAY - silty
- trace organics
- moist, firm
- oxidized
- olive brown (2.5Y 4/4)

1.2m  4.0ft
TILL - silt, clayey
- moist, stiff to hard
- oxidized, iron and manganese stains
- salt crystals
- dark grayish brown (2.5Y 4/2)

2.1m  7.0ft
CLAY - silty
- moist, very stiff to hard
- oxidized
- reddish brown (5YR 4/4)

3.6m  12.0ft
SILT - sandy
- moist to very moist, loose
- olive brown (2.5Y 4/4)

4.9m  16.0ft
SAND - fine grained, silty
- wet
- oxidized
- gravelly below 10.5 metres
- dark grayish brown (2.5Y 4/2)

12.2m  END OF HOLE  40.0ft

NOTES:
1. Test hole was excavated on May 20, 2011 using a 150 mm dia. continuous flight auger.
2. No groundwater accumulation was noted immediately after completion of drilling. Test hole sloughed to 2.1 metres.
3. Test hole was backfilled to surface immediately after completion of drilling.
SAMPLE DESCRIPTION: SAND, A LITTLE GRAVEL, AND A TRACE OF SILT AND CLAY.

MATERIAL SUPPLIED BY: ____________________________ SAMPLED BY: ____________________________

SAMPLE LOCATION: TH 203 SAMPLE NUMBER: 19 AT 20'

DATE SAMPLED: May 19, 2011

DISTRIBUTION: ____________________________

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION OF THE TESTING PERFORMED BY THIS COMPANY. GROUND ENGINEERING CONSULTANTS LTD.

Per: ____________________________

KELLY MAUNDER, A.Sc.T.
**Sample Description:** Sand, a little silt and clay, a trace of gravel

**Material Supplied By:**

**Sample Location:** TH 206

**Sample Number:** 36 at 15'

**Date Sampled:** May 18, 2011

**DISTRIBUTION:**

**JOB No.:** GE-0447  
**DATE:** May 26, 2011  
**TECH:** F. MAJID

**CLIENT:** CITY OF YORKTON

**PROJECT:** PROPOSED BACKWASH WASTEWATER SEDIMENTATION PONDS

**LOCATION:** YORKTON, SASKATCHEWAN

**Grain Size Curve**

Grain size categories as designated by A.S.T.M. Standards

<table>
<thead>
<tr>
<th>Size of Opening (mm)</th>
<th>Specified % Finer Than</th>
<th>Percent Finer Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.0</td>
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</table>

**Grain Size Category**

<table>
<thead>
<tr>
<th>Particles Size Range (mm)</th>
<th>Percent Retained</th>
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</thead>
<tbody>
<tr>
<td>GRAVEL 75 to 4.75</td>
<td>2</td>
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<tr>
<td>COARSE SAND 4.75 to 2.0</td>
<td>3</td>
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<td>MEDIUM SAND 2.0 to 0.425</td>
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<tr>
<td>FINE SAND 0.425 to 0.075</td>
<td>56</td>
</tr>
<tr>
<td>SILT &amp; CLAY &lt; 0.075</td>
<td>11</td>
</tr>
</tbody>
</table>
SAMPLE DESCRIPTION: SAND, SOME GRAVEL, A LITTLE SILT AND CLAY.

MATERIAL SUPPLIED BY: R. YAREMKO OF GROUND ENGINEERING CONSULTANTS LTD.

SAMPLE LOCATION: TH 211
SAMPLE NUMBER: 66 AT 30'
DATE SAMPLED: May 19, 2011

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION OF THE TESTING PERFORMED BY THIS COMPANY GROUND ENGINEERING CONSULTANTS LTD.

Per: KELLY MAUNDER, A.Sc.T.
### Grain Size Curve - Hydrometer

**JOB No:** GE-0447  
**DATE:** June 3, 2011  
**TECH:** R. YAREMKO

**CLIENT:** CITY OF YORKTON  
**PROJECT:** PROPOSED BACKWASH WASTEWATER SEDIMENTATION PONDS  
**LOCATION:** YORKTON, SASKATCHEWAN  
**DISTRIBUTION:** CITY OF YORKTON (1)

**Grain Size Categories as Designated by A.S.T.M. Standards**

<table>
<thead>
<tr>
<th>Cobble</th>
<th>Gravel Sizes</th>
<th>Sand Sizes</th>
<th>Silty Sizes</th>
<th>Clay Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
</tr>
</tbody>
</table>

**Percent Finer Than**

**Grain Size Classification**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Percentage of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>5</td>
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<tr>
<td>Coarse Sand</td>
<td>2</td>
</tr>
<tr>
<td>Medium Sand</td>
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<td>Fine Sand</td>
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<tr>
<td>Silt</td>
<td>27</td>
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<tr>
<td>Clay</td>
<td>34</td>
</tr>
</tbody>
</table>

**Sample Description:** TILL - SAND, WITH CLAY, SOME SILT, A TRACE OF GRAVEL

**Sampled By:** R. YAREMKO OF GROUND ENGINEERING CONSULTANTS LTD

**Date Sampled:** May 19, 2011

**Test Hole Number:** 201

**Sample Number:** COMPOSITE

**Depth of Sample (ft):** 3' TO 8' BELOW GRADE

---

**We certify testing procedures in accordance with C.S.A. & A.S.T.M. Standards for that portion of the testing performed by this company.**

**Per:** KELLY MAUNDER, A.Sc.T.
GRAIN SIZE CURVE - HYDROMETER
(A.S.T.M. D-422)

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M. STANDARDS

<table>
<thead>
<tr>
<th>COBBLES</th>
<th>GRAVEL SIZES</th>
<th>SAND SIZES</th>
<th>SILT SIZES</th>
<th>CLAY SIZES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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PERCENT FINER THAN

<table>
<thead>
<tr>
<th>GRAIN SIZE CLASSIFICATION</th>
<th>PERCENTAGE OF SAMPLE</th>
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<tbody>
<tr>
<td>GRAVEL</td>
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<tr>
<td>COARSE SAND</td>
<td>0</td>
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<tr>
<td>MEDIUM SAND</td>
<td>4</td>
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<td>FINE SAND</td>
<td>6</td>
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<tr>
<td>SILT</td>
<td>47</td>
</tr>
<tr>
<td>CLAY</td>
<td>43</td>
</tr>
</tbody>
</table>

SAMPLE DESCRIPTION: SILT, WITH CLAY, A LITTLE SAND.

SAMPLED BY: R. YAREMKO OF GROUND ENGINEERING CONSULTANTS LTD.

DATE SAMPLED: May 19, 2011

TEST HOLE NUMBER: 206

SAMPLE NUMBER: COMPOSITE

DEPTH OF SAMPLE (ft): 0 TO 3 FEET

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION OF THE TESTING PERFORMED BY THIS COMPANY GROUND ENGINEERING CONSULTANTS LTD.

Per: KELLY MAUNDER, A.Sc.T.
GROUNDBED ENGINEERING
CONSULTANTS LTD.

JOB No: GE-0447 DATE: June 3, 2011 TECH: R. YAREMKO

CLIENT: CITY OF YORKTON PROJECT: PROPOSED BACKWASH WASTEWATER SEDIMENTATION PONDS

LOCATION: YORKTON, SASK. DISTRIBUTION: CITY OF YORKTON (1)

GRAIN SIZE CURVE - HYDROMETER
(A.S.T.M. D-422)

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M. STANDARDS

<table>
<thead>
<tr>
<th>COBBLES</th>
<th>GRAVEL SIZES</th>
<th>SAND SIZES</th>
<th>SILT SIZES</th>
<th>CLAY SIZES</th>
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</table>

<table>
<thead>
<tr>
<th>PERCENT FINER THAN</th>
<th>100</th>
<th>90</th>
<th>80</th>
<th>70</th>
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</tr>
</tbody>
</table>

GRAIN SIZE CLASSIFICATION | PERCENTAGE OF SAMPLE | SAMPLE DESCRIPTION: TILL - CLAY, WITH SILT, SOME SAND AND A LITTLE GRAVEL.

| GRAVEL | 5 |
| COARSE SAND | 2 |
| MEDIUM SAND | 7 |
| FINE SAND | 17 |
| SILT | 32 |
| CLAY | 37 |

SAMPLED BY: R. YAREMKO OF GROUND ENGINEERING CONSULTANTS LTD.

DATE SAMPLED: May 19, 2011

TEST HOLE NUMBER: 206

SAMPLE NUMBER: COMPOSITE

DEPTH OF SAMPLE (ft): 3 TO 6 FEET

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION OF THE TESTING PERFORMED BY THIS COMPANY GE GROUND ENGINEERING LTD.

Per: KELLY MAUNDER, A.Sc.T.
GRAIN SIZE CURVE - HYDROMETER
(A.S.T.M. D-422)

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M. STANDARDS

<table>
<thead>
<tr>
<th>COBBLES</th>
<th>GRAVEL SIZES</th>
<th>SAND SIZES</th>
<th>SILT SIZES</th>
<th>CLAY SIZES</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>COARSE</td>
<td>MEDIUM</td>
<td>FINE</td>
<td></td>
</tr>
</tbody>
</table>

PERCENT FINER THAN

GRAIN SIZE CLASSIFICATION | PERCENTAGE OF SAMPLE | SAMPLE DESCRIPTION |
---|------------------------|---------------------|
GRAVEL | 0 | CLAY, WITH SILT, AND A TRACE OF SAND. |
COARSE SAND | 0 | |
MEDIUM SAND | 1 | |
FINE SAND | 2 | |
SILT | 44 | |
CLAY | 53 | |

DATE SAMPLED: May 19, 2011
TEST HOLE NUMBER: 207
SAMPLE NUMBER: COMPOSITE
DEPTH OF SAMPLE (ft): 1 TO 6 FEET

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION OF THE TESTING PERFORMED BY THIS COMPANY.
GROUND ENGINEERING CONSULTANTS LTD.

Per: KELLY MAUNDER, A.Sc.T.
**Grain Size Curve - Hydrometer (A.S.T.M. D-422)**

<table>
<thead>
<tr>
<th>Grain Size Classification</th>
<th>Percentage of Sample</th>
<th>Sample Description</th>
<th>Sampled By</th>
<th>Date Sampled</th>
<th>Test Hole Number</th>
<th>Sample Number</th>
<th>Depth of Sample (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>0</td>
<td>Clay, with silt, and a trace of sand.</td>
<td>R. Yaremko of Ground Engineering Consultants Ltd.</td>
<td>May 19, 2011</td>
<td>209</td>
<td>Composite</td>
<td>1 to 6 feet</td>
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<tr>
<td>Coarse Sand</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Medium Sand</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Sand</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Silt</td>
<td>42</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>54</td>
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**Grain Size Categories as Designated by A.S.T.M. Standards**

<table>
<thead>
<tr>
<th>Cobbles</th>
<th>Gravel Sizes</th>
<th>Sand Sizes</th>
<th>Silts Sizes</th>
<th>Clay Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Finer Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>80</td>
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<tr>
<td>70</td>
</tr>
<tr>
<td>60</td>
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<tr>
<td>50</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

**Grain Size - Millimetres**

- 0.0010
- 0.0100
- 0.1000
- 1.0000
- 10.0000
- 100.0000

**Ground Engineering Consultants Ltd.**

- Job No: GE-047
- Date: June 3, 2011
- Tech: R. Yaremko
- Client: City of Yorkton
- Project: Proposed Backwash Wastewater Sedimentation Ponds
- Location: Yorkton, Saskatchewan
**Grain Size Curve - Hydrometer**

(A.S.T.M. D-422)

**Grain Size Categories as Designated by A.S.T.M. Standards**

<table>
<thead>
<tr>
<th>Cobbles</th>
<th>Gravel Sizes</th>
<th>Sand Sizes</th>
<th>Silts Sizes</th>
<th>Clay Sizes</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Percent Finer Than**

- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10
- 5
- 1
- 0.5
- 0.1
- 0.01
- 0.001
- 0.0001

**Grain Size Classification**

- Gravel: 4
- Coarse Sand: 3
- Medium Sand: 10
- Fine Sand: 22
- Silt: 27
- Clay: 34

**Sample Description:**

Till - Sand, with Clay, some Silt, a trace of gravel.

**Sampled By:**

R. Yaremko of Ground Engineering Consultants Ltd.

**Date Sampled:**

May 19, 2011

**Test Hole Number:**

202, 204, 207 & 208

**Sample Number:**

Composite

**Depth of Sample (ft):**

---

**We certify testing procedures in accordance with C.S.A. & A.S.T.M. standards for that portion of the testing performed by this company. Ground Engineering Consultants Ltd.**

Per: ________________________________

KELLY MAUNDER, A.Sc.T.
GROUNDSIZE CURVE - HYDROMETER
(A.S.T.M. D-422)

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M. STANDARDS

<table>
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<tr>
<th>COBBLES</th>
<th>GRAVEL SIZES</th>
<th>SAND SIZES</th>
<th>SILT SIZES</th>
<th>CLAY SIZES</th>
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<tbody>
<tr>
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</tr>
</tbody>
</table>

PERCENT FINER THAN

GRAIN SIZE - millimetres

<table>
<thead>
<tr>
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<th>PERCENTAGE OF SAMPLE</th>
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<tbody>
<tr>
<td>GRAVEL</td>
<td>1</td>
</tr>
<tr>
<td>COARSE SAND</td>
<td>7</td>
</tr>
<tr>
<td>MEDIUM SAND</td>
<td>9</td>
</tr>
<tr>
<td>FINE SAND</td>
<td>20</td>
</tr>
<tr>
<td>SILT</td>
<td>28</td>
</tr>
<tr>
<td>CLAY</td>
<td>35</td>
</tr>
</tbody>
</table>

SAMPLE DESCRIPTION: TILL - SAND, WITH CLAY, SOME SILT, A TRACE OF GRAVEL

SAMPLED BY: R. YAREMKO OF GROUND ENGINEERING CONSULTANTS LTD.

