Hydrogeological Investigation
Grasswood Estates Subdivision
W1/2 26-35-5 West of 3rd Meridian

R.M. of Corman Park, Saskatchewan

File S1607.7 14 September 2012

Executive Summary

Clifton Associates Ltd. was retained to conduct a hydrogeological investigation of the proposed Grasswood Estates subdivision development (Site) located south of the City of Saskatoon. The objective of the work was to characterize the groundwater conditions with particular emphasis on characterizing the cumulative impact of 80 individual proposed septic disposal fields. Individual waste water systems and a communal water supply system are proposed.

The site is located on the Saskatoon Low. The stratigraphy consists of sediments of the Haultain Formation overlying thick sediments of the Battleford Till overlying clay shale bedrock of the Bearpaw Formation. The Haultain formation is a glacio-fluvial unit consisting of a surficial sand unit underlain by interbedded sand and clay facies. At the site, surficial sand predominates with stratified clay present within 2 m of surface in several instances.

Site investigations and piezometer installations were conducted on 26 June 2012 and 28 June 2012 with groundwater levels obtained within days of the installation. Thirteen piezometers were installed to a depth of between 6 m to 14 m to characterize the soil conditions and measure the groundwater level. An additional piezometer from a previous investigation completed in 2008 was also included in the monitoring program. Preliminary monitoring of groundwater depths, groundwater chemistry, and hydraulic conductivity analysis was performed on each piezometer.

Water wells within a 1 km radius of the site were identified, surveyed and water elevation measurements obtained. A regional piezometric surface was developed from the on-site piezometers and the adjacent water wells. Groundwater flow is from east to west.

The depth from surface to the normal groundwater levels varied from 1.2 m to 5.8 m. The shallowest groundwater levels were observed near the north east corner of the Site and also in the South east low relief area of the Site. Deeper groundwater depths were observed in the central east portions of the Site.

Background groundwater chemistry was conducted for two purposes, one of which was to characterize baseline Site conditions, and second was to provide data for development of the contaminant transport model to simulate groundwater conditions based on our understanding of the effluent loading proposed. Baseline results indicate that existing nitrate impacts are present in the north central region of the site, elevated levels of sulphates, chlorides and TDS

in the south region, and throughout the site elevated levels of metals exist. Elevated concentration of metals are not uncommon in Saskatchewan groundwater. A spatial pattern was not apparent to correlate the concentrations; therefore no source could be identified. They are presumed to be background conditions at this time. The south eastern area has elevated TDS, alkalinity, sulphates and chloride. In the area where we see high alkalinity, the site is low lying, with potential for accumulation of alkali conditions. This may have occured as a result of evapotranspiration creating elevated concentrations as noted above. A land use investigation indicated that an intensive livestock farm existed in the area where nitrate concentrations are elevated.

The proposed development consists of 80 lots over an area of 128 hectares. Potable water will be piped to the site. No groundwater wells for potable water are proposed. The proposed system is the FAST® Wastewater Treatment System. Homeowners will be required to install this system. It provides a 70% reduction in nitrate concentration in the effluent.

A groundwater model was developed for the site using Visual MODFLOW software. A single strata model extending from the east of the site to west of the site was developed and calibrated to the existing groundwater elevations. Nitrate was the contaminant of concern modeled. A 100 year model duration was used.

Nitrate sources consisted of the individual effluent disposal fields at typical locations within each proposed lot. In addition, existing nitrate of 51 mg/L was encountered in one of the piezometers and is associated with previous cattle operations at the site. This source was also modeled. Two source concentrations were modeled. The first is 40 mg/L and reflects the nitrate concentration in the treatment systems proposed for the site. The second concentration is 350 mg/L and associated with untreated effluent. Model predictions were obtained for each source concentration with and without the existing cattle operation source.

Model results predict that the existing cattle operation source will result in off-site concentrations of approximately 30 mg/L with a concentration of 10 mg/L extending to the west bound of the model.

For the 40 mg/L source, the predicted maximum off site concentration is 1 mg/L with concentrations within the development of approximately 10 mg/L in the low hydraulic conductivity areas and typically up to 0.5 mg/L in the high hydraulic conductivity areas.

For the 350 mg/L source the maximum offsite concentration resulting from the development is proportionally higher. In the northern sections the concentration within the development are up to 10 mg/L. In the southern section the local concentrations are generally in the 30 mg/L range with a maximum off site concentration of 10 mg/L.

The predicted impact from the development is best represented by the 40 mg/L case with a maximum off site nitrate concentration of 1 mg/L. The predicted impact from the development is much less than the present impact from the historic cattle operation.

Source removal in the cattle operation area is recommended. Gradual decreases in nitrate concentrations are anticipated upon removal.

The predicted nitrate impacts are additive to the existing conditions and nitrate that may be present from the upstream development. The area appears fully developed at a lower density than the proposed development. Similar to lower concentrations than predicted in this model are anticipated. There was no evidence of upstream nitrate in the monitoring; however an expanded upstream monitoring system is recommended.

In summary nitrate concentrations off site resulting from the development of less than 1 mg/L are predicted.

Site suitability for adsorption fields was evaluated and tabulated at each bore hole location. The most sensitive soil in the upper 2 m was evaluated. In general all soil logged in the field as “Sand” was supported by laboratory testing to be a suitable soil. Soil logged as clay was generally not suitable without further evaluation. If the clay is within 2 m of the surface, then further evaluation is required. Bore holes with measured or interpreted groundwater elevations within 2 m of surface were identified. In these areas the adsorption field would need to be raised or a mound system employed.

High groundwater table is a potential hazard for basement construction. A map was prepared identifying areas of high groundwater table. Approximately 20 lots are affected. Development in these areas would need to raise the elevation of the basement floor to be above the groundwater table to minimize the potential for groundwater infiltration.

Two storm water detention ponds are proposed. Modeling was conducted to estimate the groundwater inflow to the ponds for various pond water elevations.

Recommendations include:

- Installation of a groundwater monitoring system at the up and downstream boundaries of the site.
- Removal of the impacted surface soil in the area of the cattle operation. Search for and remove buried animal carcasses.
- Conduct site specific adsorption field assessments for each of the disposal sites when the locations are defined.
- Assess site specific groundwater conditions for each building site prior to construction.

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1.0 Introduction

1.1 General

Clifton Associates Ltd. (CAL) was retained by Urban Elements Development Corporation to conduct a cumulative impact assessment of the proposed 80 lot residential subdivision, namely Grasswood Estates. The objective of the work was to assess the potential impacts of the proposed individual septic systems on the groundwater system. The potential contaminants of concern are constituents of domestic sewage, most notably nitrate. A previous assessment was conducted on this site summarized in "Subdivision Development Investigation Casa Grande" dated August 29, 2008 by Clifton Associates Ltd. This report was commented on by Saskatchewan Public Health and it was determined that further analysis was required.

As quoted by Brent Latimer with the Saskatoon Public Health Region via email:

Due to human health and environmental concerns related to the density of the development, it is recommended that the proponent determine the larger scale environmental impact of this and surrounding developments and to identify an appropriate method of onsite wastewater treatment and disposal…

The proposed Grasswood Estates subdivision (Site) is located 4 km south of Saskatoon, Saskatchewan east of Highway 11 on the corner of Grasswood Road and Preston Avenue. The site location is shown in Drawing 01.

The legal land description is W1/2-26-35-5W3. The land is presently used as hay land but surrounds three residential acreages located near the western border of the Site which currently exist within the section. External land use is predominantly residential with Corman Park School neighbouring the Site to the south west.

1.2 Scope of Work

The objective of this investigation is to characterize the hydrogeologic conditions within the proposed Grasswood Estates subdivision with particular emphasis on the potential impact of groundwater quality resulting from treated effluent disposal in sewage mounds.

The scope of the investigation included the following:

- Review of existing site and regional geology information and compilation of the regional geology;
- Field drilling investigation including installation of piezometers, measurement of groundwater elevation, and response testing to assess soil hydraulic conductivity;
- Identify nearby wells and water sources within a 1 km radius;
- Identify effluent loading rates;
- Development of a fate and transport groundwater model to assess cumulative impacts; and,
- Report the hydrogeologic conditions and the model results.

1.3 Authorization

Authorization to proceed with this work was received from Mr. Darren Hagen, by email dated 25 June 2012.

2.0 Proposed Development

The proposed development consists of 80 lots each averaging 2.47 hectares in size as shown in Drawing 02. Individual waste water systems and a communal water supply system is proposed.

The proposed septic system for use on site is the MicroFast 0.5 Waste Water Treatment System with a Type II mound. System details were provided by Mr. Greg Plett with Tanksmart. System details can be found in Appendix A.

Many parameters are significant when considering effluent impact, such as Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), and nitrates. For the purposes of this analysis, nitrogen was used as the contaminant source to assess cumulative impact.

To calculate the areas that would be subject to loading on each residential lot, direction was provided by Greg Plett with Tanksmart. In summary, the loading area was assumed to be a Type II mound which consists of perforated laterals with a gravel bed and sand media.

Loading volumes were based on the estimated volume of flow per day per household. This volume was calculated based on 75 gal/person/day x 1.5 people/bedroom. It was assumed that a 4 bedroom house would be the average in this area, which may be conservative. Calculated volume was 450 gallons per day. Due to using a package treatment system, as per the Saskatchewan Onsite Wastewater Disposal Guidelines, a 30% reduction in the infiltrative surface is required. Actual infiltrative surface area required was calculated to be 450 sq ft/0.63 gallons/sq ft x 0.7. Total surface area of the Type II mound was calculated to be 500 square feet as provided by information provided by TankSmart. A 22.4 ft^2 footprint was used as the mound dimensions for the purposes of modeling.

Finally, concentration of the effluent needed to be defined. This was based on recommended loading rates according to the On-Site Wastewater Treatment Systems in Subdivisions 29 September 2009 Project No SH/SWA H01-2009 Final Report. Effluent nitrate concentration selected was 40 mg/L as N. TankSmart ® loading rates were discussed in the literature, however a loading rate could not be well defined, therefore to be conservative, the recommended loading rate of 40 mg/L was used.

3.0 Field and Laboratory Investigation

3.1 Field Drilling

The subsurface investigation was conducted in two drilling events dated 26 June 2012 and 28 June 2012. Prior subsurface investigation had been conducted in 2008 by Clifton Associates Ltd., however, an initial site investigation conducted on 24 June 2012 indicated that all previously installed piezometers had been destroyed with the exception of one, namely BH104. As such, updated groundwater data was required in response to the request from Saskatoon Health Region to comply with updated standards for approval.

The drilling and installation of the 200 series of piezometers was conducted using a truck-mounted drill rig and 125 mm diameter solid stem continuous flight auger completed from surface to a depth of between 6.0 m to 15.0 m.

Piezometers were logged at 1.5 m intervals and sampled where a change in stratigraphy was noted. Laboratory soil testing consisted of determination of moisture content on all samples, hydrometer particle size analysis and Unified Soil Classifications (USC) were performed on selected samples. Results are provided in **Bore Hole Logs and Laboratory Test Data** appended. The 100 series bore hole logs are included for reference as well.

Piezometers were constructed using 50 mm diameter Schedule 40 PVC pipe with PVC screens. The piezometers were installed with 1.52 m screen length and the screen was surrounded with either frac sand or slough material while the remainder of the annulus was backfilled with bentonite.

Piezometer locations and elevations were determined by GPS RTK survey. They were referenced to a local coordinate system developed on Site.

Observations made during the field investigations, visual descriptions and the results of laboratory tests are recorded in the **Bore Hole Logs and Laboratory Test Data**, and are appended to this report. An explanation of the symbols and terms used in the bore hole logs is included in the **Symbols and Terms** section of this report.

3.2 Groundwater Monitoring

Groundwater elevations were monitored within 6 days of the holes being drilled. Table 3.2-1 presents the groundwater elevation measurements. Water levels ranged from 1.4 m to 5.6 m during the July monitoring program. The bore hole locations are presented in Drawing 02. A summary of the monitor well conditions are included in Table 3.2-1 Site Groundwater Elevations and Field Measurements.

Water samples were obtained from piezometers on the site and chemical analyses conducted. Prior to sampling, the wells were then purged using dedicated bailers. Approximately three volumes of standing water were purged from the groundwater monitor wells.

Groundwater samples were collected from BH104, BH201, BH202, BH203, BH204, BH206, BH207, BH208, BH210, BH211, BH212 and BH213 on 4 July 2012 and were submitted to ALS Analytical Labs, Saskatoon, Saskatchewan. BH209 was dry at time of sampling. Groundwater samples were analyzed for Routine- Potable Water, Health and Toxicity Metals, Total Coliforms including E. Coli and Heterotrophic Plate Count, and BOD. Laboratory results can be found in Appendix B.

Groundwater samples were collected using dedicated bailers and nitrile gloves for each monitor well to reduce any cross-contamination. All samples were preserved with the applicable acid supplied by ALS. The dedicated bailers remain in each monitor well for future monitoring and sampling.

3.3 Hydraulic Conductivity

Falling head (slug) tests were performed in 9 of the piezometers installed in June 2012 (BH201, BH202, BH203, BH204, BH207, BH208, BH210, BH211 and BH212) as well as BH104 from the previous investigation. The test is used to determine the hydraulic conductivity of the soil immediately surrounding the piezometer screen. An automated Solinst levelogger was put down the hole, and a metal slug inserted into the groundwater to raise the water above its equilibrium level. The logger records the falling hydraulic head as it comes back to its equilibrium level. The data was analyzed manually by hand as well as using Waterloo Hydrogeologic Aquifer Test program, and the graphical representations of the Hvorslev method analysis are appended to this report in Graphical Analysis of Hydraulic Conductivity (Appendix C). The hydraulic conductivities of the bore holes including their piezometer tip elevation are included in Table 3.3-1. The piezometers presented in Table 3.3-1 all had their screen interval within a sand stratum, which generally was some silt to silty, and had trace clay. Most of the piezometers were installed in sloughing conditions. Stratified cross-section indicating piezometer depth and associated stratum is provided in Drawings 03 & 04.

Table 3.3-1
Hydraulic Conductivity Results
Grasswood Hydrogeology

Piezometer	Bottom of Piezometer Elevation (masl)	Hydraulic Conductivity (Hvorslev) Aquifer Test (m/s)
BH104	504.1*	3.28E-06
BH201	505.5	1.12E-05
BH202	499.5	6.57E-06
BH203	505.7	1.21E-06
BH204	505.2	1.52E-05
BH207	504.4	4.53E-06
BH208	506.8	1.32E-05
BH210	506.9	1.13E-05
BH211	505.7	1.58E-06
BH212	496.5	1.19E-06
Geometric Mean		4.73E-06

**Adjusted 100 Series Bore hole to updated local coordinate system and elevations (23.5 m vertical variance)*

3.4 Surrounding 1 Kilometer Water Well Investigation

Saskatchewan Watershed Authority website indicated that approximately 52 wells were located within 1 km of Site. Attempts to locate these wells occurred between 29 June 2012 and 3 July 2012. As a result, 30 were identified, geo-referenced and tied to the established local coordinate system and groundwater elevations recorded. Results for this investigation are provided in the attached Table 3.4-1 Surrounding Water Well Elevations. See Drawing 05 for locations of the wells.

Pumping activities were not monitored prior to collection of groundwater elevations noted in this report and as such pumping influences were not considered. However, in spite of potential errors due to pumping of domestic wells, a consistent groundwater gradient was established.

Piped domestic water is provided in the east subdivision. The wells present are used for irrigation and non-potable use. Piped domestic water is available in the west subdivision; however it is not clear whether all of the dwellings are connected to the piped system.

4.0 Site Characteristics

4.1 Regional Geology

4.1.1 Regional Stratigraphy

The Grasswood subdivision lies in the Grasswood area south of Saskatoon, about 6 km south of the junction of highways 11 and 16. It lies west of Highway 11, in the southern half of a rectangle bounded on the west by Range Road 3052 (Preston Ave.), on the east by the CNR track, on the south by Township Road 354 (Baker Road) and on the north by Township Road 360 (Grasswood Road).

Most of the area lies just above the 510 m contour elevation. Surface drainage of the site appears to be easterly, into a southeasterly trending series of small sloughs.

The regional stratigraphy was developed from a review of published literature and of regional bore hole logs from the Saskatchewan Watershed Authority water well database.

Bedrock Geology

The youngest underlying rocks belong to the Snakebite Member of the Upper Cretaceous Bearpaw Formation. The Bearpaw Formation is a succession of grey, non-calcareous marine silty shales and minor sandstone deposited during the last transgression of the North American interior seaway. Following withdrawal of the Bearpaw Sea, the area was eroded by rivers draining northeasterly and easterly off the rising Rocky Mountains. These cut a number of buried valleys, including the southeasterly trending Hatfield Valley and its tributaries, the easterly trending Battleford Valley, and the northeasterly trending Tyner and Swift Current valleys. The buried valleys are filled by Tertiary gravels and sands of the Empress Formation. Depth to the top of the Bearpaw Formation is about 145 m in the Grasswood area (Figure 3). Bedrock geology has little or no influence on the surficial geology and hydrogeology of the Grasswood site.

A structural low developed on the Cretaceous bedrock surface south of Saskatoon is called the Saskatoon Low (Figure 1). It is discussed in a later section because it likely formed relatively late during deposition of the surficial deposits. The site is located within the Saskatoon Low as described by Christiansen (2011). The Saskatoon Low is a salt collapse structure where the bedrock has collapsed as a result of dissolution of the Prairie Evaporite Formation. The collapse has been filled with thick sediments of the Battleford Formation till and overlain by glacio-fluvial deposits of the Haultain Formation.

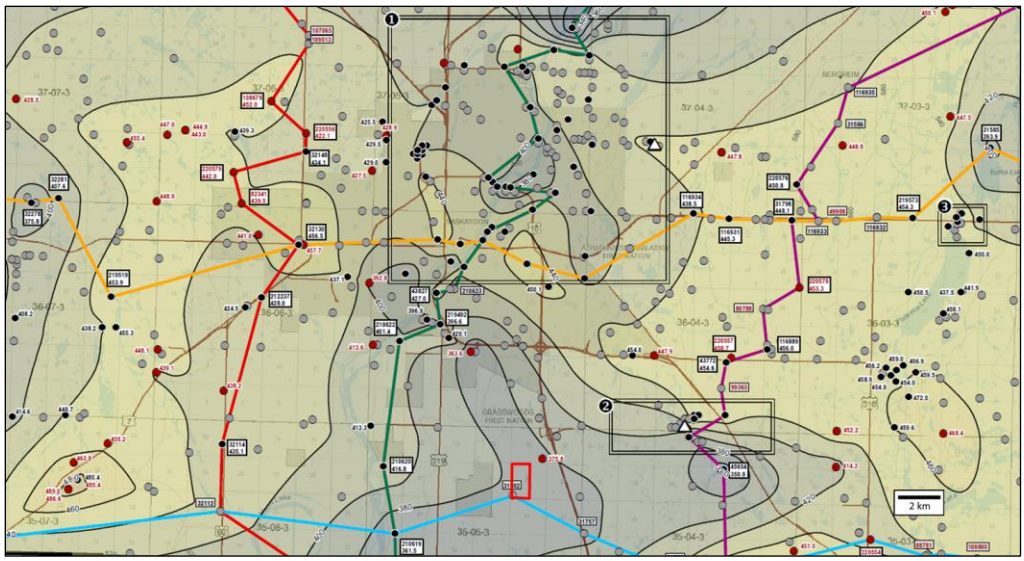

Figure 1 – Structure contour map on the Cretaceous bedrock surface (MDH, 2011). The Casa Grande site is indicated by a red rectangle. Note the extensive structural low south of Saskatoon.

Surficial Geology

Reference bore hole 31902 (Figures 2 and 3) at the junction of Range Road 3052 and Township Road 354 indicates that the southern Grasswood area is underlain by about 95 m of Battleford Formation till; overlain by 30 m of Haultain Formation glacio-lacustrine clay, silt and sand; capped by about 20 m of Pike Lake Formation glacio-lacustrine/glacio-fluvial deposits on which Aeolian dunes have developed (MDH, 2011).

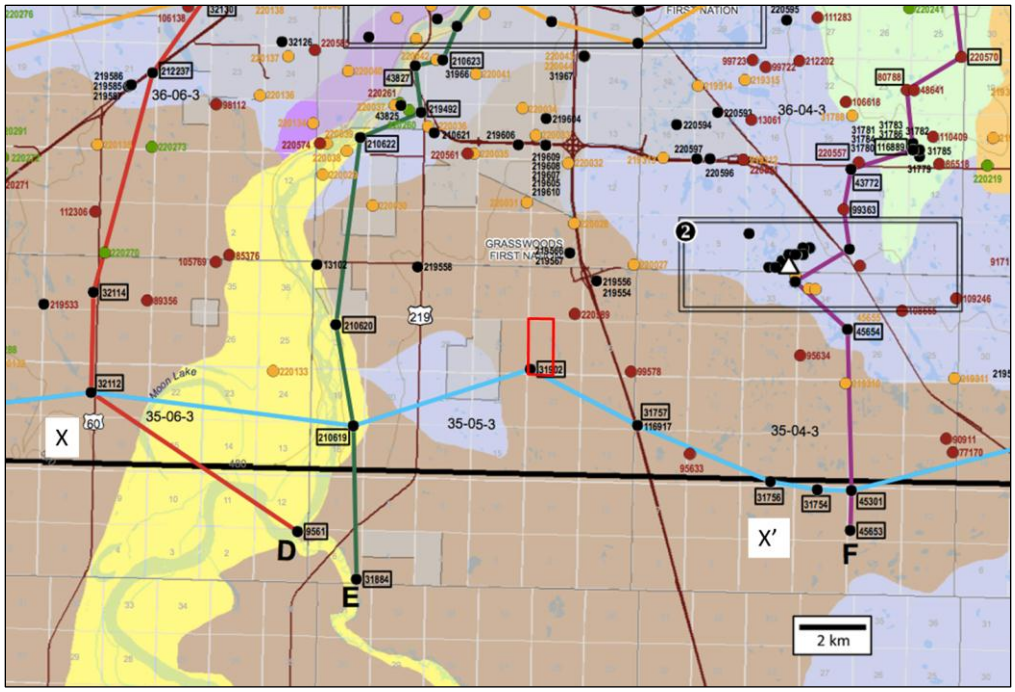

Figure 2 - Surficial geology of the area south of Saskatoon (SK Geological Atlas). The Grasswood area is underlain by undifferentiated Aeolian deposits (brown), whereas most of Saskatoon is underlain by glacio-lacustrine deposits (purple). Fluvial deposits (yellow) are found along the South Saskatchewan River and glacial till (pale green) forms the Strawberry Hills to the northeast. Two reference bore holes (Figure 3) lie within of near the site: Bore Hole 31902 lies near the junction of Range Road 3052 and Township Road 354. Bore Hole 220589 lies west of Range Road 3051 midway between Township roads 354 and 360. Section X-X' (blue line) is shown in Figure 3.

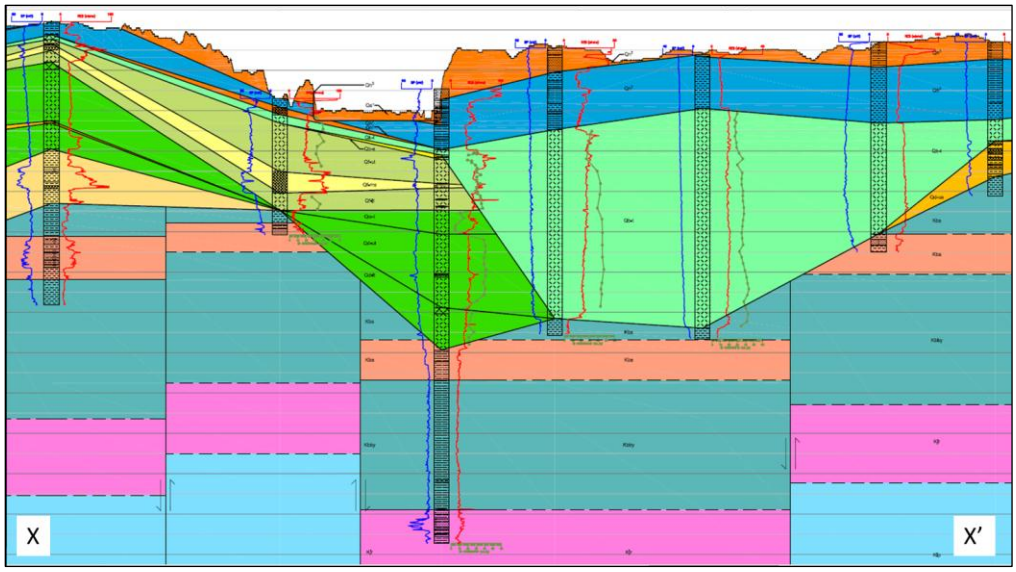

Figure 3 - West-east section X-X' (Figure 2) through the Grasswood area (Excerpt from Section H-H' in MDH, 2011). From west to east, bore holes shown are: 32257, 32112, 210619 (E side of river), 31902, 31757 and 31756. Bore Hole 31902 lies at the southwest corner of the Grasswood subdivision area (Figure 2). Vertical scale lines are 10 m apart. Bedrock units: Lea Park Fm (Klp - pale blue), Judith River Fm (Kjr - magenta), Bearpaw Fm includes Beechy Mbr (Kbby - grey-blue), Ardkenneth (Kba - tan), Snakebite (Kbs - grey-blue) members; Unconsolidated strata: Empress Group (Qte - pale yellow), upper till of Lower Dundurn Fm (Qd-lt - green), Upper Dundurn sand (Qd-us - orange), Upper Dundurn till (Qd-ut = green), Upper Warman till (Qw-t - green), upper till of Lower Floral Fm (Qf-lt - olive), Riddell Member (Qf-ms - pale yellow), Upper Floral till (Qf-ut - olive), Battleford sand (Qb-s - yellow), Battleford till (Qb-t - pale green), Lower Haultain silt-sand-gravel (Qh1 - brown), Lower Haultain clay-silt-sand (Qh2 - blue), Upper Haultain silt-sand-gravel (Qh3 - brown), Lower Pike Lake silt-sand-gravel (Qa1 - brown).

The Battleford till (pale green in Figure 3) is typically soft, massive and oxidized compared to the underlying tills (Christiansen, 1979). Except for a basal gravel-sand unit, which is absent in the Grasswood area, this unit is an aquiclude.

The Haultain Formation (blue in Figure 3) comprises up to 30 m of soft grey silt and clay interbedded with sand. Its contact with the Battleford Formation is commonly gradational. These strata were deposited in deeper parts of the proglacial Lake Saskatchewan as it shifted northerly with the retreating ice front, following the Battleford advance (Figure 2). The type section for the Haultain Formation is a bore hole in SW-4-26-35-5-W3 approximately 800m west of the site. The Haultain Formation consists of interbedded sand/silt and silt/clay facies. The type section describes an upper sand and silt facies extending to a depth of 11.9 m over an upper silt and clay facies extending to a depth of 20 m over a lower sand and silt facies and a lower silt and clay facies extending to a 40.2 m depth. The Haultain Formation overlies till

of the Battleford Formation to a depth approximately 130 m The Battleford Formation is underlain by clay shale of the Bearpaw Formation.

The Pike Lake Formation (orange in Figure 3) comprises up to 19 m of sand and silt deposited in the shallower parts of the proglacial Lake Saskatchewan as it shifted northerly, or in outwash rivers draining into the lake and partly reworked into Aeolian dunes following withdrawal of the lake.

The Haultain and Pike Lake formations form an important near-surface aquifer. Hydraulic conductivity ranges between 2.6 and 22 $x10^{-3}$ m/s (MDH, 2011). Transmissivity ranges from 130 to 4,000 m^2/d.

As indicated in Figure 3, although the surficial stratigraphy is relatively simple, truncation and removal of the pre-Battleford units indicates a complex depositional history. The unconsolidated strata in the Grasswood area are unusually thick because they overlie part of the Saskatoon Low. This is an extensive solution-collapse structure resulting from solution and removal of about 150 m of the Devonian age Prairie Evaporite (Holter, 1969) and consequent fault collapse of overlying strata. The sheared and faulted pre-Battleford tills and sands were easily bulldozed out of the upper part of the solution collapse structure during the final local ice advance (Christiansen and Sauer, 2001). The resulting depression was filled by the Battleford till, which is locally up to 140 m thick. The basal Battleford gravel and sand is absent in this area (MDH, 2011).

Soils

According to Acton and Ellis (1978) (Figure 4), most of the Grasswood area is underlain by dark brown soils of the Asquith soil association (**A6**sl-fl/Fa3), developed on gently sloping or roughly undulating, pitted outwash plain (i.e. Pike Lake Formation). The Asquith soils are dark brown chernozems developed on sandy glacial fluvial or lacustrine deposits.

They are weakly to moderately calcareous, low in clay (<15%) and low in organic matter. In contrast with most of the Asquith soil series, which typically have high permeability and are hence well drained with low moisture holding capacity, the A6 sub-unit of the Asquith series, which comprises Carbonated and Saline Chernozemic Dark Brown and Carbonated and Saline Gelysolic soils, are relatively poorly drained.

Small areas in the southwest and northeast are underlain by Dune Sands (**DS1**ls-s/E4 and **DS1**ls-s/E3 respectively) loamy sand and sand developed on undulating proglacial Aeolian plain deposits.

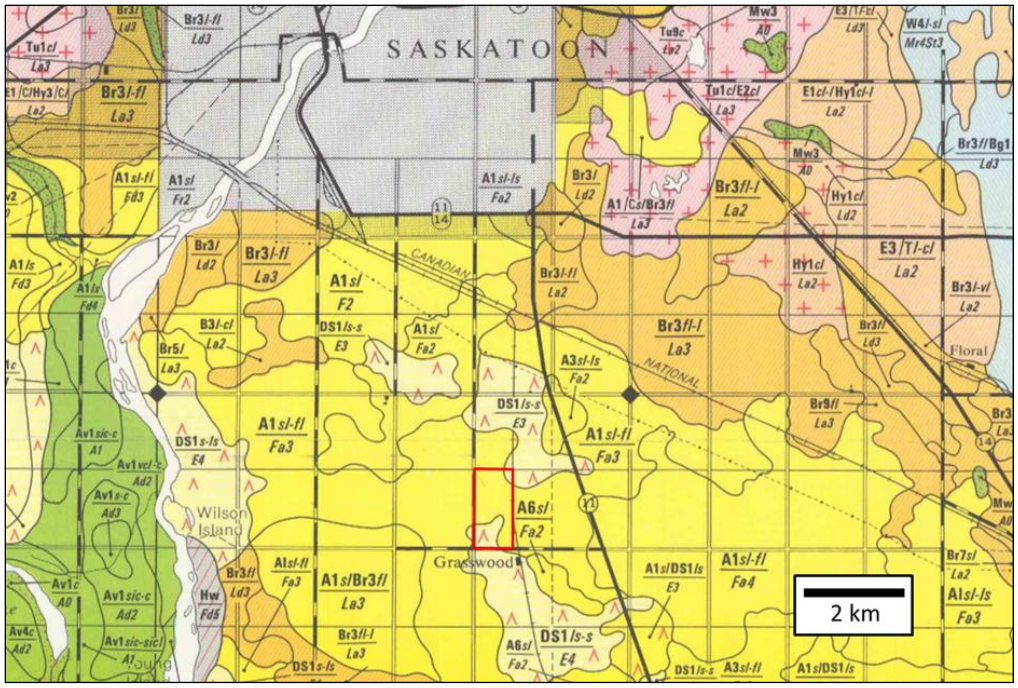

*Figure 4 - Soil map of the area south of Saskatoon area (Acton and Ellis, 1978). Most of the Grasswood area (red rectangle) is underlain by dark brown soils of the Asquith soil association (**A6**sl-fl/Fa3), developed on gently sloping or roughly undulating, pitted outwash plain. Small areas in the southwest and northeast are underlain by Dune Sands (**DS1**ls-s/E4 and **DS1**ls-s/E3 respectively) loamy sand and sand developed on undulating proglacial Aeolian plain deposits.*

The Asquith soils are non-plastic; and hence have no reported Atterberg Limit values (Acton and Ellis, 1978). They have a reported shrinkage limit of 16.8.