DATE SAMPLED: May 19, 2011

TEST HOLE NUMBER: 203, 205, 206 & 209

SAMPLE NUMBER: COMPOSITE

DEPTH OF SAMPLE (ft):
STANDARD PROCTOR TEST
(ASTM D-698)

FILE NUMBER: GE-0447
SAMPLE NUMBER: COMPOSITE SAMPLE

PROJECT: PROPOSED BACKWASH WASTEWATER SEDIMENTATION PONDS
CLIENT: CITY OF YORKTON

LOCATION: YORKTON, SASKATCHEWAN
DIST.: CITY OF YORKTON (1)

TECH: I. HUSSAIN
DATE: June 2, 2011

COMPACTED DENSITY AND MOISTURE CONTENTS:

<table>
<thead>
<tr>
<th>DRY DENSITY (kg/m³)</th>
<th>1718</th>
<th>1819</th>
<th>1831</th>
<th>1766</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOISTURE CONTENT (%)</td>
<td>11.0</td>
<td>13.1</td>
<td>14.8</td>
<td>16.6</td>
</tr>
</tbody>
</table>

MAXIMUM DRY DENSITY = 1840 (kg/m³)
OPTIMUM MOISTURE CONTENT = 14.1 (%)

METHOD OF COMPACTION: STANDARD PROCTOR
ASTM D-698, METHOD B

METHOD OF PREPARATION: DRY
DIAMETER OF MOLD (mm): 100
NUMBER OF LAYERS: 3
NUMBER OF BLOWS PER LAYER: 25
HEIGHT OF FREE FALL (mm): 305.0
WEIGHT OF TAMPER (kg): 2.49
DESCRIPTION OF COMPACTOR: ROUND, FLAT, 50mm DIAMETER

TYPE OF MATERIAL: TILL, CLAYEY
USED FOR: PROPOSED LINER MATERIAL

SAMPLED BY: R. YAREMKO OF GROUND ENG. LTD.
SAMPLED FROM: COMPOSITE SAMPLE FROM
TEST HOLES 202, 204, 207 AND 208
DATE SAMPLED: May 20, 2011
SUPPLIED BY:
ROCK CORRECTION APPLIED: NO
SPECIFIC GRAVITY = 2.60 (ASSUMED)

REVIEWED BY: 

FORMULA: ZERO AIR VOIDS (ZAVD) = (1000/DRY DENSITY) - (1/SPECIFIC GRAVITY)
# STANDARD PROCTOR TEST
(ASTM D-698)

**FILE NUMBER:** GE-0447  
**SAMPLE NUMBER:** COMPOSITE SAMPLE

**PROJECT:** PROPOSED BACKWASH WASTEWATER SEDIMENTATION PONDS  
**CLIENT:** CITY OF YORKTON

**LOCATION:** YORKTON, SASKATCHEWAN  
**DIST.:** CITY OF YORKTON (1)

**TECH.:** I. HUSSAIN  
**DATE:** June 2, 2011

## COMPACTED DENSITY AND MOISTURE CONTENTS:

<table>
<thead>
<tr>
<th>DRY DENSITY (kg/m³)</th>
<th>1739</th>
<th>1812</th>
<th>1795</th>
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<tbody>
<tr>
<td>MOISTURE CONTENT (%)</td>
<td>12.6</td>
<td>14.5</td>
<td>16.5</td>
</tr>
</tbody>
</table>

---

**MAXIMUM DRY DENSITY = 1820 (kg/m³)**

**OPTIMUM MOISTURE CONTENT = 15.3 (%)**

**METHOD OF COMPACTION:** STANDARD PROCTOR  
ASTM D-698, METHOD B

**METHOD OF PREPARATION:** DRY

**DIAMETER OF MOLD (mm):** 100

**NUMBER OF LAYERS:** 3

**NUMBER OF BLOWS PER LAYER:** 25

**HEIGHT OF FREE FALL (mm):** 305.0

**WEIGHT OF TAMPER (kg):** 2.49

**DESCRIPTION OF COMPACTOR:** ROUND, FLAT, 50mm DIAMETER

**TYPE OF MATERIAL:** TILL, CLAYEY

**USED FOR:** PROPOSED LINER MATERIAL

** SAMPLED BY:** R. YAREMKO OF GROUND ENG. LTD.

**SAMPLED FROM:** COMPOSITE SAMPLE FROM TEST HOLES 203, 205, 206 AND 209

**DATE SAMPLED:** May 20, 2011

**SUPPLIED BY:**

**ROCK CORRECTION APPLIED:** NO

**SPECIFIC GRAVITY = 2.65 (ASSUMED)**

**FORMULA:** ZERO AIR VOIDS (ZAVD) = \( \frac{1000 \times \text{DENSITY}}{\text{SPECIFIC GRAVITY}} \)

**REVIEWED BY:**

---

GE-0447-34
SAMPLE PREPARATION AND COMPACTION

TEST NUMBER: 1  MAXIMUM DRY DENSITY: 1840 kg/m³
TEST HOLE NUMBER: TH 202, 204, 207, 208  OPTIMUM MOISTURE CONTENT: 14.1%
SAMPLE NUMBER: COMPOSITE  METHOD OF COMPACTION: STANDARD PROCTOR
SAMPLE LOCATION: COMPOSITE SAMPLE FROM TH 202, 204, 207 & 208 - TILL MATERIAL
SAMPLE DESCRIPTION: TILL - SAND, WITH CLAY, SOME SILT, A TRACE OF GRAVEL
MOLDING DRY DENSITY: 1842 kg/m³
MOLDING MOISTURE CONTENT: 14.2%
METHOD OF COMPACTION: PNEUMATIC
PERCENT COMPACTION: 100.1%
SAMPLE DIAMETER: 10.10 cm
SAMPLE HEIGHT: 11.60 cm

ADDITIONAL TESTING PERFORMED

ATTERBERRY LIMIT TEST RESULTS
AVERAGE PLASTIC LIMIT: 9
AVERAGE LIQUID LIMIT: 32
PLASTICITY INDEX: 21
TYPE OF MATERIAL: TILL - MEDIUM PLASTICITY

HYDROMETER ANALYSIS

<table>
<thead>
<tr>
<th>GRAIN SIZE CLASSIFICATION</th>
<th>PERCENTAGE OF SAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAVEL</td>
<td>4</td>
</tr>
<tr>
<td>COARSE SAND</td>
<td>3</td>
</tr>
<tr>
<td>MEDIUM SAND</td>
<td>10</td>
</tr>
<tr>
<td>FINE SAND</td>
<td>22</td>
</tr>
<tr>
<td>SILT</td>
<td>27</td>
</tr>
<tr>
<td>CLAY</td>
<td>34</td>
</tr>
</tbody>
</table>

HYDRAULIC CONDUCTIVITY

\[ k = 3.46 \times 10^{-9} \text{ cm/s AT 18234 minutes} \]

REVIEWED BY:
HYDRAULIC CONDUCTIVITY
ASTM D-2434

SAMPLE PREPARATION AND COMPACTION

<table>
<thead>
<tr>
<th>TEST NUMBER:</th>
<th>MAXIMUM DRY DENSITY:</th>
<th>1820 kg/m³</th>
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</thead>
<tbody>
<tr>
<td>TEST HOLE NUMBER:</td>
<td>TH 203, 205, 206, 209</td>
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<tr>
<td>SAMPLE NUMBER:</td>
<td>COMPOSITE</td>
<td></td>
</tr>
<tr>
<td>SAMPLE LOCATION:</td>
<td>COMPOSITE SAMPLE FROM TH 203, 205, 206 &amp; 209 - TILL MATERIAL</td>
<td></td>
</tr>
<tr>
<td>SAMPLE DESCRIPTION:</td>
<td>TILL - SAND, WITH CLAY, SOME SILT, A TRACE OF GRAVEL</td>
<td></td>
</tr>
<tr>
<td>MOLDING DRY DENSITY:</td>
<td>1799 kg/m³</td>
<td></td>
</tr>
<tr>
<td>MOLDING MOISTURE CONTENT:</td>
<td>15.9 %</td>
<td></td>
</tr>
<tr>
<td>METHOD OF COMPACTION:</td>
<td>PNEUMATIC</td>
<td></td>
</tr>
<tr>
<td>PERCENT COMPACTION:</td>
<td>98.8 %</td>
<td></td>
</tr>
<tr>
<td>SAMPLE DIAMETER:</td>
<td>10.10 cm</td>
<td></td>
</tr>
<tr>
<td>SAMPLE HEIGHT:</td>
<td>11.60 cm</td>
<td></td>
</tr>
</tbody>
</table>

ADDITIONAL TESTING PERFORMED

ATTERBERG LIMIT TEST RESULTS

| AVERAGE PLASTIC LIMIT: | 10 |
| AVERAGE LIQUID LIMIT: | 33 |
| PLASTICITY INDEX: | 23 |
| TYPE OF MATERIAL: | TILL - MEDIUM PLASTICITY |

HYDROMETER ANALYSIS

<table>
<thead>
<tr>
<th>GRAIN SIZE CLASSIFICATION</th>
<th>PERCENTAGE OF SAMPLE</th>
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<tr>
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<td>SILT</td>
<td>28</td>
</tr>
<tr>
<td>CLAY</td>
<td>35</td>
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</tbody>
</table>

HYDRAULIC CONDUCTIVITY

\[ k = 3.01 \times 10^{-9} \text{ cm/s} \] AT 18234 minutes

REVIEWED BY:
Appendix H - Hydrogeological Investigation

BHL Report
The City of Yorkton
Water Treatment Plant
Wastewater Reuse Feasibility Study
Hydrogeology

Prepared for:
The City of Yorkton
Box 400, 37 – 3rd Avenue North
Yorkton, Saskatchewan
S3N 2W3

Prepared by:
Beckie Hydrogeologists Ltd.
381 Park Street
Regina, Saskatchewan
S4N 5B2

Association of Professional Engineers & Geoscientists of Saskatchewan
CERTIFICATE OF AUTHORIZATION
Beckie Hydrogeologists (1990) Ltd.
Number 664
Permission to Consult Held By:
Discipline     Sask. Reg. No.     Signature
Hydrogeological  9716     M.S. Famulak

Mike S. Famulak, P.Geo, P. Geol.
December 12, 2011
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
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<td>TABLE OF CONTENTS</td>
<td>i</td>
</tr>
<tr>
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<td>ii</td>
</tr>
<tr>
<td>REPORT LIMITATIONS AND CONFIDENTIALITY</td>
<td>iii</td>
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<td>GLOSSARY OF UNITS</td>
<td>iv</td>
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<tr>
<td>EXECUTIVE SUMMARY</td>
<td>v</td>
</tr>
<tr>
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<td>1</td>
</tr>
<tr>
<td>2.0 GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA</td>
<td>3</td>
</tr>
<tr>
<td>2.1 General Geology of the Logan Aquifer System and of the Bredenbury Aquifer</td>
<td>4</td>
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<tr>
<td>2.2 General Hydrogeology of the Logan Aquifer System and of the Bredenbury Aquifer</td>
<td>5</td>
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<tr>
<td>3.0 CURRENT WELL(S) APPROVALS FROM THE SASKATCHEWAN WATERSHED AUTHORITY</td>
<td>6</td>
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<tr>
<td>4.0 ANNUAL WELL(S) PRODUCTION VOLUMES</td>
<td>8</td>
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<tr>
<td>5.0 ANTICIPATED WASTE STREAM VOLUMES</td>
<td>9</td>
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<tr>
<td>6.0 CONSTRUCTION AND DEVELOPMENT OF PIEZOMETERS AND TEST WATER WELLS</td>
<td>9</td>
</tr>
<tr>
<td>6.1 Construction of Test Wells LW1-2007 and LW2-2007</td>
<td>9</td>
</tr>
<tr>
<td>6.2 Test Drilling and Installation of 51 mm Diameter Piezometers</td>
<td>9</td>
</tr>
<tr>
<td>6.3 Construction of Test Well PW2B-2011</td>
<td>10</td>
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<td>6.4 Development of Test Wells</td>
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<tr>
<td>7.0 PRELIMINARY TEST WELL(S) PUMPING TESTS</td>
<td>11</td>
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<tr>
<td>7.1 Test Well LW1-2007</td>
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<td>7.2 Test Well LW2-2007</td>
<td>12</td>
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<td>7.3 Test Well PW2B-2011</td>
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<td>8.0 WATER QUALITY</td>
<td>13</td>
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<td>9.0 CONCLUSIONS AND RECOMMENDATIONS</td>
<td>14</td>
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LIST OF DRAWINGS AND APPENDICES

DRAWINGS: (following text)

1 - General Location Drawing
2 - Major Aquifers in the Yorkton Area
3 - Geologic Cross Section A-A’
4 - Potentiometric Surface of the Logan/Bredenbury Aquifer Systems
5 - Construction Details of Test Well LW1-2007 (BHL2007-160LW1)
6 - Construction Details of Test Well LW2-2007 (BHL2007-159LW2)
7 - Construction Details of 2011 Piezometers
8 - Construction Details of Test Well 2B-2011 (BHL2011-169PW2B)

APPENDICES:

A - Geologic and Electric Logs
B - Pumping and Recovery Test Data
C - Raw Water Quality Data
REPORT LIMITATIONS AND CONFIDENTIALITY

This hydrogeologic report has been prepared by Beckie Hydrogeologists (1990) Ltd. (BHL) for the exclusive use of the addressee and BHL, for the project described therein. This report contains proprietary information that shall not be disclosed to any other parties without the prior written permission of BHL to do so. Any use of this report by any other party is the sole responsibility of that party and BHL is not responsible for any actions taken by that party as a result of the information presented within this report.

This report has been compiled by BHL with the standard of care and diligence that is reasonably expected within the engineering and geoscience profession within Saskatchewan. Based on the hydrogeologic information that was available to BHL at the time of preparation, it is believed that this report is complete and accurate. However, it should be understood that hydrogeology is an interpretive science and BHL does not make any guarantee through the issuance of this report that the testing and analyses that were completed during this assignment have been exhaustive and/or that the conclusions and recommendations presented in this report won’t change if additional hydrogeologic information becomes available to BHL at a later date.

In accordance with Canadian Copyright Law, the information contained within this report is considered to be the intellectual property of BHL.
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<tr>
<td><strong>Length</strong></td>
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</tr>
<tr>
<td>1.0 m</td>
<td>= 1.0 metre</td>
</tr>
<tr>
<td>= 1.000 millimetres</td>
<td>= 3.281 feet</td>
</tr>
<tr>
<td>= 3.281 inches</td>
<td>= 0.621 miles</td>
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<tr>
<td>1.0 ig</td>
<td>= 1.0 imperial gallon</td>
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<tr>
<td>= 4.54 litres</td>
<td>= 0.221 imperial gallons</td>
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<tr>
<td>= 0.029 barrels</td>
<td>= 0.264 US gallons</td>
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<td>= 0.00454 cubic metres</td>
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<tr>
<td><strong>Rate</strong></td>
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</tr>
<tr>
<td>1.0 igpm</td>
<td>= 1.0 imperial gallon per minute</td>
</tr>
<tr>
<td>= 1.20 US gallons per minute</td>
<td>= 13.22 igpm</td>
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<tr>
<td>= 0.076 litres per second</td>
<td>= 15.86 US gpm</td>
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<tr>
<td>= 6.54 m³/day</td>
<td>= 86.40 m³/day</td>
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<td>= 1.94 acre feet/year</td>
<td>= 31.54 dam³/year</td>
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</tr>
<tr>
<td></td>
<td>= 1,000 cubic metres per year</td>
</tr>
<tr>
<td></td>
<td>= 220,083 imp gallons per year</td>
</tr>
<tr>
<td></td>
<td>= 35,320 cubic feet per year</td>
</tr>
<tr>
<td></td>
<td>= 1,000,000 litres per year</td>
</tr>
<tr>
<td><strong>Transmissivity</strong></td>
<td></td>
</tr>
<tr>
<td>1.0 m²/day</td>
<td>= 1.0 cubic metres/day/metre</td>
</tr>
<tr>
<td>= 67.05 imp gallons/day/foot</td>
<td>= 20.44 imp gallons/day/square foot</td>
</tr>
</tbody>
</table>
Executive Summary

Beckie Hydrogeologists Ltd. (BHL) was retained by the City of Yorkton to provide hydrogeological services related to the Water Treatment Plan Wastewater Reuse Feasibility Study. BHL has been providing professional hydrogeologic services to the City since 1998 and have developed a strong working knowledge of the aquifer systems in the vicinity of Yorkton.

The City of Yorkton relies completely on groundwater to satisfy their municipal water requirements and currently operates thirteen (13) production water wells that have been grouped into five (5) separate well fields. Prior to 2011 the City operated four separate groundwater treatment plants. In 2007, the City initiated the design and construction of one centrally located groundwater treatment plant in an area overlying the Logan West Valley Aquifer. This plant, referred to as the Queen Street Water Treatment Plant (QSWTP) was commissioned in 2011 and the City subsequently decommissioned three of their existing water treatment plants and converted one existing plant into a water pumping station.