Only the near-surface Haultain and Pike Lake formations are an important aquifer. The underlying Battleford till is an aquiclude and the basal Battleford sands and gravels are absent in this area.

4.1.2 Site Stratigraphy

The site investigation extended to a depth of 15 m and encountered sediments of the upper sand and silt facies of the Haultain Formation and in some bore holes encountered the upper silt and clay facies of the Haultain Formation. Thin silt and clay beds within the upper sand and silt facies were encountered.

The clay facies is more prevalent to the south. There is between 150 mm to 750 mm of organic topsoil at the surface.

Drawing No. 02 depicts the Bore Hole Location and Site Plan with a stratigraphic cross section index to summarize the lithology of the Site.

Cross Section A-A′ to D-D’ (Drawing No. 03 and Drawing No. 04) presents further details of geologic Site conditions.

4.2 Groundwater Conditions

A piezometric surface was developed based on local bore hole groundwater elevations as well as from the regional water wells within a 1 km radius of the site. See Drawing No. 05. All groundwater elevations were tied into the local coordinate system developed on Site using RTK GPS data collectors accurate to within five centimeters and referenced to a local coordinate system. A hydraulic gradient was developed based on this surface which was used for modeling purposes.

Drawing 06 presents the piezometric surface for the site and surrounding areas. The groundwater elevation is higher to the northeast and lower to the west indicating an east to west groundwater flow direction. The groundwater gradient is locally flat in the south east area of the site and the adjacent area to the east.

The groundwater sampling results are presented in Table 4.2.1 and the laboratory report attached in Appendix B. Drinking water quality guidelines are presented in Table 4.2.1 for comparison purposes only. Within the development, a communal water supply will be provided and no direct use of groundwater is anticipated.

Geochemistry indicates that exceedances occur most notably groundwater nitrate exceeded the drinking water guidelines in BH203.

Upon investigation of historical land uses, it has been reported that a stock yard was present on Site for a period of 10 years near BH203. Mr. Rick King who is a local to the area reported that there was a cattle and grain farmer in this area for a period of at least 10 years. During this time, a herd of up to 300 head of cattle were managed for long periods of time. Carcasses were reportedly buried on site as well which may create more concerns, particularly BOD loading. He also noted that manure and old hay was disposed in the northwest corner (low area near the pond). Sampling was not completed in this area, as it was not accessible at the time of the Site investigation. This means that there is a potential for a higher nitrate load than 51mg/L near the north area of the pond. In light of this information, consideration of this area and the associated nitrate loading had to be made in the analysis. Therefore in the area of BH203 a loading area of 5000 m^2 was used to simulate current conditions.

TDS, alkalinity, and chlorides were present in the south area near BH207. These elevated values are interpreted to be associated with concentrations due to groundwater evaporation as the water level is close to ground surface in this area.

Metals exceeded drinking water guidelines in several instances. There was no spatial pattern to the exceedances and no source could be identified. They are presumed to be background conditions at this time.

Coliforms and E. coli parameters exceeded guidelines in many of the bore holes. Although, all care was taken to sample without cross contamination of the sample, these results are suspect and not considered further in this report.

5.0 Groundwater Transport Modeling

5.1 Model Realization

The modeling of the groundwater flow and contaminant transport on the site was conducted by using the Visual MODFLOW 2011 software. Visual MODFLOW is a modeling environment for practical applications in three-dimensional groundwater flow and contaminant transport simulation.

Some of the assumptions made during the development of the model included:

- Source concentration of 40 mg/L and 350 mg/L for the sewage mounds corresponding to treated and untreated effluent.

- Daily sewage flow of 2045 L/day based on a 4 bedroom home.
- 100 year assessment period.
- Effective loaded surface area of each disposal mound of 46 m^2.
- Effective loading in existing waste pile area near BH203 assumed to be 5000 m^2.

The topographic survey and collected field information were used to create the modeling domain containing one stratigraphic layer. The top surface of the model represents the surveyed ground surface, as the bottom surface of the model is a plane surface with the assigned elevation of 495 m. The thickness of the layer varies from 12.7 m to 19.4 m. The hydraulic conductivities obtained through the field investigation were used as initial inputs and were subject to adjustment through the groundwater flow calibration process. The groundwater flow model was calibrated to the constant head boundary conditions assigned to the modeling domain sides. The values of the groundwater heads were obtained from the piezometric surface which was created based on the measured ground water elevations.

The model was divided into three regions, north, middle and south to achieve the acceptable calibration and to reflect the bore hole logs data which show that soil of the south and north regions of the site contains more clay than the middle part of it.

Table 5.1-1
Calibrated Hydraulic Conductivities

Region	Kx, m/sec	Ky, m/sec	Kz, m/sec
North and South	$2x10^{-5}$	$2x10^{-5}$	$2x10^{-6}$
Middle	$7x10^{-4}$	$7x10^{-4}$	$7x10^{-5}$

The correlation coefficient between the calculated and observed piezometric surface of 0.909 was attained.

The model space is presented in Drawing 06. A recharge flux of 4% of precipitation was used. It is recognized that this is low for sandy terrain with poorly integrated drainage; however, the low recharge rate is conservative with respect to dilution and contaminant transport.

The model is an advection and dispersion model only. No decay of nitrate was modeled. A longitudinal dispersivity of 10.0 m and a transverse dispersivity of 1.0 m were used.

Visual MODFLOW supports several different versions of the MT3D contaminant transport modeling programs. The MT3DMS program (engine) was used to calculate contaminant transport at the site. MT3DMS is a transport model for simulation advection, dispersion and chemical reactions of contaminants in groundwater flow systems. It solves the advective-dispersive equation and describes the fate and transport of contaminant of species in three-dimensional transient groundwater flow system. The upstream finite difference solution method was used to calculate nitrate levels.

The contaminant was introduced into the model by using the recharge concentration boundary conditions assigned to the cells where the contaminant sources will be located, therefore the size of the modeling grid was chosen based of the infiltration area of the contaminant sources. The source was assumed constant through the 100 years of calculation time.

Four scenarios were modeled:

Current Conditions

- This included current nitrate impact (51mg/L) near BH203 after 100 years.

Development Conditions - 40 mg/L Loading with Source at BH203

- This included the package treatment system loading with existing nitrate impact near BH203 after 100 years.

Development Conditions - 40 mg/L Loading without Source at BH203

- This included the package treatment system loading without existing nitrate impact near BH203 after 100 years.

Conventional - 350 mg/L Loading Source at BH203

- This included the conventional loading (which is comparable to raw sewage) with existing nitrate impact near BH203. The loading used was recommended by Saskatoon Public Health.

Conventional - 350 mg/L Loading Without Source at BH203

- This included the conventional loading system without nitrate impact near BH203 after 100 years.

5.2 Modeling Results

The modeling results are presented in Drawings No. 07 to No. 11.

Drawing 07 presents a model of the current conditions. A nitrate concentration of 51.0 mg/L in BH203 was observed. The source of the nitrate was an historic cattle operation at this location. The existing nitrate was modeled as a source with a constant concentration of 51.0 mg/L over an area of 4650 m^2. Drawing 07 identifies a predicted westerly trending nitrate plume from this location with a maximum concentration of 50 mg/L (source concentration), in excess of 30 mg/L at the west site boundary and up to 10 mg/L at the west boundary of the model. The measured concentration in BH210 is 0.67 mg/L and the predicted concentration is approximately 1 mg/L which is a good match. BH208, north of the predicted plume, had a measured concentration of 7.1 mg/L. No impact is predicted at this location. This may be the result of another source or the result of a different impacted area than was assumed in the model.

Drawing 08 presents the development condition for a 40 mg/L source loading in addition to the existing conditions. The predicted nitrate concentrations are dominated by the existing nitrate conditions. The extent and nature of the existing plume is essentially unchanged from the existing conditions presented in Drawing 06.

Drawing 09 presents the development condition for a 40 mg/L source loading without the existing conditions. This represents the nitrate loading resulting from the development. The magenta squares are the assumed source mound areas. The predicted nitrate concentrations within the northern portion of the site are in the 0.1 to 0.5 mg/L range with a maximum off site concentration of 0.1 mg/L. In the southern portion of the site where the hydraulic conductivity is lower, the concentrations are approximately 10 mg/L in the immediate vicinity of the source mounds and generally 0.5 to 1.0 mg/L throughout the bulk of the development area. The maximum concentration at the downstream boundary is 1.0 mg/L. The concentrations are higher in the southern area because the hydraulic conductivity is lower and the natural groundwater gradients are lower as well resulting in a less active natural flow system.

Drawing 11 presents the predicted impact for a source concentration of 350 mg/L which is the typical untreated effluent concentration. In the northern section the concentrations are typically in the 1.0 mg/L range with localized concentrations near the mounds up to 10 mg/L. The maximum off site concentration in the northern portion of the site is 1.0 mg/L. In the

southern portion of the site where the groundwater flow system is less active, the concentrations are higher with local concentrations up to 30 mg/L and a general concentration in the order of 10 mg/L. A maximum point concentration of 250 mg/L was observed in the vicinity of BH212 in the extreme south east corner of the site. The maximum off site concentration is just less than 10 mg/L.

Drawing 10 presents the combined existing and 350 mg/L development scenario. Again, the existing plume dominates the off-site concentrations.

The predicted impact from the proposed development is best represented by Drawing 09. The source concentration of 40 mg/L corresponding to treated effluent is used. The maximum predicted off site concentration is 1 mg/L.

The existing impact from the cattle operations far outweighs the significance of the proposed development. Remedial work will be required in this area to remove existing sources of nitrates in order to prepare the lots for sale. This will not remove the impact in the groundwater, but will reduce the source term lead to a reducing nitrate concentration in the plume area.

Due to what appears to be historical land use practices, background concentrations of nitrates currently exceed Saskatchewan Drinking Water Standards and Objectives. In all model scenarios that consider this, which are presented in Drawings 07, 08 and 10 the maximum nitrate concentrations off site remain the same, namely 30 mg/L, the only difference in these models, are the extent of the plumes. The Development Condition Models that do not consider this background nitrate concentration, namely Drawings 09 and 11, effectively model conditions that can exist if this nitrate source is removed. In these scenarios, the proposed development causes a cumulative off site impact which does not exceed 1 mg/L.

All modeling conducted was conservative in an effort to present the worst case scenario. The conservative nature of the parameters used in the modeling are summarized as follows:

- Loading concentrations used in the model Developed Conditions are likely 70% higher than the proposed FAST® Wastewater disposal systems that are proposed to be used.

- Rainfall precipitation was assumed to be 4% of average precipitation which is a conservative value.

- Decay rates were not considered although research has indicated that half-life of nitrate is in the range of 1-2.3 years. Almasri, *et al (2007).*

A Modeling sensitivity analysis was conducted by changing the precipitation rate, longitudinal dispersivity and hydraulic conductivity. The response of concentration to changing of values is presented on Figure 5. The results show that the changing of hydraulic conductivity would affect the concentration in higher rate than changing the rate of infiltration from precipitation or dispersion parameters.

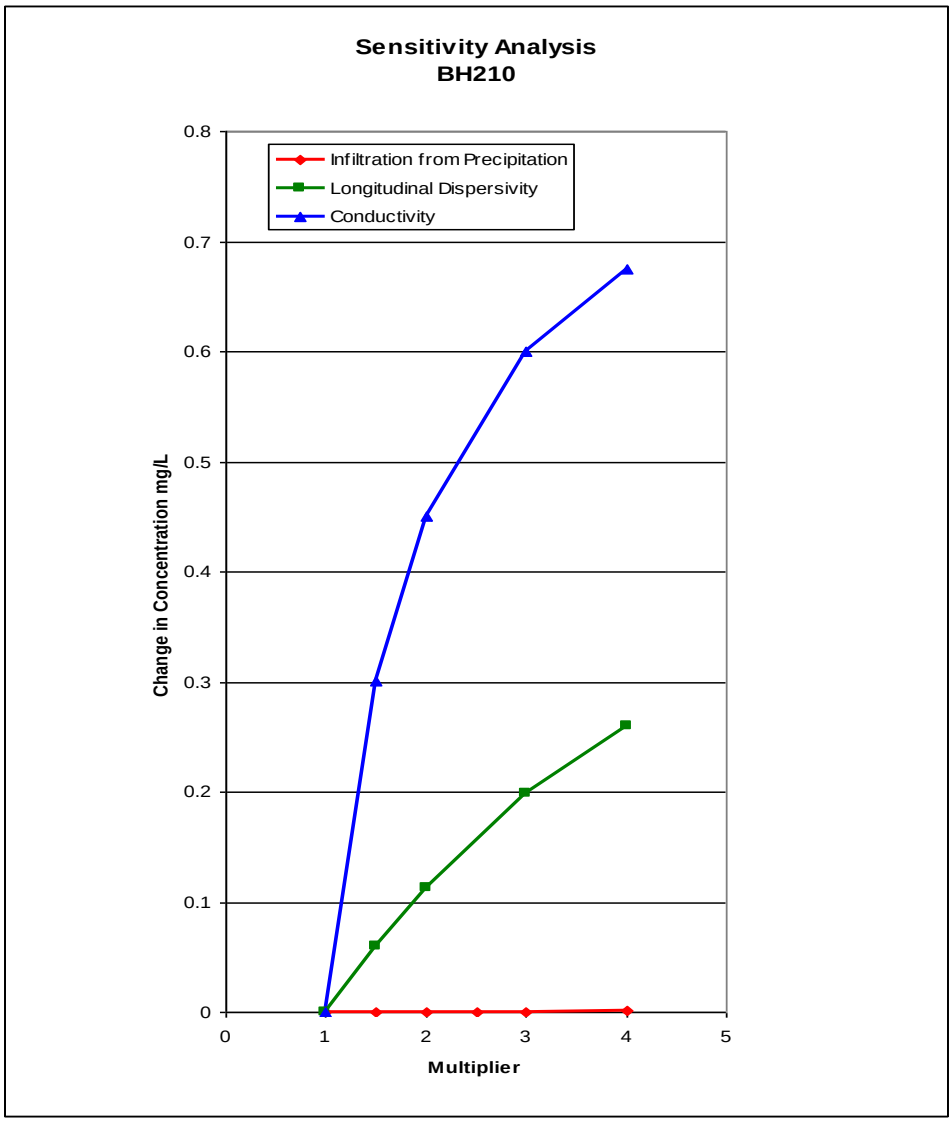

Figure 5- Sensitivity Analysis

The model is a comprehensive model that considers not just flow within the site but also considers groundwater entering the site and leaving the site. The contaminant transport model

is additive that is; it predicts the concentration of nitrate that is added to the groundwater system. It assumes that the groundwater entering the site has no nitrate concentration. The upstream development is similar to the proposed development with a lower density. It would be reasonable to assume that similar performance can be expected from the upstream development and that the concentration of nitrate entering the site will be minimal. It will be prudent to monitor and measure the upstream nitrate concentration to confirm this assumption.

In summary, the predicted cumulative effects of the proposed sewage disposal systems results in additional off site nitrate concentrations of approximately 1.0 mg/L. This would be added to the concentration of nitrate entering the site. Monitoring is required to define the concentration entering the site. The upstream community is fully developed and changes in density are not anticipated. The greatest impact arises from the previous cattle operation on the site from which nitrate concentrations of approximately 30 mg/L are predicted to be exiting the development. Monitoring is required to confirm the exit concentrations. Removal of the source material from the cattle operation is anticipated which will result in reduced concentrations in the future.

5.3 Infiltration into Storm Water Ponds

Storm water ponds in the north and south of the development are proposed. Drawing 12 shows the proposed location of the ponds and Drawings 13 & 14 show the proposed cross section and operating conditions

To evaluate infiltration from the proposed retention ponds the lake boundary conditions feature of MODFLOW were assigned to the areas were the North and South ponds are proposed to be constructed. The lake boundary condition of MODFLOW allows simulation of the effects of stationary surface-water bodies such as lakes and reservoirs on the groundwater system. To evaluate the seepage from groundwater to the ponds the model was run with different ponds water elevations. The results are shown in Figure 6. It should be mentioned that the average for the site hydrogeological properties of the soils are incorporated into the model. The spot conditions could be quite different, for instance, at the North Pond location sand layer prevails, as at the South Pond location silty clay layer was found. Therefore the infiltration rate to the South Pond is expected to be less than it is calculated.

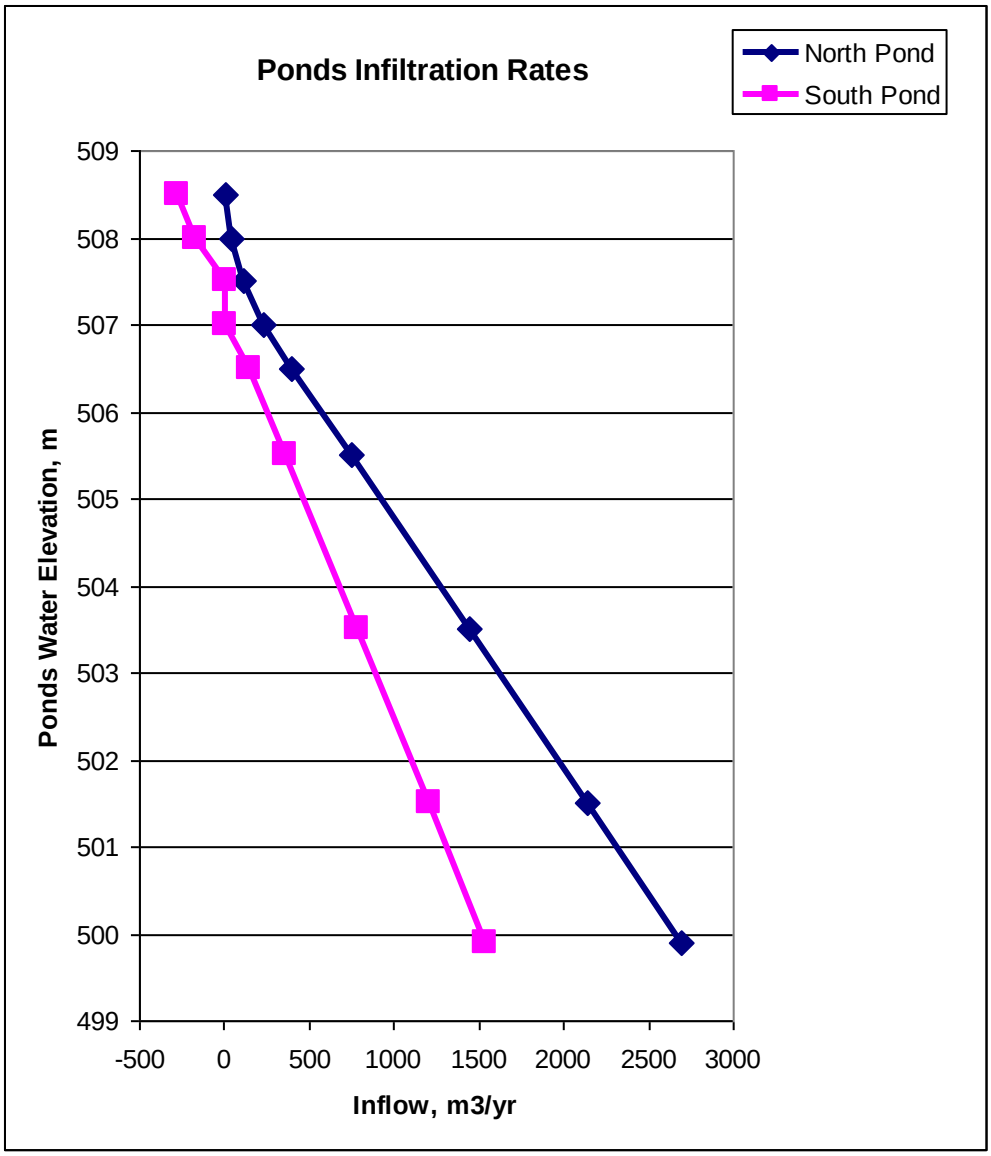

Figure 6 - Predicted Ponds Infiltration Rates

6.0 Adsorption Field Suitability

Criteria for adsorption field suitability are provided by Saskatchewan Ministry of Health (2009). The criteria include:

- The minimum depth from the base of the field to the water table is 1.5 m.
- Clay textured soils are not suitable for adsorption field. Guidance is provided for allowable adsorption rates for more coarsely textured soils.

Results of hydrometer testing on select samples for the 200 bore hole series are presented below.

Table 6.0-1
Summary of Particle Size Analysis
and Soil Texture Classification of Upper Soil Units

Soil Type	Bore Hole Number	Sample Number	Depth	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Soil Texture as per SOWDG & USDA
Sand	BH201	CF27	1.5 m	0.0	74.6	8.1	17.3	Sandy Loam
Clay	BH203	CF32	1.2 m	0.0	36.1	35.5	28.4	Clay Loam
Silt	BH204	CF35	8.5 m	0.0	31.8	51.6	16.7	Silty Loam
Sand	BH209	CF20	1.6 m	0.0	65.5	19.7	14.9	Sandy Loam
Clay	BH213	CF23	3.1 m	0.0	3.9	60.7	35.4	Silty Clay Loam
Sand	BH203	CF33	3.1 m	0.0	75.1	15.0	9.9	Sandy Loam
Sand	BH212	CF2	4.1 m	0.0	70.0	14.0	16.1	Sandy Loam

The maximum depth of burial of the adsorption field tile is 600 mm. The water table must be 1.5 m below the tile for a total maximum depth to the water table of approximately 2 m below the ground surface.

The depth to the water is provided in Drawing 15. The drawing was developed by interpolation of the groundwater surface between bore holes and subtracting this surface from the surveyed ground surface. Green areas have a depth to the water table of greater than 2 m and are suitable from a depth to groundwater perspective. Yellow areas are marginal and orange and red areas are unsuitable. In the unsuitable areas, the adsorption field can be elevated on fill or as an alternative a mound constructed. The groundwater constraint affects approximately 20 lots.

The soil texture constraint is summarized in Table 6.0-2 Soil Classifications. Data is available at bore hole locations but data at individual lots is not available. Refer to **Bore Hole Logs and Laboratory Test Data** for the stratigraphy at each bore hole and summarized laboratory testing performed to characterize the soil. The Unified Classification consists of a measurement of the amount of soil of silt plus clay sizes as well as the plasticity characteristics of the soil. The textural classification measures the silt and clay content as required in the Saskatchewan Ministry of Health (2009) document. Soils that have a primary classification of “clay” require further investigation to assess the suitability as provided by Appendix 15 of the Ministry of Environment (2009). The sand on site is fine grained and

silty. It is classed as SM (silty sand) under the unified system and sandy loam or loamy sand under the textural system. Where only unified classification exists, it was assumed that all of the fines are silt and the textural classification assigned accordingly. This is consistent with the cases where a full textural classification was available. In all cases, the laboratory testing confirmed that soils logged in the field as "Sand" were suitable for a disposal field.

No guidance is provided on the effects of stratification on the suitability of the soil by the Saskatchewan Ministry of Health (2009). Froese (2009) suggests that the retention time in the vadose zone should be approximately 60 days. The design infiltration rate for a silty loam is 0.28 gal/day/ft^2 which is equivalent to a vertical flow velocity of 1.1 x 10^{-7} m/sec. A somewhat higher infiltration rate was used in the flow modeling as this is a conservative assumption with respect to nitrate transport. The saturated hydraulic conductivity of the sand averaged 4.73E-06. Under gravity drainage conditions, the vertical gradient is unity. The infiltration rate (water applied) is less than the measured hydraulic conductivity of the sand (ability to transmit water under unity gradient). As a result, unsaturated soil conditions can be anticipated under the adsorption field. For the purposes of assessing soil suitability under stratified conditions, the most restrictive soil within 2 m of surface was selected for the site suitability. For example, if a clay was encountered at a depth of 1.5 m then, the suitability was related to the clay soil. If the clay was encountered at a depth of 2 m or greater, then the overlying sand was used to assess the site suitability.

Sites with more than 2 m of surface sand were classified as "Suitable". In cases where clay was at surface or within 2 m of surface, the site suitability was classified as "Further Testing". Bore hole locations where the water table is less than 2 m depth was noted as a groundwater limitation. For those bore holes with no direct measurement of water depth, the depth of water map (Drawing 15) was consulted and if the interpreted water table was less than 2 m deep then a groundwater comment of "Potential Groundwater Limitation" was provided.

Note that the assessment is valid at the bore hole locations only. Conditions may vary locally.

7.0 Basement Elevations

In some areas of the development the groundwater table is above the normal basement excavation depth. Drawing 15 shows the approximate depth to groundwater. In areas with high groundwater, some filling of the building location may be required to keep the basement above the groundwater elevation. Site specific investigations are recommended to establish the groundwater elevation at the building locations.

8.0 Recommendations

Existing conditions of the site appear to have background impact from several potential sources. In terms of nitrogen impacts, there does not appear to be a concern for cumulative impact due to the subdivision development. This assumption is based on available data presented from the subsurface investigation. However, it would be prudent to assess the following to manage and mitigate existing conditions on Site:

- Monitor upstream flow onto the Site, namely place piezometers on the eastern border of the Site for all parameters noted in this report.

- Monitor the downstream water quality in general and specifically in those areas where the cattle operation plume is predicted.

- Delineate and remove the source of nitrogen in the north area, around BH203 and area where reported manure disposal occurred to prevent further impact and improve the aesthetic features of the land.

- Continuing groundwater monitoring to evaluate current Site conditions.

- Site specific investigations are needed for the adsorption field and water depth at building locations.

9.0 Closure

This report was prepared by Clifton Associates Ltd. for the use of the Urban Elements Development Corporation and their agents for specific application to the proposed Grasswood Subdivision. The material in it reflects Clifton Associates Ltd. best judgment available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Clifton Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report has been prepared in accordance with generally accepted engineering practice common to the local area. No other warranty, expressed or implied, is made.

Our conclusions and recommendations are preliminary and based upon the information obtained from the referenced subsurface exploration. The bore holes and associated laboratory testing indicate subsurface and groundwater conditions only at the specific locations and times investigated, only to the depth penetrated and only for the soil properties tested. The subsurface conditions may vary between the bore holes and with time. The subsurface interpretation provided is a professional opinion of conditions and not a certification of the site conditions. The nature and extent of subsurface variation may not become evident until construction or further investigation. If variations or other latent conditions do become evident, Clifton Associates Ltd. should be notified immediately so that we may re-evaluate our conclusions and recommendations.

The enclosed report contains the results of our investigations as well as certain recommendations arising out of such investigations. Our recommendations do not constitute a design, in whole or in part, of any of the elements of the proposed work. Incorporation of any or all of our recommendations into the design of any such element does not constitute us as designers or co-designers of such elements, nor does it mean that such design is appropriate in geotechnical terms.

The designers of such elements must consider the appropriateness of our recommendations in light of all design criteria known to them, many of which may not be known to us. Our mandate has been to investigate and recommend which we have completed by means of this report. We have had no mandate to design, or review the design of, any elements of the proposed work and accept no responsibility for such design or design review.

Clifton Associates Ltd.

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Cindy Friesen, Geoscientist in Training

Association of Professional
Engineers of Saskatchewan
Cert. of Authorization No. 238

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Symbols and Terms

Soil Descriptive Terms

A soil description for geotechnical applications includes a description of the following properties:

- texture
- color, oxidation
- consistency and condition
- primary and secondary structure

Texture

The soil texture refers to the size, size distribution and shape of the individual soil particles which comprise the soil. The Unified Soil Classification System (ASTM D2487-00) is a quantitative method of describing the soil texture. The basis of this system is presented overleaf. The following terms are commonly used to describe the soil texture.

Particle Size (ASTM D2487-00)

Boulder	300 mm plus
Cobble	75 - 300 mm
Gravel	4.75 - 75 mm
Coarse	19 - 75 mm
Fine	4.75 - 19 mm
Sand	0.075 - 4.75 mm
Coarse	2 - 4.75 mm
Medium	0.425 - 2 mm
Fine	0.075 - 0.425 mm
Silt and Clay	Smaller than 0.075 mm

Relative Proportions (CFEM, 3rd Ed., 1992)

Trace	1 - 10 %
Some	10 - 20 %
Gravelly, sandy, silty, clayey, etc.	20 - 35 %
And	>35 %
Gravel, Sand, Silt, Clay	>35 % and main fraction

Gradation

Well Graded	Having a wide range of grain sizes and substantial amount of all intermediate sizes.
Uniform or Poorly Graded	Possessing particles of predominantly one size.
Gap Graded	Possessing particles of two distinct sizes.

Particle Shape

Angular	Sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Similar to 'angular' but have rounded edges.
Subrounded	Well-rounded corners and edges, nearly plane sides.
Rounded	No edges and smoothly curved sides.

Also may be flat, elongated or both.

The term "TILL" may be used as a textural term to describe a soil which has been deposited by glaciers and contains an unsorted, wide range of particle sizes.

Color And Oxidation

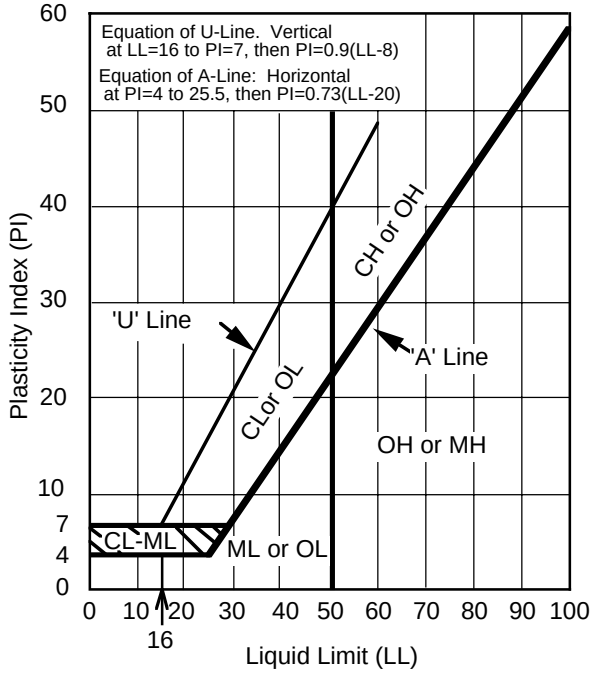
The soil color at its natural moisture content is described by common colors and, quantitatively, in terms of the Munsell color notation; (eg. 5Y 3/1). The notation combines three variables, hue, value and chroma to describe the soil color. The hue indicates its relation to red, yellow, green, blue and purple. The value indicates its lightness. The chroma indicates its strength of departure from a neutral of the same lightness.