The wastewater that is generated during the water treatment process is commonly piped to a user’s sanitary sewage facility. However, during the initial design phase of the QSWTP project the City decided to investigate innovative and environmentally responsible alternatives for the treatment and reuse of the QSWTP wastewater. To assist with this initiative, the City applied for and received funding assistance under the Federal Government’s Green Municipal Fund.

In collaboration with the appropriate regulatory agencies, with several community stakeholders and with their consultants, the City developed a concept plan that involved pumping the QSWTP wastewater into lined sedimentation ponds. After providing sufficient time for the majority of the concentrated particles to precipitate, a mixture of treated wastewater and storm water runoff would flow east by gravity, through a fish pond and wetlands area and then into a proposed infiltration pond. The infiltration pond will be constructed so that its base fully penetrates the top of the underlying Bredenbury Aquifer. Based on hydrogeologic data compiled during this study, it is theorized that the infiltrating water will artificially recharge the Bredenbury Aquifer and the hydraulically connected Logan West and Logan East Valley Aquifers.

The additional groundwater that becomes available from the Logan West Wellfield as a result of the proposed artificial recharge will be extracted from test well PW2B-2011 and then used as irrigation water for the proposed sporting fields, local tree nursery and community gardens.

Information compiled from the three (3) test water wells and the five (5) - 51 mm diameter piezometers installed during this project was used during the preparation of this report. However, additional hydrogeologic testing and data analyses are still required to fully assess the feasibility of the City’s proposed concept plan. Therefore, it is recommended that the new and existing water wells and piezometers be monitored with City pumping over the next one to three years. The data collected during this period should then be used to more accurately determine the extent and magnitude of the proposed artificial recharge and the effect that this recharge will have on the Bredenbury and Logan Valley Aquifer systems and on the water wells that are developed within these aquifers.
1.0 INTRODUCTION AND BACKGROUND

The City of Yorkton relies completely on groundwater to satisfy their municipal water requirements. The City currently operates thirteen production water wells which are grouped into five separate well fields. These wellfields are referred to as the Sturdee Wellfield, the Collacott Wellfield, the Leech Lake Wellfield, the Logan West (Flats) Wellfield and the Logan East Wellfield. The project that is described herein is centered on the Logan West Wellfield.

Prior to 2011 the City operated four (4) separate groundwater treatment plants. These plants were referred to as the West Broadway Plant, the Park Street Plant, the Aerrolator (seasonal use only) and Water Treatment Plant No. 4.

In 2003 the City retained Associated Engineering Ltd. (AE) to provide planning, design and project management services to upgrade and expand their entire water system. AE subsequently recommended the design and construction of one central water treatment facility and the construction of the new Queen Street Water Treatment Plant (QSWTP) began in 2007. In 2011 the City commissioned the QSWTP and subsequently decommissioned three (3) of the existing water treatment facilities and converted Water Plant No. 4 into a pumping station.

The wastewater (filter backwash) that is generated during the water treatment process is commonly piped to a user’s sanitary sewage facility. However, during the initial design phase of the QSWTP project, the City decided to investigate innovative and environmentally responsible alternatives for the treatment and reuse of the QSWTP wastewater. To assist with this initiative the City retained AE and several other professional consultants; Beckie Hydrogeologists Ltd. (BHL) were retained to provide services related to the hydrogeologic components of this initiative.

In 2005 the City of Yorkton submitted an application for funding under the Federal Government’s Green Municipal Fund. This application was approved and on January 25, 2007, the City and the Federation of Canadian Municipalities (FCM) entered into a jointly funded project titled “City of Yorkton Water Treatment Plan Wastewater Reuse Feasibility Study”.

In collaboration with the appropriate regulatory agencies, with several community stakeholder groups and with their consultants, the City developed a preliminary concept plan that involved wastewater discharge into two (2) lined sedimentation ponds that would be constructed at a location immediately north of the QSWTP. Under this preliminary concept plan, after providing sufficient time for the majority of the concentrated particles to precipitate, the “treated” backwash water would be discharged into unlined infiltration ponds that would be constructed in the general vicinity of the sedimentation ponds. It was theorized that the treated backwash
water would then infiltrate into and thereby artificially recharge and potentially increase the sustainable production capacity of the underlying Logan West Valley Aquifer.

The design and implementation of the initial hydrogeologic program that was completed during this project was based on the preliminary concept plan. This work, which included the construction of test water wells LW1-2007 and LW2-2007, was completed in June of 2007. The locations of these works are shown on an annotated air photograph, which is included in this report as Drawing No. 1.

Following further feasibility review by the City and their consultants and in response to additional input from representatives of the Saskatchewan Ministry of the Environment (MOE), the preliminary concept plan was modified such that the proposed infiltration pond would be located approximately 1,500 metres east of the sedimentation ponds, in an area of naturally occurring wetlands overlying the Bredenbury Aquifer. By increasing the horizontal distance between the sedimentation and the infiltration ponds, it was theorized that the potential to cause deterioration of the natural water quality in the Logan Wellfield(s) and/or of a resultant GUDI positive (groundwater under the direct influence of surface water) classification would be minimized.

Under the modified concept plan a mixture of surface runoff water and treated backwash water would flow by gravity through a constructed surface diversion channel, through a constructed fish pond(s) area, through constructed and natural wetland areas and finally, into the proposed infiltration pond. To maximize the potential infiltration volume, the infiltration pond will be constructed so that its base fully penetrates the top of the underlying Bredenbury Aquifer. The locations of the existing and proposed works are shown on Drawing No. 1.

The section of the Bredenbury Aquifer underlying the proposed infiltration area is already being naturally recharged through the infiltration of surface runoff water and the proposed construction of an adjacent infiltration pond would serve to enhance this natural recharge mechanism. Based on analyses of the hydrogeologic data compiled during this study, it has been tentatively concluded that the Bredenbury Aquifer and the Logan Valley Aquifers are hydraulically connected within the study area and that as such, both aquifer systems should receive natural and artificial recharge under the modified concept plan.

The design and implementation of the supplementary hydrogeologic program that was completed during this project was based on the modified concept plan. This work, which included the installation of several piezometers and automatic data loggers in the Logan West Valley and the Bredenbury Aquifers and the construction of test well PW2B-2011, was completed in November of 2011. The locations of these works are shown on Drawing No. 1.

The modified concept plan is described in detail by AE and by others in the accompanying reports and in general, includes the following works:
 Construction of lined gravity sedimentation ponds to remove the oxidized iron, manganese, arsenic and any other particles removed during the QSWTP water treatment process;

 Creation of lined fish ponds for recreational and educational purposes;

 Creation of linear wetland(s) to polish treated effluent exiting the sedimentation ponds;

 Creation of infiltration ponds to allow treated and polished wastewater to artificially recharge the Bredenbury and Logan Aquifer systems;

 Re-direction of natural surface water runoff through the fish ponds, the wetlands and the proposed infiltration area to provide improved storm water management within the study area and to increase the potential for successful artificial aquifer(s) recharge;

 Construction of irrigated sports fields;

 Construction of test water wells and piezometers to facilitate aquifer(s) testing and analyses and long term aquifer(s) monitoring. The new test well(s) will also be used at a later date to provide irrigation water for the sporting fields, the local tree nursery and the community gardens; any excess water available from these wells will also be directed to the QSWTP for treatment and municipal distribution.

2.0 GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The regional geology and hydrogeology of the Yorkton area have been previously assessed and described in detail by Meneley and Christianson (1975), Maathuis (1977, 1991 and 2006) and BHL (1999, 2000, 2001 and 2002). Information pertaining to these assessments was presented in the following reports:


2.1 General Geology of the Logan Aquifer System and of the Bredenbury Aquifer

The Logan Aquifer System and the related portions of the Bredenbury Aquifer are central to the current wastewater reuse feasibility study.

The inferred boundaries of the Logan West and the Logan East Valley Aquifers and of the Bredenbury Aquifer (Logan South) have been illustrated on Drawing No. 1.

The inferred distribution of all the known major regional aquifer systems within an approximate 20 kilometre radius of the City of Yorkton is illustrated on Drawing no. 2.

The inferred geologic and hydrogeologic correlation of the Logan West Valley Aquifer and the Bredenbury (Logan South) Aquifer has been illustrated on Cross-Section A-A’, which is included as Drawing No. 3.

For the purpose of this current report, the following description(s) of the Logan Aquifer System and the Bredenbury Aquifer have been compiled from information previously presented in the reports listed above. The term Logan Aquifer System was introduced by Maathuis (1991) to name a complex aquifer system identified in the southern half of section 35-Tp 25-Rg 04-W2, in the western half of section 36-Tp 25-Rg 04-W2 and in the north-western portion of section 31-Tp 25-Rg 03-W2. The Logan Aquifer system is comprised of the Logan Valley Aquifer(s) and the related aquifers formed by the granular material (Bredenbury Aquifer) that is present on the adjacent valley terraces. Maathuis (June, 2006) also referred to the Bredenbury terrace aquifers as the Logan North and the Logan South Aquifers.

Due to the inferred presence of a partial aquifer discontinuity (blockage) near the center of section 36-Tp 25-Rg 04-W2, the Logan Valley Aquifer has been separated into the Logan West Valley Aquifer and the Logan East Valley Aquifer; the exact location and degree of this discontinuity is yet to be identified. It is currently believed that existing test wells LW1-2007, LW2-2007 and PW2B-2011 and production well PW10-1979 are located on the west side of the inferred aquifer blockage and that existing production wells PW11-1981, PW12-1987 and PW14-2001 are located on the east side of the inferred aquifer blockage.
The Logan West Valley and Logan East Valley Aquifers are incised into the underlying clays of the Pierre Shale and where it was present, through the Bredenbury Aquifer and into the underlying Pierre Shale. As shown on geologic cross-section A-A’, the Logan Valley Aquifer(s) is generally confined by and directly underlain by glacial till. Comparing the base elevation and noting the presence or absence of glacial till is one field method of differentiating the Logan Valley Aquifer(s) from the Bredenbury Aquifer.

The Logan Valley Aquifer(s) are approximately 13 kilometres long and between 400 and 500 metres wide. The aquifers are comprised primarily of coarse grained sand and gravel, which is overlain by up to 5 metres of surficial glacial till or clay. In the center of the Valley, the sands and gravels are up to 45 metres thick. In the vicinity of the City’s existing well PW11-1981 the Yorkton Creek crosses over and is incised into the top of the Logan East Valley Aquifer.

Within the study area, the Bredenbury Aquifer is commonly between 5 and 10 metres thick and is overlain by 5 to 10 metres of surficial silt, clay or till. The Bredenbury Aquifer is directly underlain by the clays of the Pierre Shale.

2.2 General Hydrogeology of the Logan Aquifer System and of the Bredenbury Aquifer

The hydrogeologic setting of the Logan Aquifer System was described by Maathuis (2006) as consisting of one highly transmissive valley type aquifer which is hydraulically connected over parts of its length to bedrock aquifers with a lower transmissivity.

The static water level elevations shown on cross-section A-A’ indicates a groundwater flow direction from the Bredenbury Aquifer into the Logan Valley Aquifer(s). On November 16, 2011, the groundwater flow gradient (under non-pumping conditions) between Bredenbury piezometer BHL2011-164PZ (located on the berm north of the proposed infiltration area) and test well PW2B-2011 was 1.72 metres per kilometre. The groundwater flow direction and gradient and the inferred location of the hydraulic aquifer discontinuity is also illustrated on a potentiometric surface contour map, included in this report as Drawing No. 4.

Based on the coarse grain size of the granular materials that were encountered during test drilling at the proposed infiltration area (piezometer BHL2011-164PZ site) and on the observed local groundwater flow gradient and direction, it has been tentatively concluded that the implementation of the City’s modified concept plan will result in the Bredenbury Aquifer and the hydraulically connected Logan Valley Aquifers being artificially recharged through the infiltration of treated backwash water and naturally occurring surface runoff water. However, additional hydrogeologic testing and analyses is required to confirm or revise this conclusion and to determine the extent and magnitude of the infiltration.

Prior to well(s) development by the City, recharge to the Logan Aquifer system was derived primarily from infiltrating precipitation and Yorkton Creek acted as a groundwater discharge
area where it incised the top of the Logan East Valley aquifer in NE31-Tp 25-Rg 03-W2. However, with wellfield development and the resultant formation of a cone of water level depression in the Logan Valley Aquifer(s), the Yorkton Creek and possibly the natural wetlands areas now also acts as a source of recharge to the Logan Valley Aquifer System. It is theorized that the construction of the proposed infiltration area will enhance the recharge into the Bredenbury Aquifer and into the hydraulically connected Logan Valley Aquifer System.

3.0 Current Well(s) Approvals from the Saskatchewan Watershed Authority

Over the past several years the City has submitted applications to the Saskatchewan Watershed Authority (SWA) for “Water Rights License(s)” and for “Approval(s) to Construct and Operate Works” for their existing production water wells.

The current status of the SWA approvals, separated by wellfield, is tabulated below:

**Logan West Wellfield:**

<table>
<thead>
<tr>
<th>Well No – Year of Construction</th>
<th>Date of ATC</th>
<th>Date of ATO</th>
<th>SWA File Number</th>
<th>Approved Diversion Rate (L/sec)</th>
<th>Approved Allocation Volume (dam³ per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW-LW1-2007</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>TW-LW2-2007</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>PW1A-1957</td>
<td>Dec 15/75</td>
<td>Jan 13/86</td>
<td>WR 0297</td>
<td>30.0</td>
<td>185.0</td>
</tr>
<tr>
<td>PW2/2A-1957</td>
<td>Dec 15/75</td>
<td>Jan 13/86</td>
<td>WR 0519</td>
<td>30.0</td>
<td>136.0</td>
</tr>
<tr>
<td>PW2B-2011</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>PW3-1964 * (Bredenbury)</td>
<td>Dec 15/75</td>
<td>Jan 13/86</td>
<td>WR 0520</td>
<td>5.0</td>
<td>123.0</td>
</tr>
<tr>
<td>PW10-1979</td>
<td>April 12/84</td>
<td>pending</td>
<td>WR 1778</td>
<td>n/a</td>
<td>pending</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td>65.0</td>
<td>444.0</td>
</tr>
</tbody>
</table>

* Well PW3-1964 and the associated ancillary works were decommissioned in November 2001; an application should be submitted to the SWA to transfer the allocation from this well to one of the other Logan West water wells.