Departure of the soil color from a neutral color indicates the soil has been oxidized. Oxidation of a soil occurs in a oxygen rich environment where most commonly metallic iron, oxidizes and turns a neutral colored soil 'rusty' or reddish brown. Oxidized manganese gives a purplish tinge to the soil. Oxidation may occur throughout the entire soil mass or on fracture/joint/fissure surfaces.

Classification of Soils for Engineering Purposes

ASTM Designation D 2487-00 (Unified Soil Classification System)

Major divisions			Group Symbols	Typical names	Classification criteria			
Coarse-grained soils: More than 50% retained on No. 200 sieve* (>0.075 mm)	Gravels: More than 50% of coarse fraction retained on No. 4 sieve(≥4.75 mm)	Clean gravels <5% fines	GW	Well-graded gravel	If ≥ 15% sand add "with sand" to group name	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve.....GW, GP, SW, SP More than 12% pass No. 200 sieve.....GM, GC, SM, SC 5 to 12% pass No. 200 sieve.....Borderline classifications requiring use of dual symbols	$C_u = \frac{D_{60}}{D_{10}} \geq 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravel			Not meeting either C_u or C_c criteria for GW	
		Gravels with fines >12% fines	GM	Silty gravel			Atterberg limits below "A" line or PI less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravel			Atterberg limits on or above "A" line and PI > 7	If fines are organic add "with orgnic fines" to group name
	Sands: 50% or more of coarse fraction passes No. 4 sieve(<4.75 mm)	Clean sands <5% fines	SW	Well-graded sand	If ≥ 15% gravel add "with gravel to group name		$C_u = \frac{D_{60}}{D_{10}} \geq 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sand			Not meeting either C_u or C_c criteria for SW	
		Sands with fines >12% fines	SM	Silty sand			Atterberg limits below "A" line or PI less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sand			Atterberg limits on or above "A" line and PI > 7	If fines are organic add "with orgnic fines" to group name
Fine-grained soils: 50% or more passes No. 200 sieve* (≤0.075 mm)	Silts and Clays: Liquid limit <50%	Inorganic	ML	Silt	If 15 to 29% coarse-grained, add "with sand" or "with gravel" as appropriate If > 30% coarse-grained , add "sandy" or "gravelly" as appropriate Class as organic when oven dried liquid limit is < 75% of undried liquid limit	Plasticity Chart		
			CL	Lean Clay -low plasticity				
		Organic	OL	Organic clay or silt (Clay plots above 'A' Line)				
	Silts and Clays: Liquid limit ≥50%	Inorganic	MH	Elastic silt				
			CH	Fat Clay -high plasticity				
		Organic	OH	Organic clay or silt (Clay plots above 'A' Line)				
	Highly organic soils		PT	Peat, muck and other highly organic soils				



*Based on the material passing the 3 in.(75 mm) sieve, if field samples contain cobbles or boulders, add "with cobbles or boulders" to group name

Consistency And Condition

The consistency of a cohesive soil is a qualitative description of its resistance to deformation and can be correlated with the undrained shear strength of the soil. The condition of a coarse grained soil qualitatively describes the soil compactness and can be correlated with the standard penetration resistance (ASTM D1586-99).

Consistency Of Cohesive Soil (CFEM, 3rd Edit., 1992)

Consistency	Undrained Shear Strength (kPa) (CFEM, 3rd Edt., 1992)	Field Identification (ASTM D 2488-00)
Very Soft	<12	Thumb will penetrate soil more than 25 mm.
Soft	12-25	Thumb will penetrate soil about 25 mm.
Firm	25-50	Thumb will indent soil about 6 mm.
Stiff	50-100	Thumb will indent, but penetrate only with great effort (CFEM).
Very Stiff	100-200	Readily indented by thumbnail (CFEM).
Hard	>200	Thumb will not indent soil but readily indented with thumbnail.
Very Hard	N/A	Thumbnail will not indent soil.

Condition Of Coarse Grained Soil (CFEM, 3rd Edt., 1992)

Compactness Condition	SPT N - Index (Blows/300mm)
Very Loose	0 - 4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very Dense	over 50

Moisture Conditions (ASTM D2488-00)

Description	Criteria
Dry	Absence of moisture, dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible, free water, usually soil is below water table

Structure

The soil structure is the manner in which the individual soil particles are assembled to form the soil mass. The primary soil structure is the arrangement of soil particles as originally deposited. The secondary soil structure refers to any rearrangement of the soil such as deformation and cracking which has taken place since deposition.

Primary Soil Structure (Depositional)

A. Geometry

Stratum	-	A single sedimentary 'layer', greater than 10 mm in thickness, visibly separable from other strata by a discrete change in lithology and/or sharp physical break.
Homogeneous	-	Same color and appearance throughout.
Stratified	-	Consisting of a sequence of layers which are generally of contrasting texture or color.
Laminated	-	Stratified with layer thicknesses between 2 mm and 10 mm.
Thinly laminated	-	Stratified with layer thickness less than 2 mm.
Bedded	-	Stratified with layer thicknesses greater than 10 mm.
Very Thinly Bedded (Flaggy)	-	Stratified with layer thicknesses between 10 and 50 mm.
Thinly Bedded (Slabby)	-	Stratified with layer thicknesses between 50 and 600 mm.
Thickly Bedded (Blocky)	-	Stratified with layer thicknesses between 600 and 1200 mm.
Thick-Bedded (Massive)	-	Stratified with layer thicknesses greater than 1200 mm.
Lensed	-	Inclusions of small pockets of different soils, such as small lenses of sand material throughout a mass of clay.

B. Bedding Structures

Cross-bedding	-	Internal 'bedding' inclined to the general bedding plane.
Ripple-bedding	-	Internal 'wavy bedding'.
Graded-bedding	-	Internal gradation of grain size from coarse at base to finer at top of bed.
Horizontal bedded	-	Internal bedding is parallel and flat lying

Secondary Soil Structure (Post-Depositional)

A. Accretionary Structures

Includes nodules, concretions, crystal aggregates, veinlets, color banding and

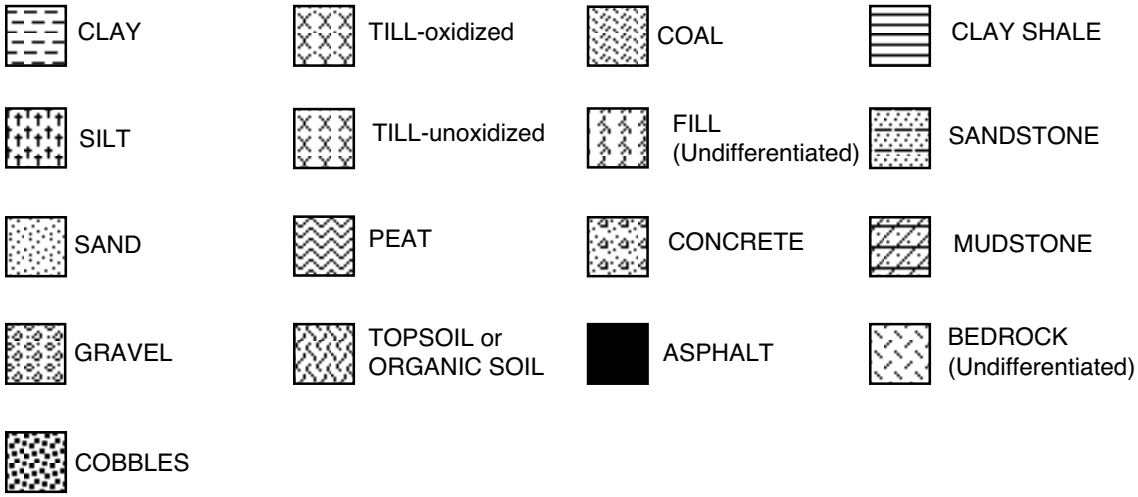
Cementation	-	Chemically precipitated material, commonly calcite ($CaCO_3$), binds the grains of soil, usually sandstone. Described as weak, moderate, strong (ASTM D2488-00).
Salt Crystals	-	Groundwater flowing through the soil/rock often precipitates visible amounts of salts. Calcite ($CaCO_3$), glauber salts ($Na_2Ca(SO_4)_2$), and gypsum ($CaSO_4*2H_2O$) are common.

B. Fracture Structures

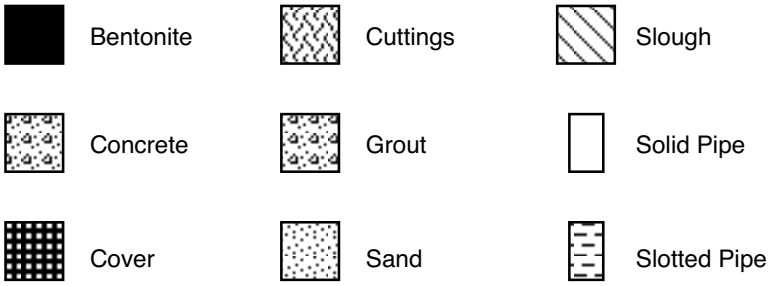
Fracture	-	A break or discontinuity in the soil or rock mass caused by stress exceeding the materials strength.
Joint	-	A fracture along which no displacement has occurred.
Fissure	-	A gapped fracture, which may open and close seasonally. Usually an extensive network of closely spaced fractures, giving the soil a 'nuggetty' structure.
Slickensides	-	Fractures in a clay that are slick and glossy in appearance, caused by shear movements.
Brecciated	-	Contains randomly oriented angular fragments in a finer mass, usually associated with shear displacements in soils.
Fault	-	A fracture or fracture zone along which there has been displacement.
Blocky	-	A cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Symbols Used on Bore Hole Logs

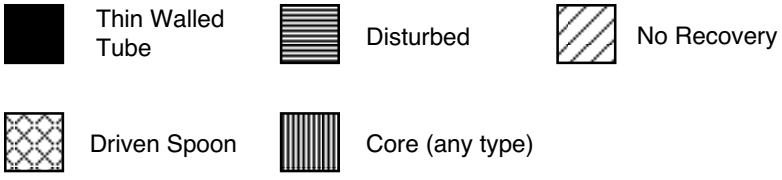
Lithology Type



Borehole Completion and Backfill Materials



Soil Sample Type

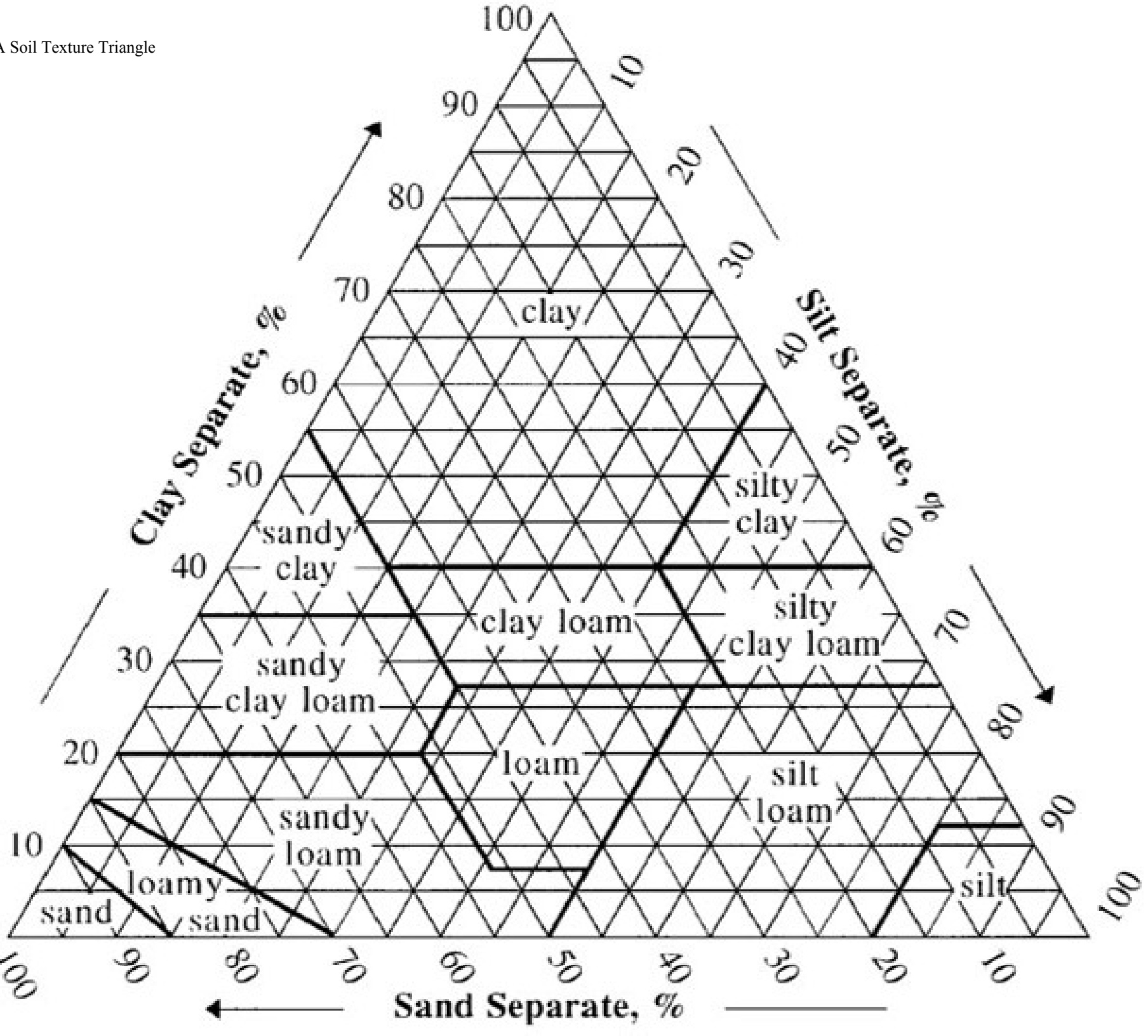


Groundwater Symbols

▼ Piezometric elevation as determined by a piezometer installation

▽ Water levels measured in borings at the time and under the conditions noted

UDA Soil Texture Triangle



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Bore Hole Logs
and
Laboratory Test Data

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BORE HOLE LOG

Bore Hole: 101
Page: 1 of 2

Client:	Neil Ketilson	Northing:	5,765,376.985 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	388,679.686 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.448 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	488.412 m	Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
487 / 0		SAND: Fine grained. Silty. Trace clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Dry.		KB1 KB2		SM				Cuttings
486 / 1		CLAY: Trace silt and sand. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist and stiff. Laminated.		KB3		CH				50 mm sch 40 PVC pipe; Bentonite
485 / 2		SAND: Fine grained. Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist. Stratified. Black streaks.		KB4		SM				Frac sand
484 / 3				KB5						
483 / 4		@ 4.6 m: Becoming Very dark grayish brown (2.5Y 3/2)		KB6		SM				482.572 m (25 Feb 08)
482 / 5										
481 / 6		CLAY: Trace silt and sand. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist and stiff. Laminated.		KB7						
480 / 7										50 mm sch 40 PVC slotted
479 / 8		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist.		KB8 KB9		CH				
478 / 9		CLAY: Trace silt and sand. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist and sitff. Laminated. Sand lenses.		KB10		CH				
10										

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BORE HOLE LOG

Bore Hole: 101
Page: 2 of 2

Client:	Neil Ketilson	Northing:	5,765,376.985 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	388,679.686 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.448 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	488.412 m	Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000) / Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
10 / 477		CLAY: Trace silt and sand. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist and sitff. Laminated. Sand lenses.		KB11		CH				
11 / 476		SILT: Sandy, trace clay. Oxidized. Calcareous. Very dark grayish brown (2.5Y 3/2). Moist and stiff. Dilatant.								
12 / 475				KB12						
13 / 474		NOTES: 125 mm continuous flight auger used. Seepage @ 4.6 m.								
14 / 473										
15 / 472										
16 / 471										
17 / 470										
18 / 469										
19 / 468										
20										

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BORE HOLE LOG

Bore Hole: 102
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Client:	Neil Ketilson	Northing:	5,765,592.890 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	388,709.567 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	490.021 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
490 / 0		SAND: Fine grained. Silty, trace clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Dry and compact. Homogeneous.		KB13 KB14	14					
489 / 1				KB15 KB16	13					
488 / 2				KB17 KB18	17					
487 / 3				KB19 KB20	16					
486 / 4										
485 / 5		CLAY: Trace sand and silt. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist and very stiff. Laminated. Iron staining. Silt partings. Lensed with sand.		KB21 KB22	18					
484 / 6				KB23 KB24						
483 / 7		NOTES: 125 mm continuous flight auger used. No sloughing.								
482 / 8										
481 / 9										
10										

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BORE HOLE LOG

Bore Hole: 103
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Client:	Neil Ketilson	Northing:	5,765,974.919 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	388,747.079 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	489.299 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
489 / 0		SAND: Fine grained. Some silt and clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist. Homogeneous.		KB25						
488 / 1				KB26						
487 / 2		SILT: Some clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		KB27						
		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		KB28						
486 / 3		SILT: Some clay, trace sand. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogenous. Iron staining.								
485 / 4		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		KB29						
484 / 5		SILT: Some clay, trace sand. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogenous.								
483 / 6		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		KB30						
482 / 7		NOTES: 125 mm continuous flight auger used. No sloughing.								
481 / 8										
480 / 9										
10										

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BORE HOLE LOG

Bore Hole: 104
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Client:	Neil Ketilson	Northing:	5,766,116.545 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,077.547 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	489.012 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	489.896 m	Logged by:	KB

Elev (m)	Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
489	0		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist. Homogenous.		KB31		SM				50 mm sch 40 PVC pipe
											Cuttings
488	1				KB32		CL				
			CLAY: Silty, sandy. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist. Hard. Homogeneous.								
487	2				KB33		CL				
486	3		@ 3.04m: Trace sand. Iron staining. Silt partings.		KB34 KB35		CH				Bentonite
485	4				KB36						
			SAND: Fine grained. Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist. Iron and Manganese staining.		KB37		SM				
484	5										Frac sand
483	6		@ 6.1m: Clayey.		KB38						
											482.262 m (19 March 08)
482	7										
					KB39		SM				50 mm sch 40 PVC slotted
481	8										
480	9				KB40						
			NOTES: 125 mm continuous flight auger used. Sloughing @ 5.8 m. Seepage @ 5.8 m.								
	10										

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BORE HOLE LOG

Bore Hole: 105
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Client:	Neil Ketilson	Northing:	5,765,861.154 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,077.457 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.030 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000) / Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
487 / 0		CLAY: 300 mm organic material. Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/6). Moist. Homogeneous.		KB41						
486 / 1				KB42						
		SAND: Fine Grained. Silty, some clay. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Stratified.		KB43						
485 / 2										
484 / 3				KB44						
483 / 4										
482 / 5				KB45						
481 / 6		NOTES: 125 mm continuous flight auger used. Sloughing @ 4.3 m. Seepage @ 4.3 m.		KB46						
480 / 7										
479 / 8										
478 / 9										
10										

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BORE HOLE LOG

Bore Hole: 106
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Client:	Neil Ketilson	Northing:	5,765,600.569 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,053.995 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	489.115 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
489 / 0		SAND: Fine grained. Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		KB47						
488 / 1				KB48						
487 / 2		CLAY: Silty, sandy. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Hard. Laminated.		KB49						
486 / 3				KB50						
485 / 4										
484 / 5		@ 4.6m: Trace sand. Iron and Manganese staining. Some calcium carbonate concretions.		KB51						
483 / 6				KB52 KB53						
482 / 7		NOTES: 125 mm continuous flight auger used.								
481 / 8										
480 / 9										
10										

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BORE HOLE LOG

Bore Hole: 107
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Client:	Neil Ketilson	Northing:	5,765,367.001 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,086.446 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	485.723 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
485 / 0		SAND: Fine grained. Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/3). Moist. Homogeneous.		KB54						
484 / 1		@ 1.5m: Wet.		KB55						
483 / 2				KB56						
482 / 3				KB57						
481 / 4				KB58						
480 / 5		CLAY: Silty, sandy. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist. Soft. Laminated. Manganese staining.								
479 / 6		CLAY: Some silt. Oxidized. Calcareous. Very dark grayish brown (2.5Y 3/2). Moist. Stiff. Laminated. Iron staining.		KB59						
478 / 7		NOTES: 125 mm continuous flight auger used. Sloughing @ 2.1 m.								
477 / 8										
476 / 9										
10										

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BORE HOLE LOG

Bore Hole: 108
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Client:	Neil Ketilson	Northing:	5,765,324.170 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,461.073 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	486.440 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	487.390 m	Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
486 / 0		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Compact. Homogeneous.		KB60						50 mm sch 40 PVC pipe
485 / 1				KB61		SM				Cuttings
				KB62	11					
484 / 2		CLAY: Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Soft. Iron staining. Laminated. Lensed with sand.		KB63		SM				Bentonite
				KB64						
				KB64B	9					
483 / 3		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Compact. Manganese staining. Homogeneous.		KB65		CL				Frac Sand
				KB66	12					
482 / 4				KB67						482.400 m (25 Feb 08)
481 / 5										Slough
480 / 6		CLAY: Trace silt. Oxidized. Calcareous. Very dark grayish brown (2.5Y 3/2). Moist. Firm. Laminated.		KB68						
				KB69		CH				
479 / 7		SAND: Fine grained. Silty. Oxidized. Calcareous. Dark grayish brown (2.5Y4/2). Wet. Homogeneous.		KB70						50 mm sch 40 PVC slotted
478 / 8										
477 / 9				KB71						
10										

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BORE HOLE LOG

Bore Hole: 108
Page: 2 of 2

Client:	Neil Ketilson	Northing:	5,765,324.170 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,461.073 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	486.440 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	487.390 m	Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000) / Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
10 / 476		SAND: Fine grained. Silty. Oxidized. Calcareous. Dark grayish brown (2.5Y4/2). Wet. Homogeneous.		KB72						
11 / 475										
12 / 474				KB73						
		NOTES: 125 mm continuous flight auger used. Water @ 6.9 m. Seepage @ 4.9 m.								
13 / 473										
14 / 472										
15 / 471										
16 / 470										
17 / 469										
18 / 468										
19 / 467										
20										

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BORE HOLE LOG

Bore Hole: 109
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Client:	Neil Ketilson	Northing:	5,765,594.201 (UTM)	Date Drilled:	17 January 2007
Project:	Casa Grande Subdivision	Easting:	389,458.870 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	486.558 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
486 / 0		SAND: Fine grained. Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous.		KB74						
485 / 1				KB75						
484 / 2				KB76						
483 / 3		CLAY: Silty, sandy. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Soft. Homogeneous. Iron and Manganese staining.		KB77 KB78						
482 / 4		@ 4.3 m: Wet.		KB79 KB80						
481 / 5		SAND: Fine grained. Silty. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist. Iron staining.								
480 / 6				KB81						
479 / 7		NOTES: 125 mm continuous flight auger used. Sloughing @ 4.3 m.								
478 / 8										
477 / 9										
10										

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BORE HOLE LOG

Bore Hole: 110
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Client:	Neil Ketilson	Northing:	5,765,865.177 (UTM)	Date Drilled:	17 January 2008
Project:	Casa Grande Subdivision	Easting:	389,397.072 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.043 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	KB

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
487 / 0		CLAY: Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		KB82						
486 / 1		SAND: Silty. Oxidized. Calcareous. Dark olive brown (2.5Y 3/3). Moist. Homogeneous.		KB83						
485 / 2		CLAY: With silt. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Firm. Laminated. Iron staining.		KB84						
484 / 3				KB85						
483 / 4		SAND: Fine grained. Silty, some clay. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous.		KB86						
482 / 5										
481 / 6				KB87						
		NOTES: 125 mm continuous flight auger used. Sloughing @ 4.3 m.								
480 / 7										
479 / 8										
478 / 9										
10										

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BORE HOLE LOG

Bore Hole: 111
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Client:	Neil Ketilson	Northing:	5,766,906.065 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,475.333 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.281 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	488.094 m	Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
487 / 0		SAND: Some silt, some clay. Calcareous. Oxidized. Olive brown (2.5Y 4/3). Moist. Homogeneous.		MN25						Cuttings
486 / 1				MN26						50 mm sch 40 PVC pipe
485 / 2				MN27						Bentonite
484 / 3		CLAY: Some silt, some sand. Calcareous. Oxidized. Olive gray (5Y 4/2). Moist. Firm. Iron and manganese stains. Homogeneous.		MN28						485.264 m (25 Feb 08)
483 / 4		SAND: And silt. Calcareous. Oxidized. Olive gray (5Y 4/2). Moist. Manganese stains. Homogeneous.		MN29						Frac sand
482 / 5										
481 / 6		CLAY: Some silt. Unoxidized. Calcareous. Dark gray (2.5Y 4/1). Moist. Stiff. Homogeneous. Blocky.		MN30						50 mm sch 40 PVC slotted
480 / 7										
479 / 8				MN31						
478 / 9				MN32						
10										

Geotech BH m Elev CAL v03.tdf

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BORE HOLE LOG

Bore Hole: 111
Page: 2 of 2

Client:	Neil Ketilson	Northing:	5,766,906.065 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,475.333 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.281 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:	488.094 m	Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000) / Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
10 / 477		CLAY: Some silt. Unoxidized. Calcareous. Dark gray (2.5Y 4/1). Moist. Stiff. Homogeneous. Blocky.		MN33						
11 / 476										
12 / 475				MN34						
13 / 474										
				MN35						
14 / 473		NOTES: 125 mm continuous flight auger used. Sloughing @ 4.3 m. Seepage @ 5.8 m.								
15 / 472										
16 / 471										
17 / 470										
18 / 469										
19 / 468										
20										

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BORE HOLE LOG

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Client:	Neil Ketilson	Northing:	5,766,912.968 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,067.950 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.154 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
487 / 0		SAND: Fine grained. Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/4). Moist. Homogeneous.		MN13						
486 / 1										
		@ 1.5 m: And silt. Light olive brown (2.5Y 5/4). Salt inclusions.		MN14						
485 / 2										
		CLAY: Silty. Trace sand. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Homogeneous. Iron staining.		MN15						
484 / 3				MN16						
		@ 4.3 m: Wet.		MN17						
483 / 4										
482 / 5		CLAY: Some silt. Unoxidized. Calcareous. Dark gray (2.5Y 4/1). Moist. Stiff. Homogeneous. Blocky.								
481 / 6				MN18						
		NOTES: 125 mm continuous flight auger used. Seepage @ 4.3 m.								
480 / 7										
479 / 8										
478 / 9										
10										

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BORE HOLE LOG

Bore Hole: 113
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Client:	Neil Ketilson	Northing:	5,766,642.442 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,078.575 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.616 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
487 / 0		CLAY: Silty, sandy. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Dry. Homogeneous.		MN19						
486 / 1				MN20						
485 / 2		SAND: Fine grained. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Dry. Homogeneous. @ 2.3 m: Moist.		MN21						
484 / 3		CLAY: And silt. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Very soft. Homogeneous. Iron and manganese staining. Salt inclusions. @ 3.7 m: Trace silt.		MN22						
483 / 4				MN23						
482 / 5		CLAY: Trace silt. Unoxidized. Calcareous. Dark gray (2.5Y 4/1). Moist. Stiff. Homogeneous. Iron and manganese staining.		MN24						
481 / 6		NOTES: 125 mm continuous flight auger used.								
480 / 7										
479 / 8										
478 / 9										
10										

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BORE HOLE LOG

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Client:	Neil Ketilson	Northing:	5,766,644.763 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,462.535 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	486.131m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
486 / 0		SAND: Fine grained. Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous.		MN36						
485 / 1		@ 1.5 m: Iron staining.		MN37						
484 / 2		CLAY: Silty, trace sand. Oxidized. Calcareous. Light olive brown (2.5y 5/3). Moist. Stiff. Homogeneous. Blocky. Iron and manganese staining.		MN38						
				MN38A						
483 / 3				MN39						
482 / 4										
				MN40						
481 / 5		SAND: Fine grained. Silty. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Wet. Very soft. Homogeneous.								
480 / 6				MN41						
		NOTES: 125 mm continuous flight auger used.								
479 / 7										
478 / 8										
477 / 9										
10										

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BORE HOLE LOG

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Client:	Neil Ketilson	Northing:	5,766,653.031 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	388,734.367 m (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	487.645 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
0 / 487		SAND: Fine grained. Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous.		MN58			0.01			
1										
1.5 / 486		CLAY: Silty. Trace sand. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist. Stiff. Homogeneous. Iron staining. Salt inlcusions.		MN59			0.14			
2				MN60						
2.19 / 485		@ 2.19 m: Light olive brown (2.5Y 5/3). Very stiff. Blocky.								
3				MN61						
4 / 484										
4.5 / 483				MN62						
5										
6 / 482				MN63						
6.5 / 481		NOTES: 125 mm continuous flight auger used.								
7										
8 / 480										
9 / 479										
10 / 478										

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BORE HOLE LOG

Bore Hole: 116
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Client:	Neil Ketilson	Northing:	5,765,643.118 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,291.604 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	486.963 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
0		SAND: Fine grained. Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous. Iron staining. Salt inclusions.		MN1						
486 – 1		CLAY: Silty. Oxidized. Calcareous. Dark olive brown (2.5Y 3/3). Moist. Stiff. Homogeneous. Iron staining. Salt inclusions.		MN2						
485 – 2				MN3						
484 – 3				MN4						
483 – 4										
				MN5						
482 – 5		@ 5.2 m: Interbedded clay and silt.								
481 – 6				MN6						
		NOTES: 125 mm continuous flight auger used. Seepage @ 5.8 m.								
480 – 7										
479 – 8										
478 – 9										
477 – 10										

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BORE HOLE LOG

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Client:	Neil Ketilson	Northing:	5,765,569.269 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	388,792.867 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	486.094 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000) / Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
486 / 0		SAND: 900 mm organic material. Silty, trace clay. Oxidized. Calcareous. Olive brown (2.5Y 4/4). Moist. Homogeneous.		MN7						
485 / 1				MN8						
484 / 2		CLAY: Some silt. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous. Iron staining. Salt inclusions. Blocky.		MN9						
483 / 3				MN10						
482 / 4										
481 / 5		@ 4.6 m: Very dark grayish brown (2.5Y 3/2). @ 5.5 m: Sand lense. Wet.		MN11						
480 / 6				MN12						
479 / 7		NOTES: 125 mm continuous flight auger used.								
478 / 8										
477 / 9										
10										