**Logan East Wellfield:**

<table>
<thead>
<tr>
<th>Well No – Year of Construction</th>
<th>Date of ATC</th>
<th>Date of ATO</th>
<th>SWA File Number</th>
<th>Approved Diversion Rate (L/sec)</th>
<th>Approved Allocation Volume (dam³ per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW11-1981</td>
<td>Sept 16/04</td>
<td>Sept 16/04</td>
<td>WR 1532</td>
<td>50.0</td>
<td>pending</td>
</tr>
<tr>
<td>PW12-1987</td>
<td>Sept 16/04</td>
<td>Sept 16/04</td>
<td>WR 2023</td>
<td>50.0</td>
<td>pending</td>
</tr>
<tr>
<td>PW14-2001</td>
<td>Dec 11/02</td>
<td>Sept 16/04</td>
<td>WR 3292</td>
<td>75.0</td>
<td>800.0</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td>175.0</td>
<td>800.0</td>
</tr>
</tbody>
</table>
Collacott Wellfield:

<table>
<thead>
<tr>
<th>Well No – Year of Construction</th>
<th>Date of ATC</th>
<th>Date of ATO</th>
<th>SWA File Number</th>
<th>Approved Diversion Rate (L/sec)</th>
<th>Approved Allocation Volume (dam$^3$ per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW4/4A-1987*</td>
<td>Dec 15/75</td>
<td>Jan 13/86</td>
<td>WR 0521</td>
<td>27.0</td>
<td>308.0</td>
</tr>
<tr>
<td>PW5-1952</td>
<td>Feb 18/76</td>
<td>pending</td>
<td>WR 0522</td>
<td>pending</td>
<td>pending</td>
</tr>
<tr>
<td>PW6/6A-2000</td>
<td>Feb 18/76</td>
<td>Jan 13/86</td>
<td>WR 0523</td>
<td>30.0</td>
<td>493.0</td>
</tr>
<tr>
<td>PW7-1967</td>
<td>May 15/67</td>
<td>Jan 13/86</td>
<td>WR 0297</td>
<td>23.0</td>
<td>493.0</td>
</tr>
<tr>
<td>PW13-1981</td>
<td>pending</td>
<td>pending</td>
<td>WR 1533</td>
<td>pending</td>
<td>pending</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td>80.0</td>
<td>1,294.0</td>
</tr>
</tbody>
</table>

* Well PW4A-1987 and the associated ancillary works were decommissioned in August 2011; an application should be submitted to the SWA to transfer the allocation from this well to one of the other Collacott water wells.

Leech Lake Wellfield:

<table>
<thead>
<tr>
<th>Well No – Year of Construction</th>
<th>Date of ATC</th>
<th>Date of ATO</th>
<th>SWA File Number</th>
<th>Approved Diversion Rate (L/sec)</th>
<th>Approved Allocation Volume (dam$^3$ per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW8-1969</td>
<td>June 11/69</td>
<td>Jan 13/86</td>
<td>WR 0618</td>
<td>57.0</td>
<td>1,110.0</td>
</tr>
<tr>
<td>PW9-1976</td>
<td>pending</td>
<td>pending</td>
<td>WR 1347</td>
<td>pending</td>
<td>pending</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td>57.0</td>
<td>1,110.0</td>
</tr>
</tbody>
</table>

Sturdee Wellfield:

<table>
<thead>
<tr>
<th>Well No – Year of Construction</th>
<th>Date of ATC</th>
<th>Date of ATO</th>
<th>SWA File Number</th>
<th>Approved Diversion Rate (L/sec)</th>
<th>Approved Allocation Volume (dam$^3$ per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW15-2001</td>
<td>Dec 11/02</td>
<td>Sept 15/04</td>
<td>WR 3303</td>
<td>75.0</td>
<td>1,000.0</td>
</tr>
<tr>
<td>PW16 (Proposed)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td>75.0</td>
<td>1,000.0</td>
</tr>
</tbody>
</table>

The SWA has verbally advised BHL that there are no outstanding issues preventing the issuance of the pending well(s) approvals and that these approvals should be issued in due course. Without considering the pending well(s) approvals, the City has an approved allocation volume of 4,648 cubic decametres (dam$^3$) per year, which is equal to a combined average day well(s) production rate of 12,734 cubic metres (m$^3$) per day.

With the implementation of the proposed artificial aquifer recharge, it is hoped that the annual allocation from the Logan West Valley Aquifer and perhaps from the Logan East Valley Aquifer can be increased accordingly; additional hydrogeologic testing and analyses and subsequent collaboration with the SWA is required to determine this.
4.0 **ANNUAL WELL(s) PRODUCTION VOLUMES**

The City of Yorkton’s annual water well(s) production volumes since 2009, separated by well and by well field, are tabulated below in cubic decametres (dam³):

<table>
<thead>
<tr>
<th>Well Number</th>
<th>Well Field</th>
<th>2009 (Jan 1 to Nov 30 only)</th>
<th>2010 (Jan 1 to Nov 30 only)</th>
<th>2011 (Jan 1 to Nov 30 only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW-LW1-2007</td>
<td>Logan West</td>
<td>0.00</td>
<td>22.23</td>
<td>200.76</td>
</tr>
<tr>
<td>TW-LW2-2007</td>
<td>Logan West</td>
<td>0.00</td>
<td>315.91</td>
<td>0.00</td>
</tr>
<tr>
<td>PW1A-1957</td>
<td></td>
<td>97.27</td>
<td>26.77</td>
<td>0.00</td>
</tr>
<tr>
<td>PW2A-1957</td>
<td></td>
<td>0.00</td>
<td>259.33</td>
<td>0.00</td>
</tr>
<tr>
<td>PW2B-2011</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>PW10-1979</td>
<td></td>
<td>0.00</td>
<td>7.75</td>
<td>904.05</td>
</tr>
<tr>
<td><strong>Sub Total Logan West</strong></td>
<td></td>
<td>97.27</td>
<td>631.99</td>
<td>1,104.81</td>
</tr>
<tr>
<td>PW11-1981</td>
<td>Logan East</td>
<td>593.08</td>
<td>250.06</td>
<td>0.00</td>
</tr>
<tr>
<td>PW12-1987</td>
<td>Logan East</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>PW14-2001</td>
<td>Logan East</td>
<td>0.00</td>
<td>0.00</td>
<td>100.92</td>
</tr>
<tr>
<td><strong>Sub Total Logan East</strong></td>
<td></td>
<td>593.08</td>
<td>250.06</td>
<td>100.92</td>
</tr>
<tr>
<td>PW4A-1987</td>
<td>Collacott</td>
<td>34.54</td>
<td>41.42</td>
<td>4.21</td>
</tr>
<tr>
<td>PW5-1952</td>
<td>Collacott</td>
<td>106.09</td>
<td>129.56</td>
<td>18.86</td>
</tr>
<tr>
<td>PW6A-2000</td>
<td>Collacott</td>
<td>0.00</td>
<td>0.00</td>
<td>24.94</td>
</tr>
<tr>
<td>PW7-1967</td>
<td>Collacott</td>
<td>102.43</td>
<td>128.91</td>
<td>27.55</td>
</tr>
<tr>
<td>PW13-1981</td>
<td>Collacott</td>
<td>0.00</td>
<td>12.75</td>
<td>681.21</td>
</tr>
<tr>
<td><strong>Sub Total Collacott</strong></td>
<td></td>
<td>243.06</td>
<td>312.64</td>
<td>756.77</td>
</tr>
<tr>
<td>PW8-1969</td>
<td>Leech Lake</td>
<td>664.31</td>
<td>488.98</td>
<td>0.00</td>
</tr>
<tr>
<td>PW9-1976</td>
<td>Leech Lake</td>
<td>307.86</td>
<td>1,074.96</td>
<td>32.56</td>
</tr>
<tr>
<td><strong>Sub Total Leech Lake</strong></td>
<td></td>
<td>972.17</td>
<td>1,563.94</td>
<td>32.56</td>
</tr>
<tr>
<td>PW15-2001</td>
<td>Sturdee</td>
<td>293.98</td>
<td>580.10</td>
<td>392.06</td>
</tr>
<tr>
<td><strong>Sub Total Sturdee</strong></td>
<td></td>
<td>293.98</td>
<td>580.10</td>
<td>392.56</td>
</tr>
<tr>
<td><strong>Total Extraction Volume</strong></td>
<td></td>
<td>2,199.56</td>
<td>3,338.73</td>
<td>2,387.62 (11 months)</td>
</tr>
</tbody>
</table>

The City’s average groundwater extraction volume increased significantly since the construction of the Louis Dreyfus and the JRI seed crushing plants; the City has been supplying treated water to these two facilities since December 2009 and March 2010 respectively.

Since 2009, the City’s average day groundwater extraction volume has been 2,715 dam³ per year, which is equal to 226,250 m³ per month or 7,438 m³ per day.

Considering that the total groundwater extraction volume from the Logan West Aquifer in 2010 and 2011 was 631.99 and 1,104.81 dam³ respectively without any observed adverse effects and the increased aquifer capacity that will result if the proposed artificial aquifer recharge is successful, the City should now submit an application to the SWA for an increased allocation volume from their Logan West Wellfield.
5.0 ANTICIPATED WASTE STREAM VOLUMES

Associated Engineering has advised that the QSWTP has a 20 year average and maximum day design capacity of 13,000 and 33,000 cubic metres (m$^3$) per day respectively using three (3) independent treatment trains; the phase 1 (current) construction was limited to the installation of two (2) independent treatment trains providing an average and maximum day capacity of 8,667 and 22,000 m$^3$ per day respectively.

As reported in the preceding section, during the time period between 2009 and 2011, the City’s average day raw water requirements was 7,438 m$^3$ per day.

Using conventional groundwater treatment, including disinfection and iron and manganese reduction only, AE has estimated a 5% waste stream from the QSWTP. At design capacity, this would equate to an average day waste-stream volume of 650 m$^3$ per day being discharged into the lined sedimentation ponds.

Using demineralization (future) and conventional groundwater treatment, AE has estimated a 30% waste-stream from the QSWTP. At design capacity, this would equate to an average day waste steam volume of 3,900 m$^3$ per day being discharged into the lined sedimentation ponds.

6.0 CONSTRUCTION AND DEVELOPMENT OF PIEZOMETERS AND TEST WATER WELLS

6.1 Construction of Test Wells LW1-2007 and LW2-2007

Test wells LW1-1007 and LW2-2007 were both installed into the Logan West Valley Aquifer, at a location on the north side of the QSWTP, as illustrated on Drawing No. 1. Considering the potential production capacity of the Logan West Valley Aquifer at this location, these wells were designed to operate on an alternating rather than on a simultaneous basis; therefore, the spacing between the wells was limited to only 62 metres.

The 130 mm diameter test hole(s) was reamed to a diameter of 311 mm and to a depth of 20.73 metres at the LW1 site and a depth of 20.88 metres at the LW2 site. The 192 mm diameter PVC plastic casing and the 203 mm diameter stainless steel intake screens were installed into the reamed hole(s), with the base of the intake screens placed at depths of 20.12 and 20.42 metres respectively. The drilling fluid was then displaced with fresh water and the annular void around the outside of the intake screen and lower lengths of casing was filled with 12:20 size filter sand. The annular void above the filter sand was then filled to surface with bentonite aggregate.

The construction details of test wells LW1-2007 and LW2-2007 are illustrated on Drawing nos. 5 and 6.
6.2 Test Drilling and Installation of 51 mm diameter Piezometers

In order to locate the most suitable location in the Logan West Valley Aquifer for the installation of the supplementary test water well it was necessary to drill several exploration test holes. Based on the results of the test drilling work and on its proximity to the existing and proposed ancillary works and infrastructure, the test hole BHL2011-169 site was selected as the best location for the proposed test well; this test hole is located approximately 15 metres west of existing well PW2A-1957 and as such, will be referred to as well PW2B-2011.

In order to facilitate water level measurements during the proposed well(s) pumping tests and during future aquifer(s) monitoring, it was necessary to install several additional piezometers into the Bredenbury Aquifer and into the Logan West Valley Aquifer. A total of five (5) – 51 mm diameter piezometers were installed during this project and all of the existing 51 mm diameter piezometers in the Logan West Wellfield were re-developed to ensure that they were still functioning properly. During the re-development work it was determined that piezometer 32-75 was plugged so it was permanently decommissioned.

Eight (8) of the piezometers were equipped or will be equipped with Solinst data loggers which will be programmed to measure and record the aquifer(s) water level at 6 hour time intervals.

The locations of the existing and new wells, test holes and piezometers are illustrated on Drawing no. 1 and the construction details of the 2011 piezometers are illustrated on Drawing no. 7.

The geologic and electric testhole logs are included as Appendix A.

6.3 Construction of Test Well PW2B-2011

Testhole BHL2011-169 was reamed to a diameter of 311 mm and to a depth of 26.52 metres. The 192 mm diameter PVC plastic casing and 203 mm diameter stainless steel intake screen were installed into the reamed hole, with the base of the screen placed at a depth of 26.33 metres. The drilling fluid was then displaced with fresh water and the annular void around the outside of the intake screen and lower lengths of casing was filled with 12:20 size filter sand. The annular void above the filter sand was then filled to surface with bentonite aggregate.

The construction details of test well PW2B-2011 are illustrated on Drawing no. 8.

Test well PW2B-2011 was installed into the Logan West Valley Aquifer and was designed and located to allow the artificially introduced water to be intercepted at this location. Since the base of the intake screen in existing well PW2A-1957 is installed to a depth of only 15.08 metres and the screen section only penetrates the upper portion of the Logan West Valley Aquifer, this well is not suitable for use under the City’s proposed concept plan. Therefore, it is recommended that existing well PW2A-1957 be permanently decommissioned once test well
PW2B-2011 is placed into regular service; it is likely that some of the existing ancillary works associated with well PW2A-1957 can be re-used for test well PW2B-2011.

The additional groundwater that will become available from the Logan West Wellfield as a result of the proposed artificial recharge will be extracted from test well PW2B-2011 and then used as irrigation water for the sporting fields, the local tree nursery and the community gardens. Once the irrigation requirements have been satisfied, any excess water available from this well will be directed to the QSWTP for treatment and municipal distribution.

6.4 Development of Test Wells

The test wells were developed using an alternating combination of high pressure jetting with a concentrated chlorine solution and air lift pumping and surging.

Development work removes any remaining drilling fluid and the finer grained aquifer sediments from around the intake screen, which ensures that an efficient hydraulic connection is created between the screen, the filter sand and the surrounding aquifer sediments, thereby providing maximum pumping capacity from the well(s). The development work was continued until the discharge water with air lift pumping was visually clear and sediment free and the water discharge volume could not be increased further.

7.0 PRELIMINARY TEST WELL(S) PUMPING TESTS

Each of the three (3) new test wells was pump tested at a constant and continuous pumping rate for an appropriate period of time. The pumping was conducted with a submersible test pump and portable power generator supplied by the drilling contractor. The flow rate was measured with a calibrated circular orifice weir and was maintained constant by manually adjusting a ball valve installed in the discharge piping.

The primary purpose of these preliminary pumping tests was to facilitate an estimation of the maximum day well(s) pumping capacity and thereby to allow the subsequent selection of the well(s) pumping equipment. Once the test wells have been equipped with pumping equipment, additional pump testing and hydrogeologic data analyses will be required to allow the maximum day well(s) pumping capacity and the feasibility and potential effectiveness of the proposed artificial aquifer recharge to be more accurately assessed.

The water levels in the test wells and in the adjacent piezometers were measured at appropriate time intervals during the course of the preliminary pumping tests and during a recovery period immediately thereafter. A complete graphical and tabulated summary of the water level measurements recorded during pump testing and recovery testing is included in Appendix B.
7.1 Test Well LW1-2007

On June 13, 2007, test well LW1-2007 was pumped at a constant rate of 985 m$^3$ per day (11.4 L/s) for a continuous period of 360 minutes. The water level drawdown and recovery (residual drawdown) measurements at selected times of testing are tabulated below:

<table>
<thead>
<tr>
<th>Piezometer or Well No.</th>
<th>Distance to LW1-2007 (metres)</th>
<th>Static Water Level (metres)</th>
<th>Water Level Drawdown (metres)</th>
<th>Residual Drawdown (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time Since Pumping Began</td>
<td>Time Since Pump Stopped</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(minutes)</td>
<td>(minutes)</td>
</tr>
<tr>
<td>LW1-2007</td>
<td>0.00</td>
<td>7.257</td>
<td>3.799</td>
<td>3.833</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.885</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>0.093</td>
</tr>
<tr>
<td>GE104 *</td>
<td>32</td>
<td>8.156</td>
<td>0.034</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.099</td>
<td>n/a</td>
</tr>
<tr>
<td>LW2-2007</td>
<td>62</td>
<td>7.200</td>
<td>n/a</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.040</td>
<td>n/a</td>
</tr>
</tbody>
</table>

* Piezometer GE104 was decommissioned during the construction of the QSWTP.