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BORE HOLE LOG

Bore Hole: 118
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Client:	Neil Ketilson	Northing:	5,766,549.263 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	388,851.487 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	489.390 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
489 / 0		SAND: Fine grained. Some silt. Oxidized. Calcareous. Light olive brown (2.5Y 5/4). Moist. Homogeneous.		MN52						
488 / 1		CLAY: Sitly, trace sand. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Very stiff. Homogeneous.		MN53						
487 / 2		@ 2.2 m: Silt partings. Iron staining.		MN54						
486 / 3		SAND: Fine grained. Silty. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist. Laminated.		MN55 MN55A						
485 / 4		CLAY: And silt. Oxidized. Calcareous. Dark grayish brown (2.5Y 4/2). Moist. Very soft. Homogeneous. Iron staining. Organic inclusions.		MN56						
484 / 5		SAND: Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Wet. Homogeneous.		MN56						
483 / 6		NOTES: 125 mm continuous flight auger used. Seepage @ 5.8 m.								
482 / 7										
481 / 8										
480 / 9										
10										

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BORE HOLE LOG

Bore Hole: 119
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Client:	Neil Ketilson	Northing:	5,766,577.427 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,262.166 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	488.243 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
488 / 0		SAND: Fine grained. Silty. Oxidized. Calcareous. Light olive brown (2.5Y 5/6). Moist. Homogeneous.		MN42						
487 / 1				MN43						
486 / 2				MN44						
				MN44A						
485 / 3				MN45						
484 / 4				MN46						
483 / 5		CLAY: Silty. Oxidized. Calcareous. Olive brown (2.5Y 4/3). Moist. Homogeneous.								
482 / 6		CLAY: Silty. Unoxidized. Calcareous. Very dark gray (2.5Y 3/1). Moist. Homogeneous.		MN47						
481 / 7		SAND: Fine grained. Silty, trace clay. Unoxidized. Calcareous. Very dark gray (2.5Y 3/1). Wet. Homogeneous.		MN48						
480 / 8										
479 / 9				MN49						
10										

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BORE HOLE LOG

Bore Hole: 119
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Client:	Neil Ketilson	Northing:	5,766,577.427 (UTM)	Date Drilled:	08 February 2008
Project:	Casa Grande Subdivision	Easting:	389,262.166 (UTM)	Drill:	Brat 22
Location:	Grasswood, SK	Ground Elev.:	488.243 m (Geodetic)	Drilling Method:	Solid Stem Auger
Project No.:	S1607	Top Casing Elev.:		Logged by:	MN

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1600 – 2000) / Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
478 / 10		SAND: Fine grained. Silty, trace clay. Unoxidized. Calcareous. Very dark gray (2.5Y 3/1). Wet. Homogeneous.		MN50						
477 / 11		@ 10.7 m: Clayey. Black (2.5Y 2.5/1).								
476 / 12				MN51						
475 / 13		NOTES: 125 mm continuous flight auger used. Seepage @ 6.4 m.								
474 / 14										
473 / 15										
472 / 16										
471 / 17										
470 / 18										
469 / 19										
20										

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BORE HOLE LOG

Bore Hole: **201**

Client:	Urban Elements Development Corp.	Northing:	10456.704m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5699.239m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.074m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	511.195m	Logged by:	JR

Elev (m)	Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲, Natural Moisture ●, Liquid Limit ◆ (0–50–100)	▲ Dry Density - kg/m3 (1800–2200); Shear Strength - kPa: Unconf. ■, Pocket Pen. ●, Lab Vane ◆ (100–200–300–400)	Piezometer Construction Detail
510	0		ORGANIC SOIL: 300mm of organic soil.								50mm Sch40 Solid PVC
			SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist.								
509	1				CF27		SM		● ◆		Bentonite
508	2										508.08m measured 4 July 2012
507	3										Slough; 50mm Sch40 Slotted PVC
506	4										
505	5		CLAY: Clay, some silt. Very dark gray (2.5Y 3/1). Unoxidized. Calcareous. Manganese stains.								
504	6		NOTES: Completed to 6.1m. Sloughing at 2.4m.								
503	7										
502	8										
501	9										
	10										

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BORE HOLE LOG

Bore Hole: 202
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Client:	Urban Elements Development Corp.	Northing:	10531.515m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5500.573m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	511.436m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	512.498m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
511 / 0		ORGANIC SOIL: 150mm of organic soil.								
		SAND: Fine to medium grained sand, trace silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.		CF29		SM		●		50mm Sch40 Solid PVC; Bentonite
510 / 1										
510 / 2										509.28m measured 4 July 2012
509 / 2										
509 / 3		@ 3.0m: Becomes wet.								Slough
508 / 3										
508 / 4										
507 / 4										
507 / 5										
506 / 5										
506 / 6		CLAY: Clay, some silt. Very dark gray (2.5Y 3/1). Unoxidized. Calcareous. Manganese stains.		CF30						
505 / 6										
505 / 7										
504 / 7				CF31						
504 / 8		SAND: Fine to medium grained sand, trace silt, trace clay. Dark gray (2.5Y 4/1). Unoxidized. Calcareous. Moist. Organic inclusions.								
503 / 8										
503 / 9										
502 / 9										
502 / 10										

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BORE HOLE LOG

Bore Hole: 202
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Client:	Urban Elements Development Corp.	Northing:	10531.515m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5500.573m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	511.436m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	512.498m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲	Moisture Content (percent): Natural Moisture ●	Moisture Content (percent): Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 ▲ (1800 – 2200)	Shear Strength - kPa: Unconf. ■	Shear Strength - kPa: Pocket Pen. ●	Shear Strength - kPa: Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
501 / 10		SAND: Fine to medium grained sand, trace silt, trace clay. Dark gray (2.5Y 4/1). Unoxidized. Calcareous. Moist. Organic inclusions.													50mm Sch40 Slotted PVC
500 / 11															
499 / 12															
498 / 13		CLAY: Clay, some silt. Very dark gray (2.5Y 3/1). Unoxidized. Calcareous. Manganese stains.													
497 / 14															
496 / 15		NOTES: Completed to 15.2m. Sloughed to 2.4m. Seepage at 3.0m.													
495 / 16															
494 / 17															
493 / 18															
492 / 19															
20															

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BORE HOLE LOG

Bore Hole: 203
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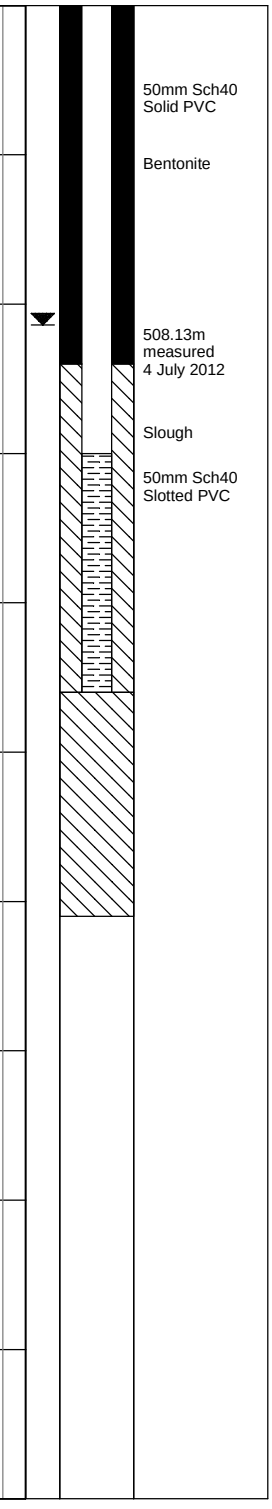
Client:	Urban Elements Development Corp.	Northing:	10336.175m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5512.287m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.265m	Drilling Method:	Hollow Stem
Project No.:	S1607.7	Top Casing Elev.:	511.309m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0, 50, 100)	Dry Density - kg/m3 (1800, 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100, 200, 300, 400)	Piezometer Construction Detail
510 / 0		ORGANIC SOIL: 450mm of organic soil.								
509 / 1		CLAY: Clay, some silt, trace fine grained sand. Dark olive brown (2.5Y 3/3). Oxidized. Calcareous. Moist.		CF32		SC				
508 / 2		SAND: Fine to medium grained sand, trace silt, clayey. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist.								
507 / 3		@ Becomes some silt, trace clay.		CF33		SM				
506 / 4		@ 4.6m: Becomes wet.								
505 / 5										
504 / 6		NOTES: Completed to 6.1m. Sloughed to 2.4m. Seepage at 4.6m.								
503 / 7										
502 / 8										
501 / 9										
10										



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BORE HOLE LOG

Bore Hole: 204
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Client:	Urban Elements Development Corp.	Northing:	10026.538m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5597.994m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	509.740m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	510.795m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
509 / 0		ORGANIC SOIL: 300mm of organic soil.								50mm Sch40 Solid PVC
509 / 1		SAND: Fine to medium grained sand, silty, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								Bentonite
508 / 2				CF34		SM				
507 / 3		@ 3m: Becomes wet.								507.40m measured 4 July 2012
506 / 4										Slough
505 / 5										50mm Sch40 Slotted PVC
504 / 6		@ 6.1m: Becomes dark gray (2.5Y 4/1). Unoxidized. Organic inclusions.								
503 / 7										
502 / 8										
501 / 9		SILT: Silt, clayey, sandy. Dark gray (2.5Y 4/1). Unoxidized. Calcareous. Wet.		CF35		CL/ ML				
500 / 10		NOTES: Completed to 9.1m. Sloughed to 2.4m. Seepage at 3.0m.								

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BORE HOLE LOG

Bore Hole: 205
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	9789.895m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5285.498m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.625m	Drilling Method:	Hollow Stem
Project No.:	S1607.7	Top Casing Elev.:	511.567m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
510 / 0		ORGANIC SOIL: 750mm of organic soil.								50mm Sch40 Solid PVC
509 / 1		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								Bentonite
508 / 2		@ 1.8m: Becomes wet. Interbedded gray clay.								
507 / 3		CLAY: Clay, some silt. Very dark gray (2.5Y 3/1). Oxidized. Calcareous. Moist. Iron staining.								Filter Sand
506 / 4										506.53 m measured 4 July 2012
505 / 5		SAND: Fine to medium grained sand, silty, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Wet. Iron staining.		CF21		SM				50mm Sch40 Slotted PVC
504 / 6										
503 / 7										Slough
502 / 8		NOTES: Completed to 7.6m. Seepage at 1.8m. Piezometer installed inside hollow stem.								
501 / 9										
10										

Geotech BH m Elev CAL v07.tdf

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BORE HOLE LOG

Bore Hole: 206
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	9353.173m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5281.355m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	509.803m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	510.736m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0, 50, 100)	Dry Density - kg/m3 (1800, 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100, 200, 300, 400)	Piezometer Construction Detail
509 / 0		SAND: Fine to medium grained sand, silty, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.		CF9						50mm Sch40 Solid PVC
508 / 1										Bentonite
507 / 2		@ 1.5m: Becomes gray.								507.29 m measured 4 July 2012
506 / 3				CF10		SM				
505 / 4										50mm Sch40 Slotted PVC
504 / 5				CF11						
503 / 6		NOTES: Completed to 6.1m. Sloughed to 2.4m.								Slough
502 / 7										
501 / 8										
500 / 9										
10										

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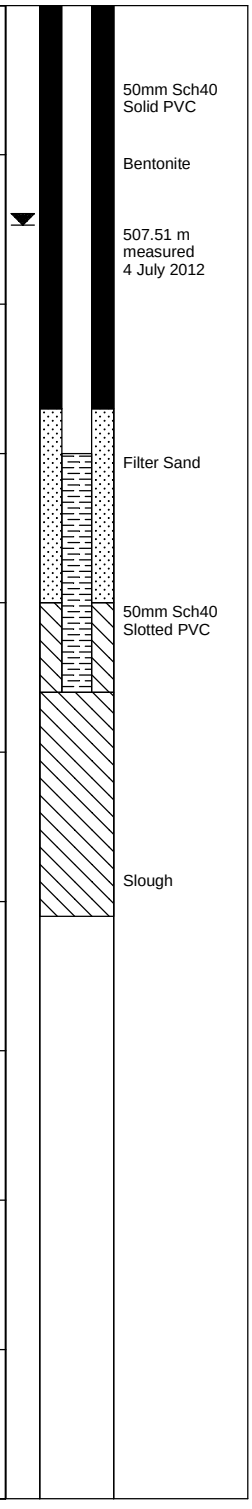
BORE HOLE LOG

Bore Hole: 207
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	9457.629m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5634.255m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	508.982m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	509.903m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
508 / 0		ORGANIC SOIL: 200mm of organic soil.								
508 / 1		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.		CF6						
507 / 2		CLAY: Clay, some silt. Olive brown (2.5Y 4/2). Oxidized. Calcareous. Iron staining.		CF7						
506 / 3		SAND: Fine to medium grained sand, silty, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Wet. Iron staining.								
505 / 4				CF8		SM				
504 / 5		@ 4.6m: Becomes gray.								
503 / 6		CLAY: Clay, some silt. Dark gray (2.5Y 4/1). Oxidized. Calcareous. Moist. Iron staining.								
502 / 7		NOTES: Completed to 6.1m. Sloughed to 4.0m. Seepage at 1.7m.								
501 / 8										
500 / 9										
499 / 10										



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BORE HOLE LOG

Bore Hole: 208
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	10561.860m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5202.471m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	511.351m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	512.366m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
511 / 0		ORGANIC SOIL: 150mm of organic soil.								50mm Sch40 Solid PVC
		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								Bentonite
510 / 1				CF25						
509 / 2		@ 2.4m: Some clay.								Filter Sand
508 / 3										508.55m measured 4 July 2012
				CF26						
507 / 4										50mm Sch40 Slotted PVC
506 / 5		CLAY: Clay, some silt. Dark gray (2.5Y 4/1). Oxidized. Calcareous. Moist. Iron staining.								
505 / 6		NOTES: Completed to 6.1m. No sloughing. No seepage.								
504 / 7										
503 / 8										
502 / 9										
501 / 10										

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BORE HOLE LOG

Bore Hole: 209
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	9716.323m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5113.209m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	512.626m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	513.512m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
512 / 0		ORGANIC SOIL: 450mm of organic soil.								50mm Sch40 Solid PVC
512 / 0.5		SAND: Fine to medium grained sand, some silty, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								
511 / 1				CF20		SM		● ◆		Bentonite
511 / 1.5										
511 / 2										Filter Sand
510 / 2.5										
510 / 3		@ 3.0m: Clayey.								50mm Sch40 Slotted PVC
509 / 3.5										
509 / 4		CLAY: Clay, some silt, trace sand. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								empty measured 4 July 2012
508 / 4.5										
508 / 5										
507 / 5.5										
507 / 6										Slough
506 / 6.5										
506 / 7										
505 / 7.5										
505 / 8		NOTES: Completed to 7.6m. Sloughed to 3.7m.								
504 / 8.5										
504 / 9										
503 / 9.5										
503 / 10										

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BORE HOLE LOG

Bore Hole: 210
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	10105.393m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5102.667m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	511.424m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	512.562m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
511 / 0		ORGANIC SOIL: 300mm of organic soil.								
		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								
510 / 1			CF36			SM		●		
509 / 2										
508 / 3										Filter Sand
507 / 4		@ 4.6m: Becomes wet.								507.25 measured 4 July 2012
506 / 5										
505 / 6		NOTES: Completed to 6.1m. Sloughed to 4.3m. Seepage at 4.6m.								Slough
504 / 7										
503 / 8										
502 / 9										
/ 10										

50mm Sch40 Solid PVC

Bentonite

50mm Sch40 Slotted PVC

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BORE HOLE LOG

Bore Hole: 211
Page: 1 of 1

Client:	Urban Elements Development Corp.	Northing:	10732.780m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5727.468m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	511.078m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	512.157m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
511 / 0		ORGANIC SOIL: 150mm of organic soil.								Bentonite
		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								
510 / 1		@ 1.2m: Becomes wet.		CF28		SM		●		509.87m measured 28 June 2012
509 / 2										50mm Sch40 Solid PVC
508 / 3										Slough
										50mm Sch40 Slotted PVC
507 / 4										
506 / 5										
505 / 6										Slough
		NOTES: Completed to 6.1m. Sloughed to 0.9m. Seepage at 1.2m.								
504 / 7										
503 / 8										
502 / 9										
10										