7.2 Test Well LW2-2007

On June 15, 2007, test well LW2-2007 was pumped at a constant rate of 985 m$^3$ per day (11.4 L/s) for a continuous period of 360 minutes. The water level drawdown and recovery (residual drawdown) measurements at selected times of testing are tabulated below:

<table>
<thead>
<tr>
<th>Piezometer or Well No.</th>
<th>Distance to LW2-2007 (metres)</th>
<th>Static Water Level (metres)</th>
<th>Water Level Drawdown (metres)</th>
<th>Residual Drawdown (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time Since Pumping Began</td>
<td>Time Since Pump Stopped</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(minutes)</td>
<td>(minutes)</td>
</tr>
<tr>
<td>LW2-2007</td>
<td>0.00</td>
<td>7.203</td>
<td>4.477</td>
<td>4.502</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.539</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>0.115</td>
</tr>
</tbody>
</table>

Based on the results of these two pumping tests, under single well operation the estimated maximum day pumping capacity of test wells LW1 and LW2-2007 is 11.5 L/s (0.69 m$^3$/minute).

7.3 Test Well PW2B-2011

On November 16, 2011, test well PW2B-2011 was pumped at a constant rate of 2,966 m$^3$ per day (34.3 L/s) for a continuous period of 1,200 minutes. To prevent the possibility of water recirculation back into the developed aquifer, all water produced during pump testing was discharged through temporary surface piping to a location approximately 100 metres northwest of test well 2B-2011.

The water level drawdown and recovery (residual drawdown) measurements at selected times of testing are tabulated below:
<table>
<thead>
<tr>
<th>Piezometer or Well No.</th>
<th>Distance to PW2B (metres)</th>
<th>Static Water Level (metres)</th>
<th>Water Level Drawdown (metres)</th>
<th>Residual Drawdown (metres)</th>
<th>Time Since Pumping Began</th>
<th>Time Since Pump Stopped</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW 2B-2011</td>
<td>0.00</td>
<td>4.946</td>
<td>2.067</td>
<td>2.204</td>
<td>1.200</td>
<td>0.139</td>
</tr>
<tr>
<td>Piezometer 36-75</td>
<td>169</td>
<td>7.360</td>
<td>0.007</td>
<td>0.026</td>
<td>0.068</td>
<td>0.053</td>
</tr>
<tr>
<td>BHL2011-165A-PZ</td>
<td>267</td>
<td>8.71</td>
<td>0.009</td>
<td>0.020</td>
<td>0.032</td>
<td>0.022</td>
</tr>
<tr>
<td>Piezometer 20-79</td>
<td>541</td>
<td>6.575</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>BHL2011-163A-PZ</td>
<td>548</td>
<td>7.300</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>BHL2011-163B-PZ</td>
<td>551</td>
<td>7.374</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Based on the results of this pumping test, the estimated maximum day pumping capacity of test well PW2B-2011 is 30.0 L/s (1.80 m³/minute).

### 8.0 Water Quality

One set of water samples was collected from each of the new test wells near the conclusion of the respective pumping tests and from each of the new piezometers near the conclusion of the development work. These water samples were submitted to the SRC laboratory in Saskatoon for major ion and chemical health and toxicity (test wells only) analyses. The analytical results have been tabulated and included in Appendix C.

The City regularly collects water samples from each of their existing production water wells. These samples are also sent to the SRC in Saskatoon for major ion and chemical health and toxicity analyses. A tabulated summary of the most recent analytical results is also included in Appendix C.

The quality of the wastewater discharge from the QSWTP and the quality of the treated water leaving the sedimentation ponds will depend on the input quality of the well(s) water entering the plant, which may vary marginally depending on which wells are operating.

At the time of report preparation, water quality data was not available for the wastewater leaving the QSWTP, for the treated water leaving the sedimentation ponds or for the water mixture entering the infiltration area. This water quality data, which should be collected over varying well(s) pumping scenarios and seasonal conditions, is required to more fully evaluate the feasibility of the City’s proposed concept plan.
9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 The City of Yorkton relies completely on groundwater to satisfy their municipal water requirements and currently operates thirteen (13) production water wells that have been grouped into five (5) separate wellfields.

9.2 In 2011 the City commissioned their new Queen Street Water Treatment Plant (QSWTP) and subsequently decommissioned their existing water treatment facilities.

9.3 In collaboration with their consultants, with several community stakeholders and with the appropriate regulatory agencies, the City of Yorkton has developed an innovative concept plan for the environmentally responsible treatment and reuse of the wastewater that will be generated by the new QSWTP.

9.4 The primary purpose of the preliminary test well(s) pumping tests was to facilitate an estimation of the maximum day well(s) pumping capacity and thereby to allow the subsequent selection of the well(s) pumping equipment. Once the test wells have been equipped with pumping equipment, additional pump testing and hydrogeologic data analyses will be required to allow the maximum day well(s) pumping capacity and the feasibility and potential effectiveness of the proposed artificial aquifer recharge to be more accurately assessed.

9.5 Under single well operation, the estimated maximum day (intermittent) pumping capacity of wells LW1 and LW2-2007 and PW2B-2011 is 11.5 L/s, 11.5 L/s and 30.0 L/s respectively.

9.6 Additional testing, monitoring and subsequent hydrogeologic data analyses are required to fully assess the feasibility of the proposed concept plan. The new and existing water wells and piezometers should be monitored with pumping over the next one to three years. The data collected during this period should then be used to more accurately determine the extent and magnitude of the proposed artificial recharge and the effect that this recharge will have on the Bredenbury and the Logan Valley Aquifer systems and on the water wells that are developed within these aquifers.

9.7 The data collected during the proposed one to three year monitoring period can also be used to further delineate the location and extent of the inferred hydraulic discontinuity between the Logan West and the Logan East Wellfields and the effect (if any) of the abandoned landfill on the water quality in the underlying Logan Valley Aquifer system.

9.8 At the time of report preparation, water quality data was not available for the wastewater leaving the QSWTP, for the treated water leaving the sedimentation ponds or for the water mixture entering the infiltration area. This water quality data, which should be collected over varying well(s) pumping scenarios and seasonal conditions, is required to more fully evaluate the feasibility of the City’s proposed concept plan.
PITLESS ADAPTER FLANGE ELEVATION (POST COMPLETION): 507.66 masl

SAND BACKFILL

NATURAL GROUND SURFACE ELEVATION: 507.15 masl

BENTONITE AGGREGATE SEAL

311mm DIAMETER HOLE

~1.2

~4.9

STATIC WATER LEVEL – 7.157 metres BELOW TOP OF CASING
JUNE 13, 2007

12:20 SIZE ROUNDED SILICA SAND

203 mm (192.13 mm ID) PVC PLASTIC CERTAINEED CERTA-LOK WELL CASING,
SDR 17, ASTM F-490, WITH SPLINED BELLED JOINTS

WELL SCREEN CENTRALIZERS (4 @ 90°)

203 mm ID (PIPE SIZE) TYPE 304 STAINLESS STEEL INTAKE SCREEN, WITH 0.635mm
CONTINUOUS SLOT OPENINGS AND THREADED JOINTS (2 x 3.05 and 1 x 1.52 metre
LENGTHS)

STAINLESS STEEL PLATE WELDED TO BOTTOM OF INTAKE SCREEN

NOTE: ALL DEPTHS ARE EXPRESSED IN METRES ABOVE OR BELOW NATURAL GROUND SURFACE, UNLESS OTHERWISE INDICATED

: CONTRACTOR – SOLIE DRILLING LTD.
: ELEVATIONS PROVIDED BY ASSOCIATED ENGINEERING (SASK) LTD.; APPROXIMATE UTM COORDINATES (NAD 83) PROVIDED BY BHL
: PUMP INTAKE INSTALLED TO A DEPTH OF 14.61 METRES BELOW THE TOP OF THE PITLESS ADAPTER ON AUGUST 10, 2011
: PUMP – GRUNDFOS MODEL A15870002–10805199 (7.5 Hp, 230 USgpm AT 80°)

BECKIE HYDROGEOLOGISTS (1990) LTD.
CONSULTING ENGINEERS AND GeOScientISTS
APEGS CERTIFICATE OF AUTHORIZATION No. 664

City of Yorkton
CONSTRUCTION DETAILS
OF TEST WELL LW1–2007
(BHL2007–160LW1 – WEST WELL)
LAND LOCATION: SE LSD 03–35–25–04 W2
EASTING: ~13 677122; NORTHING: ~5674768

ACAD FILE: LW1–2007.DWG
SCALE: NOT TO SCALE
DRAWING NO. 5
PLOT DATE: DEC. 6, 2011

DRAWN BY MUTSCHLER
APPROVED BY FAMILAK
DATE SEP. 25, 2007
DESCRIPTION: RECORD DRAWING
PITLESS ADAPTER FLANGE ELEVATION: 507.43 masl

SAND BACKFILL

NATURAL GROUND SURFACE ELEVATION: 507.03 masl

BENTONITE AGGREGATE SEAL

311mm DIAMETER HOLE

STATIC WATER LEVEL - 7.203 metres BELOW TOP OF CASING JUNE 15, 2007

12:20 SIZE ROUNDED SILICA SAND

203 mm (192.13 mm ID) PVC PLASTIC CERTAINEED CERTA-LOK WELL CASING, SDR 17, ASTM F-490, WITH SPLINED BELLED JOINTS

WELL SCREEN CENTRALIZERS (4 @ 90°)

203 mm ID (PIPE SIZE) TYPE 304 STAINLESS STEEL INTAKE SCREEN, WITH 0.635mm CONTINUOUS SLOT OPENINGS AND THREADED JOINTS (1 x 3.05 and 2 x 1.52 metre LENGHTS)

STAINLESS STEEL PLATE WELDED TO BOTTOM OF INTAKE SCREEN

NOTE: ALL DEPTHS ARE EXPRESSED IN METRES ABOVE OR BELOW NATURAL GROUND SURFACE, UNLESS OTHERWISE INDICATED

: CONTRACTOR - SOLIE DRILLING LTD.
: ELEVATIONS PROVIDED BY ASSOCIATED ENGINEERING (SASK) LTD.; APPROXIMATE UTM COORDINATES (NAD 83) PROVIDED BY BHL
: PUMP = GRUNDFOS MODEL MS4000, PC P10821, PRODUCT No. 79395511, 7.5 Hp

BECKIE HYDROGEOLOGISTS (1990) LTD.
CONSULTING ENGINEERS AND GEOSCIENTISTS
APEGS CERTIFICATE OF AUTHORIZATION No. 664

DESCRIPTION: RECORD DRAWING

ACAD FILE: LW2-2007.DWG
SCALE: NOT TO SCALE
DRAWING NO. 6
PLOT DATE: DEC. 6, 2011

CONSTRUCTION DETAILS
OF TEST WELL LW2-2007
(BHL2007-159LW2 - EAST WELL)
LAND LOCATION: SE LSD 03-35-25-04 W2
EASTING: ~13 677184; NORTING: ~5674772
LOCKABLE STEEL SURFACE PROTECTION CASING

NATURAL GROUND SURFACE ELEVATION (MASL)

BENTONITE AGGREGATE SEAL TO NATURAL GROUND SURFACE

130mm DIAMETER HOLE

STATIC WATER LEVEL – METRES BELOW TOP OF CASING
NOVEMBER 16, 2011

51mm DIAMETER PVC PLASTIC PIPE, SCH. 80, WITH GLUED BELLED JOINTS

12:20 SIZE ROUNDED SILICA SAND

51mm ID TYPE 304 STAINLESS STEEL INTAKE SCREEN, 0.76 metre LENGTH, WITH 0.508mm 0.508mm CONTINUOUS SLOT OPENINGS AND THREADED JOINTS

51mm DIAMETER PVC PLASTIC PIPE (TAILPIPE), AS ABOVE

51mm PVC PLASTIC FIGURE T WASHDOWN VALVE

<table>
<thead>
<tr>
<th>PIEZOMETER</th>
<th>HOLE DEPTH (A)</th>
<th>BOTTOM OF TAILPIPE (B)</th>
<th>BOTTOM OF SCREEN (C)</th>
<th>TOP OF SCREEN (D)</th>
<th>TOP OF SAND (E)</th>
<th>STATIC WATER LEVEL (F)</th>
<th>GROUND ELEVATION (masl) (G)</th>
<th>CASING ELEVATION (masl) (H)</th>
<th>CASING STICKUP (I)</th>
<th>LAND LOCATION</th>
<th>UTM COORDINATES (NAD 83)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHL2011–165BPZ</td>
<td>6.60</td>
<td>N/A</td>
<td>6.60</td>
<td>5.64</td>
<td>3.05</td>
<td>6.874</td>
<td>507.244</td>
<td>507.993</td>
<td>0.749</td>
<td>SE 08–35–25–04 W2</td>
<td>13 677832.984 5675192.134</td>
</tr>
</tbody>
</table>

Note: All depths are expressed in metres above or below natural ground surface, unless otherwise indicated.

Contractor – Solie Drilling Ltd.
Survey data provided by Associated Engineering (Sask.) Ltd.
Selected piezometers were equipped with Solinst Model 3001 Levelogger Edge Automatic Data Loggers (as follows):

<table>
<thead>
<tr>
<th>PIEZOMETER</th>
<th>DATA LOGGER</th>
<th>CABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TYPE</td>
<td>SERIAL NUMBER</td>
</tr>
<tr>
<td>BHL2011–163APZ</td>
<td>M20</td>
<td>15</td>
</tr>
<tr>
<td>BHL2011–164APZ</td>
<td>M20</td>
<td>15</td>
</tr>
</tbody>
</table>

City of Yorkton
WATER TREATMENT PLANT
WASTEWATER REUSE FEASIBILITY STUDY
CONSTRUCTION DETAILS OF 2011 PIEZOMETERS

Beckie Hydrogeologists (1990) Ltd.
Consulting Engineers and Geoscientists
APGSS Certificate of Authorization No. 664
PVC plastic cap glued to top of well casing
Top of casing elevation: 504.327 masl

Natural ground surface elevation: 503.791 masl

311 mm diameter hole

Static water level — 4.946 metres below top of casing
November 16, 2011

Bentonite aggregate seal

203 mm (192.13 mm I.D.) PVC plastic well casing, SDR. 17, with 12.70 mm wall thickness and splined belled joints.

12:20 size rounded silica sand

Well screen centralizers (4 @ 90°)

203 mm ID (pipe size) Type 304 stainless steel intake screen,
with 0.635 mm continuous slot openings and threaded joints
(4 x 3.05 metre lengths).

Stainless steel plate welded to the bottom of the intake screen

Note: All depths are expressed in metres above or below natural ground surface,
unless otherwise indicated.

Contractor — Solie Drilling Ltd.
Survey data (NAD 83) provided by Associated Engineering (Sask) Ltd.

City of Yorkton

CONSTRUCTION DETAILS OF
TEST WELL PW2B–2011
(BHL2011–169PW2B)

LAND LOCATION: NE LSD 02–35–25–04 W2
EASTING: 13 677659.322; NORTHING: 5674986.776
APPENDIX A

Geologic and Electric Logs
BECKIE HYDROGEOLOGISTS (1990) LTD.

Testhole: BHL2011-163APZ
Northing - NAD 83: 5675029.414
Easting - NAD 83: 13 678205.960

Total Depth: 28.42 metres
Surface Elevation: 506.49 masl
Casing Elevation: 507.176 masl
S.P.: As Shown mvolts

CITY OF YORKTON
WTP WASTEWATER REUSE FEASIBILITY STUDY
LOC_NW_Lsd_04_Sec_36_Tp_25_Rg_04_W_2
Date: October 25, 2011
Contractor: Solie Drilling Ltd.
Supervisor: Devin Mutschler, P.Eng., P.Geo
Resistivity: As Shown ohms

BHL2011-163APZ
NW Lsd 04-36-25-04 W2
Easting: 13 678205.960; Northing: 5675029.414 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>4.27</td>
</tr>
<tr>
<td>15</td>
<td>4.57</td>
</tr>
<tr>
<td>16</td>
<td>4.88</td>
</tr>
<tr>
<td>17</td>
<td>5.18</td>
</tr>
<tr>
<td>26.5</td>
<td>8.08</td>
</tr>
<tr>
<td>32.5</td>
<td>9.91</td>
</tr>
<tr>
<td>41</td>
<td>12.50</td>
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<td>44</td>
<td>13.41</td>
</tr>
<tr>
<td>47</td>
<td>14.33</td>
</tr>
<tr>
<td>57</td>
<td>17.37</td>
</tr>
<tr>
<td>67</td>
<td>20.42</td>
</tr>
</tbody>
</table>

- **Silt**, brown, soft, sticky, oxidized.
- **Sand**, fine, brown, oxidized.
- **Silt**, brown, soft, sticky, oxidized.
- **Sand**, fine to medium, brown, soft.
- **Sand**, fine to medium gravel, subrounded to subangular, clean; fine sand layers at 6.40 and 7.16 metres.
- **Silt**, light grey, moderately soft, very clay rich to silty clay.
- **Silt**, light grey, moderately soft, sticky.
- **Sand**, fine to coarse gravel, subrounded, clean, loose.
- **Sand**, fine to medium gravel, subrounded, clean, loose.
- **Sand**, fine to coarse, subrounded to subangular, clean, loose.
- **Clay**, grey, moderately hard to hard, slightly silty, greasy, non-calcareous.
BHL2011-164PZ  
SW Lsd 03-36-25-04 W2

Easting: 13 678576.443; Northing: 5674858.591 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2.44</td>
<td>Clay, brown, very silty, moderately soft, oxidized.</td>
</tr>
<tr>
<td>- 4.57</td>
<td>Till, brown, moderately hard, silty, oxidized.</td>
</tr>
<tr>
<td>- 4.88</td>
<td>Clay, light grey, very silty, moderately hard, sticky, non-oxidized.</td>
</tr>
<tr>
<td>- 7.62</td>
<td>Silt, light grey, moderately soft to moderately hard, slightly sticky.</td>
</tr>
<tr>
<td>- 9.45</td>
<td>Sand, grey, fine to very fine, silty, soft.</td>
</tr>
<tr>
<td>- 10.97</td>
<td>Sand, fine to medium gravel, subrounded, clean.</td>
</tr>
<tr>
<td>- 12.80</td>
<td>Sand, fine to medium gravel, subrounded, clean, loose.</td>
</tr>
<tr>
<td>- 13.11</td>
<td>Sand, fine to medium.</td>
</tr>
<tr>
<td>- 14.33</td>
<td>Sand, fine to fine gravel, subrounded to subangular, clean, loose.</td>
</tr>
<tr>
<td>- 14.94</td>
<td>Clay, grey, hard, greasy, silty, non-calcareous, some oxidized streaks.</td>
</tr>
<tr>
<td>- 16.76</td>
<td>Clay, grey, hard, greasy, silty, non-calcareous.</td>
</tr>
</tbody>
</table>
BHL 2011-165APZ

CITY OF YORKTON
WTP WASTEWATER REUSE FEASIBILITY STUDY

Testhole          BHL 2011-165APZ
Northing - NAD 83  5675188.92
Easting - NAD 83   13 677833.072

Total Depth       36.48 meters
Surface Elevation 507.108
Casing Elevation  507.855
S.P.              As shown

---

BHL 2011-165APZ          SE Lsd 08-35-25-04 W2

Easting: 13 677833.072; Northing: 5675188.920 (NAD 83)

Depth in Metres  Cutting Description

0 -  5.49  | Silt, brown, soft, clay rich, sticky, oxidized.
      -  5.94  | Sand, fine, soft, silty.
      -  6.40  | Sand, fine to medium.
      -  7.32  | Till, brown, moderately hard, silty, oxidized.
      - 11.58  | Sand, fine to medium gravel, subrounded to subangular, clean, loose.
      - 14.33  | Sand, fine to medium, clean.
      - 15.24  | Sand, fine to medium, with soft dark grey silt interbeds.
      - 16.92  | Sand, fine to medium, subangular to subrounded, clean.
      - 17.68  | Sand, fine to medium gravel, some coarse layers, subrounded to subangular (mostly limestone and granitics).
      - 18.90  | Sand, fine to medium, some coarse sand layers, subrounded to subangular, clean, loose.
      - 22.56  | Sand, fine to fine gravel, some medium to coarse gravel layers, subrounded to subangular, clean, loose.
      - 23.77  | Clay (till?), dark grey, moderately hard, silty, calcareous.
      - 26.52  | Sand, fine to medium gravel, subrounded to subangular.
      - 27.43  | Till, grey, moderately hard, silty, calcareous.
      - 30.48  | Clay, grey, moderately hard, silty, greasy, non-calcareous.
BHL2011-166TH

Easting: 13 677838; Northing: -5675092 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Silt, brown, soft, sticky, oxidized; few soft sandy streaks.</td>
</tr>
<tr>
<td>5.49</td>
<td>Till, brown, moderately hard, silty, oxidized; boulder at 5.49 metres.</td>
</tr>
<tr>
<td>9.14</td>
<td>Sand, fine to medium gravel, subrounded, clean, loose.</td>
</tr>
<tr>
<td>10.06</td>
<td>Till, brown, moderately hard, silty, oxidized.</td>
</tr>
<tr>
<td>13.11</td>
<td>Sand, fine to medium gravel, subrounded, clean, loose.</td>
</tr>
<tr>
<td>14.02</td>
<td>Sand, medium to coarse gravel, subrounded, clean, loose.</td>
</tr>
<tr>
<td>19.51</td>
<td>Sand, fine to medium gravel, subrounded to subangular, clean, loose.</td>
</tr>
<tr>
<td>20.12</td>
<td>Till, grey, moderately hard, silty, plastic, non-oxidized.</td>
</tr>
<tr>
<td>23.16</td>
<td>Sand, fine to medium gravel, subrounded to subangular, clean, loose.</td>
</tr>
<tr>
<td>23.47</td>
<td>Till, grey, moderately hard, silty to sandy.</td>
</tr>
<tr>
<td>24.69</td>
<td>Sand, fine to fine gravel, subrounded to subangular, clean, loose.</td>
</tr>
<tr>
<td>27.43</td>
<td>Sand, fine to coarse gravel, subangular to subrounded, clean, loose.</td>
</tr>
<tr>
<td>28.35</td>
<td>Till, grey, non-oxidized, a few coal fragments.</td>
</tr>
<tr>
<td>28.65</td>
<td>Sand, fine to coarse, with gravel layers.</td>
</tr>
<tr>
<td>28.96</td>
<td>Till.</td>
</tr>
<tr>
<td>29.87</td>
<td>Boulder.</td>
</tr>
</tbody>
</table>
Depth in Meters | Cutting Description
--- | ---
0  | Silt, brown
-  | 1.22  | Silt, brown.
-  | 4.88  | Till, brown.
-  | 10.97 | Sand, grey, fine to coarse, fine gravel layers, clean, loose, subrounded.
-  | 18.59 | Sand, as above, with fine to coarse gravel.
-  | 19.81 | Till, grey, very silty, with sand lenses; some coal fragments.
-  | 25.30 | Sand, as above, with fine to coarse gravel.
-  | 25.91 | Silt (?).
-  | 27.43 | Sand, fine to coarse, clean, loose.
-  | 32.92 | Sand, fine to coarse, occasional gravel lenses.
-  | 34.14 | Till, grey, non-oxidized, some coal fragments.
-  | 36.58 | Clay, grey.
**BHL.2011-168TH**

**NE Lsd 02-36-25-04 W2**

**Easting:** –13 677 485 **Northing:** –567 4872 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 1.83</td>
<td>Silt, brown, oxidized.</td>
</tr>
<tr>
<td>3.05</td>
<td>Till, brown, some coal fragments.</td>
</tr>
<tr>
<td>4.88</td>
<td>Sand, grey, fine to coarse, clean, loose.</td>
</tr>
<tr>
<td>8.53</td>
<td>Sand, as above, with fine gravel layers, surrounded.</td>
</tr>
<tr>
<td>15.85</td>
<td>Sand, as above, with fine to coarse gravel.</td>
</tr>
<tr>
<td>16.46</td>
<td>Till, grey.</td>
</tr>
<tr>
<td>17.07</td>
<td>Sand, fine.</td>
</tr>
<tr>
<td>18.29</td>
<td>Till, grey, silty, with thin sand lenses.</td>
</tr>
<tr>
<td>20.73</td>
<td>Sand, fine, silty.</td>
</tr>
<tr>
<td>22.56</td>
<td>Silt, grey.</td>
</tr>
<tr>
<td>24.99</td>
<td>Till, grey.</td>
</tr>
<tr>
<td>25.91</td>
<td>Clay, grey.</td>
</tr>
</tbody>
</table>
Easting: 13 677659.322; Northing: 5674986.776 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2.13</td>
<td>Silt, brown.</td>
</tr>
<tr>
<td>- 3.66</td>
<td>Till, brown, oxidized.</td>
</tr>
<tr>
<td>- 9.14</td>
<td>Sand, fine to coarse, clean, loose.</td>
</tr>
<tr>
<td>- 13.72</td>
<td>Sand, as above, with fine to medium gravel.</td>
</tr>
<tr>
<td>- 14.02</td>
<td>Silt (?).</td>
</tr>
<tr>
<td>- 16.15</td>
<td>Sand, as above, with fine to coarse gravel.</td>
</tr>
<tr>
<td>- 19.51</td>
<td>Sand, finer.</td>
</tr>
<tr>
<td>- 20.12</td>
<td>Silt (?).</td>
</tr>
<tr>
<td>- 26.82</td>
<td>Sand, fine to coarse, with fine to coarse gravel, loose; rock at 23.47 metres.</td>
</tr>
<tr>
<td>- 28.35</td>
<td>Gravel, fine to coarse, angular, rocky.</td>
</tr>
<tr>
<td>- 28.65</td>
<td>Till, grey, some coal fragments.</td>
</tr>
</tbody>
</table>

Easting: 13 485417.426; Northing: 5741242.293 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Silt, brown, moderately hard, plastic, sticky, oxidized.</td>
</tr>
<tr>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td>3.96</td>
<td>Till, brown, moderately hard, silty, oxidized; than gravel layers.</td>
</tr>
<tr>
<td>9.14</td>
<td>Sand, fine to medium gravel, subangular to subrounded, loose.</td>
</tr>
<tr>
<td>17.68</td>
<td>Sand, coarse to course gravel, subangular to subrounded, loose; soft till layer at 14.02 metres.</td>
</tr>
<tr>
<td>18.90</td>
<td>Till, brown to grey, moderately hard to moderately soft, silty.</td>
</tr>
<tr>
<td>20.42</td>
<td>Gravel, fine to coarse, subangular to subrounded, loose.</td>
</tr>
<tr>
<td>21.49</td>
<td>Till, grey, moderately hard, silty.</td>
</tr>
<tr>
<td>23.77</td>
<td>Clay, grey, moderately hard to hard, silty.</td>
</tr>
</tbody>
</table>
BHL2007-160LW1 (LW1-2007)  
SE Lsd 03-35-25-04 W2

Easting: 13 485417.426; Northing: 5741242.293 (NAD 83)

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Cutting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1.83</td>
<td>Silt, brown, moderately hard, plastic, greasy, sticky, oxidized.</td>
</tr>
<tr>
<td>- 3.96</td>
<td>Till, brown, moderately hard, silty, oxidized.</td>
</tr>
<tr>
<td>- 8.53</td>
<td>Sand, fine to medium gravel, subangular to subrounded, loose.</td>
</tr>
<tr>
<td>- 16.76</td>
<td>Sand, coarse to coarse gravel, subangular to subrounded, loose; few soft brown till layers.</td>
</tr>
<tr>
<td>- 17.07</td>
<td>Silt, brown, soft.</td>
</tr>
<tr>
<td>- 20.73</td>
<td>Gravel, fine to coarse, subangular to subrounded, loose; boulder from 18.59 to 18.90 metres.</td>
</tr>
<tr>
<td>- 23.16</td>
<td>Till, grey, moderately hard, silty, non-oxidized.</td>
</tr>
<tr>
<td>- 24.38</td>
<td>Clay, light to medium grey, moderately hard to hard, silty, greasy, non-calcareous; some olive brown oxidized streaks.</td>
</tr>
</tbody>
</table>
APPENDIX B-1(A)

Test Well LW1-2007
Pumping Test Data
### Pumping Test Data Report

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton  
**Page 1**

**Data observed at:** LW1-2007

**Pumping Test:** LW1-2007 Pumping Test

**Location:** Yorkton, Saskatchewan  
**Test Supervision:** Mike Famulak, P. Geo  
**Date:** 13/06/2007  
**Email:** bhl@sasktel.net

<table>
<thead>
<tr>
<th>Time [min]</th>
<th>Depth to WL [m]</th>
<th>Drawdown [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>10.730</td>
<td>3.573</td>
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<td>10.860</td>
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<td>1.5</td>
<td>10.880</td>
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<td>2</td>
<td>10.890</td>
<td>3.733</td>
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<tr>
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<td>10.895</td>
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<td>3</td>
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</tr>
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<td>3.5</td>
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<tr>
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<td>3.880</td>
</tr>
<tr>
<td>36</td>
<td>11.042</td>
<td>3.885</td>
</tr>
</tbody>
</table>
Pumping Test: LW1-2007 Pumping Test
Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results:
- Transmissivity: 2.44E+3 [m²/d]
- Conductivity: 3.99E+2 [m/d]

Test parameters:
- Pumping Well: LW1-2007
- Aquifer Thickness: 6.1 [m]
- Casing radius: 0.1016 [m]
- Confined Aquifer
- Screen length: 7.62 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 984.96 [m³/d]

Comments:
- Static Water Level: 7.257 metres below top of casing
- Land Location: SE Lsd 03-35-25-04 W2
- LWD1-2007 Pumping Well:
- Discharge Rate: 984.96 [m³/d]

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 16/12/2009
**Beckie Hydrogeologists (1990) Ltd.**
381 Park Street
Regina, Saskatchewan S4N 5B2
Phone: (306) 721-0846 Fax: (306) 721-7729
Email: bhl@sasktel.net

---

**Project:** City of Yorkton

**Client:** City of Yorkton

**Water Treatment Plant Wastewater Reuse Feasibility Study**

---

**Pumping Test Data Report**

**Pumping Test:** LW1-2007 Pumping Test

**Location:** Yorkton, Saskatchewan

**Test Supervision:** Mike Famulak, P. Geo

**Date:** 13/06/2007

**Depth to Static WL:** 7.2 [m]

**Distance from PW:** 62.13 [m]

**Pumping Well:** LW1-2007

**Casing radius:** 0.1016 [m]

**Boring radius:** 0.1556 [m]

**Screen length:** 7.62 [m]

**Aquifer Thickness:** 6.1 [m]

<table>
<thead>
<tr>
<th>Time [min]</th>
<th>Depth to WL [m]</th>
<th>Drawdown [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.210</td>
<td>0.010</td>
</tr>
<tr>
<td>2</td>
<td>7.220</td>
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<td>0.045</td>
</tr>
<tr>
<td>8</td>
<td>7.240</td>
<td>0.040</td>
</tr>
</tbody>
</table>
### LW1-2007 Pumping Test

**Analysis Method:** Cooper-Jacob Time-Drawdown

#### Analysis Results:
- **Transmissivity:** $4.34 \times 10^3 \text{ m}^2/\text{d}
- **Conductivity:** $7.12 \times 10^2 \text{ m/d}

#### Test Parameters:
- **Pumping Well:** LW1-2007
- **Aquifer Thickness:** 6.1 m
- **Casing radius:** 0.1016 m
- **Screen length:** 7.62 m
- **Boring radius:** 0.1556 m
- **Discharge Rate:** 984.96 m$^3$/d

#### Comments:
- Static Water Level: 7.200 metres below top of casing
- Land Location: SE Lsd 03-35-25-04 W2
- Distance from LW1-2007: 62 metres

---

**Evaluated by:** Devin Mutschler, P.Eng., P.Geo

**Evaluation Date:** 16/12/2009
Pumping Test: **LW1-2007 Pumping Test**

Analysis Method: **Theis**

Analysis Results:
- Transmissivity: $2.74 \times 10^3$ [m$^2$/d]
- Conductivity: $4.49 \times 10^2$ [m/d]
- Storativity: $7.25 \times 10^{-2}$

Test parameters:
- Pumping Well: LW1-2007
- Aquifer Thickness: 6.1 [m]
- Casing radius: 0.1016 [m]
- Screen length: 7.62 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 984.96 [m$^3$/d]

Comments: Static Water Level: 7.200 metres below top of casing
Land Location: SE Lsd 03-35-25-04 W2
Distance from LW1-2007: 62 metres

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 16/12/2009
Beckie Hydrogeologists (1990) Ltd.
381 Park Street
Regina, Saskatchewan S4N 5B2
Phone: (306) 721-0846 Fax: (306) 721-7729
Email: bhl@sasktel.net

**Pumping Test Data Report**

**Project:** City of Yorkton
**Client:** City of Yorkton

**Location:** Yorkton, Saskatchewan
**Date:** 13/06/2007

**Pumping Test:** LW1-2007 Pumping Test
**Pumping Well:** LW1-2007
**Casing radius:** 0.1016 [m]
**Boring radius:** 0.1556 [m]
**Screen length:** 7.62 [m]
**Aquifer Thickness:** 6.1 [m]

<table>
<thead>
<tr>
<th>Time [min]</th>
<th>Depth to WL [m]</th>
<th>Drawdown [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>8.166</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>8.174</td>
</tr>
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Pumping Test: **LW1-2007 Pumping Test**

Analysis Method: **Cooper-Jacob Time-Drawdown**

**Analysis Results:**
- **Transmissivity:** $2.54 \times 10^3 \text{ m}^2/\text{d}$
- **Conductivity:** $4.17 \times 10^2 \text{ m/d}$

**Test parameters:**
- **Pumping Well:** LW1-2007
- **Aquifer Thickness:** 6.1 [m]
- **Casing radius:** 0.1016 [m]
- **Screen length:** 7.62 [m]
- **Boring radius:** 0.1556 [m]
- **Discharge Rate:** 984.96 [m$^3$/d]

**Comments:**
- Static Water Level: 8.156 metres below top of casing
- Land Location: SE Lsd 03-35-25-04 W2
- Distance from LW1-2007: 32 metres

Evaluating by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 16/12/2009
Pumping Test: LW1-2007 Pumping Test  
Analysis Method: Theis  

Analysis Results:  
- Transmissivity: $1.85 \times 10^3$ [m$^2$/d]  
- Conductivity: $3.03 \times 10^2$ [m/d]  
- Storativity: $9.78 \times 10^{-2}$  

Test parameters:  
- Pumping Well: LW1-2007  
- Aquifer Thickness: 6.1 [m]  
- Casing radius: 0.1016 [m]  
- Confined Aquifer  
- Screen length: 7.62 [m]  
- Boring radius: 0.1556 [m]  
- Discharge Rate: 984.96 [m$^3$/d]  

Comments: Static Water Level: 8.156 metres below top of casing  
Land Location: SE Lsd 03-35-25-04 W2  
Distance from LW1-2007: 32 metres  

Evaluated by: Devin Mutschler, P.Eng., P.Geo  
Evaluation Date: 16/12/2009
APPENDIX B-1(B)

Test Well LW1-2007
Recovery Test Data
**Pumping Test Data Report**

**Project:** City of Yorkton  
**Client:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Data observed at:** LW1-2007  
**Pumping Test:** LW1-2007 Recovery

**Distance from PW:** 0 [m]  
**Casing radius:** 0.1016 [m]

**Depth to Static WL:** 7.157 [m]  
**Boring radius:** 0.1556 [m]

**Location:** Yorkton, Saskatchewan  
**Screen length:** 7.62 [m]

**Test Supervision:** Rae Rounce  
**Aquifer Thickness:** 6.1 [m]

**Date:** 13/06/2007

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Pumping Test: LW1-2007 Recovery
Analysis Method: Theis Recovery

Analysis Results:
- Transmissivity: 2.89E+3 [m²/d]
- Conductivity: 4.74E+2 [m/d]

Test parameters:
- Pumping Well: LW1-2007
- Aquifer Thickness: 6.1 [m]
- Casing radius: 0.1016 [m]
- Confined Aquifer
- Screen length: 7.62 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 984.96 [m³/d]
- Pumping Time: 360 [min]

Comments:
- Static Water Level: 7.157 metres below top of casing
- Land Location: SE Lsd 03-35-25-04 W2

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 13/06/2007
APPENDIX B-2(A)

Test Well LW2-2007
Pumping Test Data
Data observed at: LW2-2007

Pumping Test: LW2-2007 Pumping Test

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Pumping Test: LW2-2007 Pumping Test

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results:
- Transmissivity: 3.52E+3 [m²/d]
- Conductivity: 2.94E+2 [m/d]

Test parameters:
- Pumping Well: LW2-2007
- Casing radius: 0.1016 [m]
- Screen length: 6.1 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 984.96 [m³/d]

Aquifer Thickness: 12 [m]

Confined Aquifer

Comments:
- Static Water Level: 7.203 metres below top of casing
- Land Location: SE Lsd 03-35-25-04 W2
APPENDIX B-2(b)

Test Well LW2-2007
Recovery Test Data
### Data observed at: LW2-2007

- **Distance from PW:** 0 [m]
- **Depth to Static WL:** 7.203 [m]
- **Location:** Yorkton, Saskatchewan
- **Test Supervision:** Rae Rounce
- **Date:** 15/06/2007

## Pumping Test: LW2-2007 Recovery

- **Pumping Well:** LW2-2007
- **Casing radius:** 0.1016 [m]
- **Boring radius:** 0.1556 [m]
- **Screen length:** 6.1 [m]
- **Aquifer Thickness:** 12 [m]

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**Pumping Test Analysis Report**

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton

---

**Pumping Test:** LW2-2007 Recovery  
**Analysis Method:** Theis Recovery

**Analysis Results:**  
Transmissivity: \( 3.50 \times 10^3 \) [m²/d]  
Conductivity: \( 2.92 \times 10^2 \) [m/d]

**Test parameters:**  
Pumping Well: LW2-2007  
Aquifer Thickness: 12 [m]  
Confined Aquifer

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**Comments:**  
Static Water Level: 7.203 metres below top of casing  
Land Location: SE Lsd 03-35-25-04 W2

---

Evaluated by: Devin Mutschler, P.Eng., P.Geo  
Evaluation Date: 15/06/2007
**APPENDIX B-3(A)**

*Test Well PW2B-2011*  
*Pumping Test Data*
## Pumping Test Data Report

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton

---

### Data observed at: PW2B-2011

**Distance from PW:** 0 [m]  
**Depth to Static WL:** 4.946 [m]  
**Location:** Yorkton, Saskatchewan

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo  
**Date:** 16/11/2011

---

### Pumping Test: PW2B-2011 Pumping Test

**Casing radius:** 0.1016 [m]  
**Boring radius:** 0.1556 [m]  
**Screen length:** 12.19 [m]  
**Aquifer Thickness:** 24 [m]

### Depth to WL vs. Time

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### Data observed at: PW2B-2011

**Distance from PW:** 0 [m]

**Depth to Static WL:** 4.946 [m]

**Location:** Yorkton, Saskatchewan

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

**Date:** 16/11/2011

### Pumping Test Data Report

**Pumping Test:** PW2B-2011 Pumping Test

**Pumping Well:** PW2B-2011

**Casing radius:** 0.1016 [m]

**Boring radius:** 0.1556 [m]

**Screen length:** 12.19 [m]

**Aquifer Thickness:** 24 [m]

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PW2B-2011 (PW2B-2011 Pumping Test)

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results:
- Transmissivity: $1.25E+4 \text{ [m}^2/\text{d]}$
- Conductivity: $5.21E+2 \text{ [m/d]}$

Test parameters:
- Pumping Well: PW2B-2011
- Casing radius: 0.1016 [m]
- Screen length: 12.19 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 2966.1 [m$^3$/d]

Aquifer Thickness: 24 [m]

Static Water Level: 4.946 metres below top of casing
Land Location: NE Lsd 02-35-25-04 W2
**Pumping Test Data Report**

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton

**Date:** 16/11/2011

**Pumping Test:** PW2B-2011 Pumping Test

**Casing radius:** 0.1016 [m]  
**Boring radius:** 0.1556 [m]

**Screen length:** 12.19 [m]

**Aquifer Thickness:** 24 [m]

**Location:** Yorkton, Saskatchewan

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

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**Data observed at:** Piezometer 36-75

**Distance from PW:** 169.1 [m]

**Depth to Static WL:** 7.36 [m]

**Location:** Yorkton, Saskatchewan

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

**Date:** 16/11/2011

**Pumping Test:** PW2B-2011 Pumping Test

**Pumping Well:** PW2B-2011

**Casing radius:** 0.1016 [m]

**Boring radius:** 0.1556 [m]

**Screen length:** 12.19 [m]

**Aquifer Thickness:** 24 [m]

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Pumping Test: PW2B-2011 Pumping Test

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results:
- Transmissivity: $1.11 \times 10^4$ [m$^2$/d]
- Conductivity: $4.64 \times 10^2$ [m/d]

Test parameters:
- Pumping Well: PW2B-2011
- Aquifer Thickness: 24 [m]
- Casing radius: 0.1016 [m]
- Screen length: 12.19 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 2966.1 [m$^3$/d]

Comments:
- Static Water Level: 7.360 metres below top of casing
- Land Location: SW Lsd 08-35-25-04 W2
- Distance from PW2B-2011: 169 metres

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 28/11/2011
### Pumping Test Analysis Report

**Project:** City of Yorkton  
**Client:** City of Yorkton  

**Pumping Test:** PW2B-2011 Pumping Test  
**Analysis Method:** Theis

**Analysis Results:**  
- Transmissivity: $7.83 \times 10^3 \text{ [m}^2\text{/d]}$  
- Conductivity: $3.26 \times 10^2 \text{ [m/d]}$  
- Storativity: $5.98 \times 10^{-2}$

**Test parameters:**  
- Pumping Well: PW2B-2011  
- Aquifer Thickness: 24 [m]  
- Casing radius: 0.1016 [m]  
- Screen length: 12.19 [m]  
- Boring radius: 0.1556 [m]  
- Discharge Rate: 2966.1 [m$^3$/d]

**Comments:** Static Water Level: 7.360 metres below top of casing  
Land Location: SW Lsd 08-35-25-04 W2  
Distance from PW2B-2011: 169 metres

Evaluated by: Devin Mutschler, P.Eng., P.Geo  
Evaluation Date: 28/11/2011
**Pumping Test Analysis Report**

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**  

**Client:** City of Yorkton

---

**Pumping Test:** PW2B-2011 Pumping Test  
**Analysis Method:** Cooper-Jacob Time-Drawdown

**Analysis Results:**  
- **Transmissivity:** $3.35 \times 10^4$ [m²/d]  
- **Conductivity:** $1.40 \times 10^3$ [m/d]

**Test parameters:**  
- **Pumping Well:** PW2B-2011  
- **Aquifer Thickness:** 24 [m]  
- **Casing radius:** 0.1016 [m]  
- **Confined Aquifer**  
- **Screen length:** 12.19 [m]  
- **Boring radius:** 0.1556 [m]  
- **Discharge Rate:** 2966.1 [m³/d]

**Comments:**  
- Static Water Level: 8.710 metres below top of casing  
- Land Location: NE Lsd 08-35-25-04 W2  
- Distance from PW2B-2011: 267 metres

**Evaluated by:** Devin Mutschler, P.Eng., P.Geo  
**Evaluation Date:** 28/11/2011
Pumping Test: PW2B-2011 Pumping Test
Analysis Method: Theis

Analysis Results:
- Transmissivity: 2.84E+4 [m²/d]
- Conductivity: 1.19E+3 [m/d]
- Storativity: 1.50E-2

Test parameters:
- Pumping Well: PW2B-2011
- Aquifer Thickness: 24 [m]
- Casing radius: 0.1016 [m]
- Confined Aquifer
- Screen length: 12.19 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 2966.1 [m³/d]

Comments:
- Static Water Level: 8.710 metres below top of casing
- Land Location: NE Lsd 08-35-25-04 W2
- Distance from PW2B-2011: 267 metres

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 28/11/2011
**Beckie Hydrogeologists (1990) Ltd.**
381 Park Street
Regina, Saskatchewan S4N 5B2
Phone: (306) 721-0846  Fax: (306) 721-7729
Email: bhl@sasktel.net

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### Pumping Test Data Report

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton

**Pumping Test:** PW2B-2011 Pumping Test

**Distance from PW:** 541.46 [m]  
**Casing radius:** 0.1016 [m]

**Depth to Static WL:** 6.575 [m]  
**Boring radius:** 0.1556 [m]

**Location:** Yorkton, Saskatchewan  
**Screen length:** 12.19 [m]

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

**Date:** 16/11/2011  
**Aquifer Thickness:** 24 [m]

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### Pumping Test Data Report

**Project:** City of Yorkton  
**Client:** City of Yorkton  
**Location:** Yorkton, Saskatchewan

**Data observed at:** BHL2011-163APZ

- **Distance from PW:** 548.3 [m]
- **Depth to Static WL:** 7.3 [m]
- **Location:** Yorkton, Saskatchewan
- **Test Supervision:** Devin Mutschler, P.Eng., P.Geo
- **Date:** 16/11/2011

**Pumping Test:** PW2B-2011 Pumping Test

- **Pumping Well:** PW2B-2011
- **Casing radius:** 0.1016 [m]
- **Boring radius:** 0.1556 [m]
- **Screen length:** 12.19 [m]
- **Aquifer Thickness:** 24 [m]

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### Pumping Test Data Report

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**Data observed at:** BHL2011-163BPZ

**Distance from PW:** 550.98 [m]

**Depth to Static WL:** 7.374 [m]

**Location:** Yorkton, Saskatchewan

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

**Date:** 16/11/2011
APPENDIX B-3(b)

Test Well PW2B-2011
Recovery Test Data
### Project: City of Yorkton
### Water Treatment Plant Wastewater Reuse Feasibility Study

**Client:** City of Yorkton

**Location:** Yorkton, Saskatchewan

**Date:** 17/11/2011

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

**Pumping Test:** PW2B-2011 Recovery

**Pumping Well:** PW2B-2011

**Casing radius:** 0.1016 [m]

**Boring radius:** 0.1556 [m]

**Screen length:** 12.19 [m]

**Aquifer Thickness:** 24 [m]

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Pumping Test:  PW2B-2011 Recovery

Analysis Method:  Theis Recovery

Analysis Results:  
- Transmissivity: 1.76E+4 [m²/d]
- Conductivity: 7.35E+2 [m/d]

Test parameters:  
- Pumping Well: PW2B-2011
- Aquifer Thickness: 24 [m]
- Casing radius: 0.1016 [m]
- Screen length: 12.19 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 2966.1 [m³/d]
- Pumping Time: 1200 [min]

Comments:  
- Static Water Level: 4.946 metres below top of casing
- Land Location: NE Lsd 02-35-25-04 W2

Evaluated by:  Devin Mutschler, P.Eng., P.Geo
Evaluation Date:  28/11/2011
Pumping Test Data Report

**Project:** City of Yorkton  
**Client:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Pumping Test:** PW2B-2011 Recovery  
**Pumping Well:** PW2B-2011  
**Casing radius:** 0.1016 [m]  
**Boring radius:** 0.1556 [m]  
**Screen length:** 12.19 [m]

**Aquifer Thickness:** 24 [m]

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Pumping Test Analysis Report

Project: City of Yorkton
Water Treatment Plant Wastewater Reuse Feasibility Study

Client: City of Yorkton

Pumping Test Analysis Report

Pumping Test: PW2B-2011 Recovery
Analysis Method: Theis Recovery

Analysis Results:

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<tr>
<td>Conductivity</td>
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</tr>
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Test parameters:

- Pumping Well: PW2B-2011
- Aquifer Thickness: 24 [m]
- Casing radius: 0.1016 [m]
- Screen length: 12.19 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 2966.1 [m³/d]
- Pumping Time: 1200 [min]

Comments:
Static Water Level: 7.360 metres below top of casing
Land Location: SW Lsd 08-35-25-04 W2
Distance from PW2B-2011: 169 metres

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 28/11/2011
**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton

**Data observed at:** BHL2011-165APZ

**Distance from PW:** 266.55 [m]

**Depth to Static WL:** 8.71 [m]

**Location:** Yorkton, Saskatchewan

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo

**Date:** 17/11/2011

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</table>
Pumping Test Analysis Report

Project: City of Yorkton
Water Treatment Plant Wastewater Reuse Feasibility Study

Client: City of Yorkton

Pumping Test: PW2B-2011 Recovery
Analysis Method: Theis Recovery

Analysis Results:
- Transmissivity: 2.11E+4 [m²/d]
- Conductivity: 8.81E+2 [m/d]

Test parameters:
- Pumping Well: PW2B-2011
- Aquifer Thickness: 24 [m]
- Casing radius: 0.1016 [m]
- Confined Aquifer
- Screen length: 12.19 [m]
- Boring radius: 0.1556 [m]
- Discharge Rate: 2966.1 [m³/d]
- Pumping Time: 1200 [min]

Comments:
- Static Water Level: 8.710 metres below top of casing
- Land Location: NE Lsd 08-35-25-04 W2
- Distance from PW2B-2011: 267 metres

Evaluated by: Devin Mutschler, P.Eng., P.Geo
Evaluation Date: 29/11/2011
Pumping Test Data Report

Project: City of Yorkton
Water Treatment Plant Wastewater Reuse Feasibility Study
Client: City of Yorkton

Data observed at: Piezometer 20-79

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Pumping Test: PW2B-2011 Recovery

Distance from PW: 541.46 [m]
Depth to Static WL: 6.575 [m]
Location: Yorkton, Saskatchewan

Test Supervision: Devin Mutschler, P.Eng., P.Geo

Date: 17/11/2011

Casing radius: 0.1016 [m]
Boring radius: 0.1556 [m]
Screen length: 12.19 [m]
Aquifer Thickness: 24 [m]
### Pumping Test Data Report

**Project:** City of Yorkton  
**Water Treatment Plant Wastewater Reuse Feasibility Study**

**Client:** City of Yorkton

---

**Data observed at:** BHL2011-163APZ  
**Pumping Test:** PW2B-2011 Recovery

**Distance from PW:** 548.3 [m]  
**Pumping Well:** PW2B-2011

**Depth to Static WL:** 7.3 [m]  
**Casing radius:** 0.1016 [m]

**Location:** Yorkton, Saskatchewan  
**Boring radius:** 0.1556 [m]

**Test Supervision:** Devin Mutschler, P.Eng., P.Geo  
**Screen length:** 12.19 [m]

**Date:** 17/11/2011  
**Aquifer Thickness:** 24 [m]

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<tr>
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Pumping Test Data Report

Project: City of Yorkton
Water Treatment Plant Wastewater Reuse Feasibility Study

Client: City of Yorkton

Data observed at: BHL2011-163BPZ

Distance from PW: 550.98 [m]
Depth to Static WL: 7.374 [m]
Location: Yorkton, Saskatchewan

Test Supervision: Devin Mutschler, P.Eng., P.Geo
Date: 17/11/2011

Pumping Test: PW2B-2011 Recovery

Casing radius: 0.1016 [m]
Boring radius: 0.1556 [m]
Screen length: 12.19 [m]
Aquifer Thickness: 24 [m]

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**APPENDIX C**

*Raw Water Quality Data*
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**Major Constituents**

| Constituent | mg/L | | | | | | |
|-------------|------|------|------|------|------|------|------|------|
| Bicarbonate, HCO₃⁻ | 500 | 528 | 531 | 572 | 553 | 483 | 461 | none |
| Calcium, Ca | 90 | 106 | 136 | 139 | 103 | 90 | 105 | none |
| Carbonate, CO₃⁻ | 4 | <1 | <1 | <1 | <1 | <1 | <1 | none |
| Chloride, Cl | 32 | 18 | 16 | 123 | 55 | 92 | 70 | 250 |
| Hydroxide, OH⁻ | 68 | 64 | 65 | 95 | 79 | 52 | 83 | none |
| Magnesium, Mg | 5.5 | 5.1 | 7.3 | 7.8 | 6.8 | 7.0 | 7.4 | none |
| Potassium, K | 35 | 26 | 48 | 74 | 124 | 47 | 46 | 300 / 200 |
| Sodium, Na | 1330 | 997 | 260 | 320 | 350 | 350 | 81 | 270 |
| Sulphate, SO₄²⁻ | 866 | 877 | 1060 | 1330 | 1270 | 852 | 1040 | 1500 |
| Sum of Ions (calculated) | 548 | 433 | 435 | 469 | 453 | 396 | 378 | 500 |
| Total Hardness | 504 | 527 | 606 | 737 | 582 | 438 | 438 | 603 |

**Nutrients/Organics**

| Constituent | mg/L | | | | | | |
|-------------|------|------|------|------|------|------|------|------|
| Ammonia as Nitrogen | - | - | 0.67 | - | - | - | - | none |
| Nitrate, NO₃⁻ | 1.7 | <0.04 | <0.04 | <0.04 | 4.0 | <0.04 | <0.04 | 45 |
| Total Organic Carbon, TOC | 2.6 | 3.4 | - | - | - | - | - | none |
| Dissolved Organic Carbon, DOC | - | - | 2.6 | 3.4 | - | - | - | none |

**Trace Constituents**

| Constituent | mg/L | | | | | | |
|-------------|------|------|------|------|------|------|------|------|
| Alumium, Al | 0.0032 | 0.0038 | 0.0088 | - | - | - | - | none |
| Arsenic, As | 0.0044 | 0.021 | 0.015 | - | - | - | - | 25 / 10 |
| Barium, Ba | 0.0001 | <0.0001 | 0.0004 | - | - | - | - | none |
| Chromium, Cr | 0.0005 | <0.0005 | <0.0006 | - | - | - | - | 0.05 |
| Copper, Cu | 0.0002 | 0.0003 | 0.0006 | - | - | - | - | 1.0 |
| Iron, Fe | 10.7 | 1.83 | 2.68 | 2.23 | 0.81 | 0.91 | 2.2 | 0.3 |
| Lead, Pb | 0.0001 | 0.0001 | 0.0002 | - | - | - | - | 0.01 |
| Manganese, Mn | 0.63 | 0.69 | 0.760 | 1.03 | 0.33 | 0.75 | 0.66 | 0.05 |
| Zinc, Zn | 0.0019 | 0.0009 | 0.0016 | - | - | - | - | 5 |

**Physical Properties**

| Constituent | mg/L | | | | | | |
|-------------|------|------|------|------|------|------|------|------|
| Total Dissolved Solids, TDS | 630 | 635 | 832 | 1140 | 1030 | 649 | 899 | 1500 / 500 |
| Total Suspended Solids, TSS * | <1 | 4 | <1 | - | - | - | - | 15 |
| Turbidity * | NTU | 0.1 | 0.1 | 0.1 | - | - | - | 0.3 to 1.0 |
| Sp. Conductivity | 988 | 997 | 1210 | 1640 | 1530 | 1090 | 1300 | none |
| pH of Water | 8.30 | 8.26 | 7.67 | 8.01 | 7.83 | 8.06 | 8.01 | 6.5 - 9.0 |

**Radionuclides**

| Constituent | mg/L | | | | | | |
|-------------|------|------|------|------|------|------|------|------|
| Uranium, total | 14 | 10 | 1.3 | - | - | - | - | 20 |

---

**Legend**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>MAC</td>
<td>Maximum Acceptable Concentration</td>
</tr>
<tr>
<td>AO</td>
<td>Aesthetic Objective</td>
</tr>
<tr>
<td>*</td>
<td>Analyses performed on nitric acid preserved sample</td>
</tr>
<tr>
<td>&lt;</td>
<td>Not detected at the concentration stated</td>
</tr>
</tbody>
</table>
### Chemical Analyses - Raw Water Quality - Production Wells

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<tr>
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</thead>
<tbody>
<tr>
<td>SRC</td>
<td>SRC-49335</td>
<td>SRC-49337</td>
<td>SRC-49406</td>
<td>SRC-49407</td>
<td>SRC-49408</td>
<td>SRC-49408</td>
<td>SRC-49408</td>
<td>SRC-50237</td>
<td>SRC-50378</td>
<td>SRC-49398</td>
<td>SRC-50378</td>
<td>SRC-50240</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>39.62</td>
<td>40.84</td>
<td>49.22</td>
<td>33.00</td>
<td>35.05</td>
<td>34.14</td>
<td>17.68</td>
<td>30.91</td>
<td>40.39</td>
<td>22.57</td>
<td>58.11</td>
<td></td>
</tr>
<tr>
<td>Precipitation Depth (mm below ground)</td>
<td>16.15</td>
<td>15.08</td>
<td>27.13</td>
<td>39.62</td>
<td>40.84</td>
<td>49.22</td>
<td>33.00</td>
<td>35.05</td>
<td>34.14</td>
<td>17.68</td>
<td>30.91</td>
<td></td>
</tr>
</tbody>
</table>

### Major Constituents

- **Brackishwater, HCO₃** mg/L: 512, 521, 532, 511, 577, 317, 367, 504, 479, 569, 566, 561, 520, 572
- **Calcium, Ca** mg/L: 121, 118, 135, 142, 140, 94, 75, 137, 177, 162, 180, 211, 140, 187
- **Carbonate, CO₃** mg/L: <1, 1, <1, 1, <1, 1, <1, 1, <1, 1, <1, 1, <1, 1, <1
- **Chloride, Cl⁻** mg/L: 21, 20, 18, 37, 44, 8, 9, 54, 76, 63, 9, 5, 6, 12, 250
- **Bicarbonate, OH⁻** mg/L: 7, 6, 6, 7, 6, 5, 4, 6, 7, 6, 5, 6, 12, 240
- **Magnesium, Mg²⁺** mg/L: 40, 60, 64, 70, 65, 63, 42, 86, 87, 71, 61, 66, 62, 64, 250
- **Potassium, K** mg/L: 7.0, 6.9, 7.1, 14, 7.8, 7.9, 7.4, 8.5, 10, 8.5, 10, 9.7, 8.5, 8.7
- **Sodium, Na** mg/L: 34, 35, 43, 40, 31, 14, 33, 120, 196, 32, 27, 17, 16, 17
- **Sulphate, SO₄²⁻** mg/L: 18.0, 17.9, 24.0, 32.0, 220, 140, 140, 370, 610, 240, 280, 360, 160, 280, 500

### Nutrients/Organics

- **Nitrate, NO₃** mg/L: <0.0005, 0.0051, 0.0019, <0.0005, 0.010, 0.018, 0.022, <0.0005, 0.0012, 0.0022, 0.0002, 0.0002, 0.0002, 0.0002, 0.0002, 0.0002
- **Ammonium, NH₄** mg/L: 0.0004, 0.0001, 0.0002, 0.0001, 0.0002, 0.0001, 0.0001, <0.0001, 0.0001, <0.0001, 0.0001, 0.0001, 0.0001, 0.0001, 0.0001

### Trace Metals

- **Barium, Ba** mg/L: 0.034, 0.040, 0.033, 0.043, 0.022, 0.140, 0.049, 0.018, 0.022, 0.028, 0.027, 0.012, 0.032, 0.018, 1.0
- **Chromium, Cr** mg/L: <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005, <0.0005

### Physical Properties

- **Turbidity** *: 1110, 1100, 1210, 1370, 1310, 744, 813, 1260, 1990, 1150, 1130, 1230, 923, 1140, 1500
- **TDS** *: 713, 707, 822, 1080, 866, 497, 532, 1010, 1390, 926, 901, 971, 703, 904
- **pH of Water**: 6.78, 7.76, 7.83, 8.43, 4.67, 5.78, 7.07, 7.95, 7.92, 7.82, 7.75, 7.72, 7.88, 7.44

### Legend

- MAC = Maximum Acceptable Concentration
- AO = Aesthetic Objective
- < Not detected at the concentration stated
Appendix I - Conceptual Drawings

- Concept Plan Option I
- Concept Plan Option II
- CP-4
- Preliminary Overall Masterplan
- Preliminary Soccer Facility Master Plan
- Preliminary Soccer Facility Site Sections
Appendix J - Construction Drawings
WATER SYSTEM EXPANSION
QUEEN STREET WTP
CONTRACT 9:
PROCESS WASTEWATER TREATMENT SYSTEM

AE PROJECT No: 20034904.120
ISSUED FOR CONSTRUCTION
This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

DATE: 2011-07-26 , Brady Marshall

DRAWING REDUCED TO HALF SIZE
DRAWING REDUCED TO HALF SIZE

PLAN SCALE: 1:1000

STORM WATER POND
FLOOR ELEV. 507.2m
SIDE SLOPE 6:1

STORM WATER POND
FLOOR ELEV. 507.6m
SIDE SLOPE 6:1

RE-GRAD ED DITCH AT 0.3%

20034904-120-104

STORM WATER POND
FLOOR ELEV. 506.0m
SIDE SLOPE 6:1

TREE (TYP.)
NOT ALL SHOWN FOR CLARITY

REVISIONS