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BORE HOLE LOG

Bore Hole: 212
Page: 1 of 2

Client:	Urban Elements Development Corp.	Northing:	9247.058m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5809.272m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.111m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	511.005m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200) / Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
510 / 0		ORGANIC SOIL: 600mm of organic soil.								Bentonite
509 / 1		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.		CF1						
508 / 2		CLAY: Clay, some silt. Olive brown (2.5Y 4/2). Oxidized. Calcareous. Moist.								50mm Sch40 Solid PVC
507 / 3		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist. Iron staining.								507.77m measured 4 July 2012
506 / 4				CF2		SM		●		
505 / 5		CLAY: Clay, some silt. Dark gray (2.5Y 4/1). Oxidized. Calcareous. Moist. Iron staining.								
504 / 6										
503 / 7										
502 / 8				CF3						Slough
501 / 9										
/ 10										

Geotech BH m Elev CAL v07.tdf

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BORE HOLE LOG

Bore Hole: 212
Page: 2 of 2

Client:	Urban Elements Development Corp.	Northing:	9247.058m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5809.272m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.111m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	511.005m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
500 / 10		CLAY: Clay, some silt. Dark gray (2.5Y 4/1). Oxidized. Calcareous. Moist. Iron staining.								
499 / 11		@ 10.7m: No iron staining. Unoxidized.								
498 / 12		SAND: Fine to medium grained sand, some silt, trace clay. Dark gray (2.5Y 4/1). Unoxidized. Calcareous. Moist. Organic inclusions.		CF4						
497 / 13										50mm Sch40 Slotted PVC
496 / 14										Slough
495 / 15				CF5						
494 / 16		NOTES: Completed to 15.2m. Sloughed to 2.6m.								
493 / 17										
492 / 18										
491 / 19										
20										

Geotech BH m Elev CAL v07.tdf

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BORE HOLE LOG

Bore Hole: 213
Page: 1 of 2

Client:	Urban Elements Development Corp.	Northing:	9595.474m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5498.802m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.485m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	511.624m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0, 50, 100)	Dry Density - kg/m3 (1800, 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100, 200, 300, 400)	Piezometer Construction Detail
510 / 0		SAND: Fine to medium grained sand, some silt, trace clay. Olive brown (2.5Y 4/3). Oxidized. Calcareous. Moist.								Bentonite
509 / 1										
508 / 2		CLAY: Clay, and silt, trace sand. Olive brown (2.5Y 4/2). Oxidized. Calcareous. Moist. Iron staining.		CF22						50mm Sch40 Solid PVC
507 / 3				CF23		CL		▲ ● ◆		506.902m measured 28 June 2012
506 / 4										
505 / 5										
504 / 6										
503 / 7		@ 7.6m: Becomes dark gray (2.5Y 4/1).								
502 / 8										Slough
501 / 9		@ 9.1m: No iron staining. Unoxidized.								
10										

Geotech BH m Elev CAL v07.tdf

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BORE HOLE LOG

Bore Hole: 213
Page: 2 of 2

Client:	Urban Elements Development Corp.	Northing:	9595.474m	Date Drilled:	28 June 2012
Project:	Grasswood Estates	Easting:	5498.802m	Drill:	CME
Location:	Saskatoon, SK	Ground Elev.:	510.485m	Drilling Method:	Solid Stem
Project No.:	S1607.7	Top Casing Elev.:	511.624m	Logged by:	JR

Elev (m) / Depth (m)	Symbol	Soil Description	Sample: Type	Sample: No.	Sample: SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit / Natural Moisture / Liquid Limit (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. / Pocket Pen. / Lab Vane (100 – 200 – 300 – 400)	Piezometer Construction Detail
500 / 10		CLAY: Clay, and silt, trace sand. Olive brown (2.5Y 4/2). Oxidized. Calcareous. Moist. Iron staining.								
499 / 11		SAND: Fine to medium grained sand, some silt, trace clay. Dark gray (2.5Y 4/1). Unoxidized. Calcareous. Moist.								50mm Sch40 Slotted PVC
498 / 12			CF24							
497 / 13										
496 / 14										Slough
495 / 15		NOTES: Completed to 15.2m. Sloughed to 6.1m.								
494 / 16										
493 / 17										
492 / 18										
491 / 19										
20										

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB1	BAG		4.4													
0.76	KB2	SY	270	5.3			NP	SM	0.0	84.2	16.8				N/A	N/A	
1.52	KB3	SY	300	25.8	23.9	68.2	44.3	CH	0.0	1.4	98.6				175	160	
2.29	KB4	SY	150	9.8			NP	SM	0.0	712.0	28.0				N/A	N/A	
3.05	KB5	SY	200	7.5											N/A	N/A	
4.57	KB6	SY	200	17.8			NP	SM	0.0	85.9	14.1				N/A	N/A	
6.10	KB7	SY	460	25.1													
7.62	KB8	BAG		34.0	23.6	57.9	34.3	CH	0.0	8.3	91.7						
7.92	KB9	BAG		24.4													
9.14	KB10	BAG		38.9	28.7	77.9	49.2	CH	0.0	1.7	98.3						
10.67	KB11	BAG		34.6	24.0	74.6	50.6	CH	0.0	1.8	98.2						
12.19	KB12	BAG		27.0													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

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SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB13	BAG		4.2					0.0	76.7	13.2	10.1					
0.76	KB14	SPT		3.8													
1.52	KB15	BAG		5.1													
2.29	KB16	SPT		4.9													
3.05	KB17	BAG		4.9													
4.57	KB18	SPT		4.7													
6.10	KB19	BAG		4.5													
7.62	KB20	SPT		4.2													
7.92	KB21	BAG		23.3													
9.14	KB22	SPT		26.2													
10.67	KB23	BAG		30.9													
12.19	KB24	SPT		27.5													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

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SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB25	BAG		6.4													
1.52	KB26	BAG		6.4													
2.29	KB27	BAG		12.6													
3.05	KB28	BAG		4.2													
4.57	KB29	BAG		11.7													
6.10	KB30	BAG		6.9													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

103

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB31	BAG		9.2			NP	SM	0.0	55.4	44.6						
1.52	KB32	BAG		11.8	19.5	43.3	23.8	CL	0.0	36.0	64.0						
2.29	KB33	BAG		16.5	18.9	49.1	30.2	CL	0.0	17.7	82.3						
3.05	KB34	BAG		18.6													
3.05	KB35	SY	310	23.4	26.4	63.7	37.3	CH	0.0	1.0	99.0				260+	290+	
4.57	KB36	BAG		13.5													
4.57	KB37	SY	260	9.1			NP	SM	0.0	57.0	43.0				260+	290+	
6.10	KB38	BAG		16.3													
7.62	KB39	BAG		28.7			NP	SM	0.0	77.3	22.7						
9.14	KB40	BAG		25.6													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

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SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB41	BAG		9.8					0.0	14.9	61.3	23.8					
1.52	KB42	BAG		4.3													
2.29	KB43	BAG		4.1													
3.05	KB44	BAG		6.8													
4.57	KB45	BAG		25.5													
6.10	KB46	BAG		28.2													

Clifton Associates Ltd.
engineering science technology

PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

105

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB47	BAG		5.2													
1.52	KB48	BAG		4.6													
2.29	KB49	BAG		16.3													
3.05	KB50	BAG		19.1													
4.57	KB51	BAG		26.4													
6.10	KB52	BAG		33.0													
6.10	KB53	SY	260	29.7											120	105	

Clifton Associates Ltd.
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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

106

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB54	BAG		5.9													
1.52	KB55	BAG		5.6													
2.29	KB56	BAG		27.8													
3.05	KB57	BAG		29.0													
4.57	KB58	BAG		31.9													
6.10	KB59	BAG		36.0													

Clifton Associates Ltd.
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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

107

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB60	BAG		26.1													
1.52	KB61	BAG		36.0			NP	SM	0.0	79.2	20.8						
1.52	KB62	SPT		17.9													
2.29	KB63	BAG		6.7			NP	SM	0.0	79.8	20.2						
2.29	KB64	SPT		9.0													
2.29	KB64B	SPT		35.5													
3.05	KB65	BAG		22.4	19.9	33.7	13.8	CL	0.0	20.6	79.4						
3.05	KB66	SPT		16.4													
4.57	KB67	BAG		22.6													
6.10	KB68	BAG		25.4													
6.71	KB69	BAG		35.1	16.4	51.9	37.3	CH	0.0	3.4	96.6						
7.62	KB70	BAG		24.7													
9.14	KB71	BAG		23.0													
10.67	KB72	BAG		25.1													
12.19	KB73	BAG		25.4													

Clifton Associates Ltd.
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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

108

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB74	BAG		6.2													
1.52	KB75	BAG		5.4													
2.29	KB76	BAG		10.4													
3.05	KB77	BAG		30.7													
3.05	KB78	SY	230	23.9											N/A	N/A	
4.57	KB79	BAG		36.1													
4.57	KB80	SY	390	22.5											30	35	
6.10	KB81	BAG		25.8													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

109

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	KB82	BAG		12.8					0.0	25.4	36.2	38.5					
1.52	KB83	BAG		13.4													
2.29	KB84	BAG		22.9													
3.05	KB85	BAG		14.4													
4.57	KB86	BAG		11.7													
6.10	KB87	BAG		26.8													

Clifton Associates Ltd.
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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

110

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN25	BAG		18.0					0.0	74.6	12.6	12.8					
1.52	MN26	BAG		23.7													
2.29	MN27	BAG		24.4													
3.05	MN28	BAG		26.4													
4.57	MN29	BAG		26.2													
6.10	MN30	BAG		36.1													
7.62	MN31	BAG		35.6													
9.14	MN32	BAG		34.8													
10.67	MN33	BAG		34.9													
12.19	MN34	BAG		33.5													
13.72	MN35	BAG		36.0													

Clifton Associates Ltd.
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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

111

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN13	BAG		10.4													
1.52	MN14	BAG		25.1													
2.29	MN15	BAG		34.2													
3.05	MN16	BAG		32.1													
4.57	MN17	BAG		29.5													
6.10	MN18	BAG		31.8													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

112

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN19	BAG		8.4					0.0	32.3	50.4	17.2					
1.52	MN20	BAG		10.6													
2.29	MN21	BAG		15.5													
3.05	MN22	BAG		26.9													
4.57	MN23	BAG		37.3													
6.10	MN24	BAG		36.7													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

113

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN36	BAG		15.5													
1.52	MN37	BAG		18.1													
2.29	MN38	BAG		29.8													
2.44	MN39A	SY	395	38.1											65	65	
3.05	MN39B	BAG		37.9													
4.57	MN40	BAG		32.4													
6.10	MN41	BAG		28.1													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

114

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN58	BAG		6.9									0.01				
1.52	MN59	BAG		22.8									0.14				
2.29	MN60	BAG		33.4													
3.05	MN61	BAG		34.4													
4.57	MN62	BAG		37.7													
6.10	MN63	BAG		32.8													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

115

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN1	BAG		19.9									0.74				
1.52	MN2	BAG		23.4									1.11				
2.29	MN3	BAG		29.5													
3.05	MN4	BAG		30.5													
4.57	MN5	BAG		33.4													
6.10	MN6	BAG		30.5													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

116

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN7	BAG		11.2													
1.52	MN8	BAG		5.6													
2.29	MN9	BAG		30.8													
3.05	MN10	BAG		28.6													
4.57	MN11	BAG		34.7													
6.10	MN12	BAG		40.2													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

117

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE				WATER CONTENT	CONSISTENCY				GRADATION				SULPHATE CONTENT	SHEAR STRENGTH			DRY DENSITY
DEPTH	NUMBER	TYPE	RECOVERY		PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY		COMPRESSION TEST	LAB VANE	POCKET PEN	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN52	BAG		6.2													
1.52	MN53	BAG		30.5													
2.29	MN54	BAG		33.3													
3.05	MN55	BAG		31.5													
3.05	MN55A	SY	250	12.2											165	180	
4.57	MN56	BAG		34.0													
6.10	MN56	BAG		22.8													

Clifton Associates Ltd.
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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

118

SUMMARY OF SAMPLING AND LABORATORY TEST DATA

SAMPLE					CONSISTENCY				GRADATION					SHEAR STRENGTH			
DEPTH	NUMBER	TYPE	RECOVERY	WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	USC	GRAVEL	SAND	SILT	CLAY	SULPHATE CONTENT	COMPRESSION TEST	LAB VANE	POCKET PEN	DRY DENSITY
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
0.76	MN42	BAG		10.2													
1.52	MN43	BAG		9.4													
2.29	MN44	BAG		8.6													
2.74	MN44A	SY	220	2.8											N/A	N/A	
3.05	MN45	BAG		3.7													
4.57	MN46	BAG		23.9													
6.10	MN47	BAG		30.1													
7.62	MN48	BAG		28.0													
9.14	MN49	BAG		26.8													
10.67	MN50	BAG		33.4													
12.19	MN51	BAG		26.7													

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PROJECT Casa Grande Subdivision
LOCATION Grasswood, Saskatchewan
PROJECT NO. S1607

BORE HOLE NO.

119

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.52	CF27	Bag		13.7	21.6	23.0	1.3	SM	0.0	74.6	8.1	17.3					

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project Hydrogeology Investigation
Location Grasswood Area, near Saskatoon, SK
Project No. S1607.7

Borehole No.

201

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.52	CF29	Bag		11.6	Non Plastic			SM	0.0	75.3	24.7						

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

202

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.22	CF32	Bag		20.6	19.4	27.7	8.3	CL	0.0	44.4	33.1	22.5					
3.05	CF33	Bag		26.9	Non Plastic			SM	0.0	75.1	15.0	9.9					

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

203

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.52	CF34	Bag		9.0	Non Plastic			SM	0.0	85.1	24.9						
8.53	CF35	Bag		35.3	26.1	30.6	4.5	CL-ML	0.0	31.8	51.6	16.7					

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

204

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
5.18	CF21	Bag		31.3	Non Plastic			SM	0.0	70.2	29.8						

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

205

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
3.05	CF10	Bag		18.9	Non Plastic			SM	0.0	71.8	28.2						

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

206

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
4.57	CF8	Bag		30.8	Non Plastic			SM	0.0	80.3	19.7						

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

207

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

208

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.60	CF20	Bag		15.4	23.0	23.9	0.9	SM	0.0	65.5	19.7	14.9					

Remarks: No depth noted on grab bag for CF20.

Approved by: _____

Clifton Associates Ltd.
engineering science technology

Project Hydrogeology Investigation
Location Grasswood Area, near Saskatoon, SK
Project No. S1607.7

Borehole No.

209

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.52	CF36	Bag		9.3	Non Plastic			SM	0.0	80.8	19.2						

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

210

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
1.52	CF28	Bag		23.5	Non Plastic			SM	0.0	84.3	15.7						

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

211

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
4.11	CF2	Bag		23.2	Non Plastic			SM	0.0	69.9	14.0	16.1					

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

212

Summary of Sampling and Laboratory Test Data

Sample				Water Content	Consistency				Gradation				Sulphate Content	Shear Strength			Dry Density
Depth	Number	Type	Recovery		Plastic Limit	Liquid Limit	Plasticity Index	USC	Gravel	Sand	Silt	Clay		Compression Test	Lab Vane	Pocket Penetrometer	
meters			mm	%	%	%	%		%	%	%	%	%	kPa	kPa	kPa	kg/m^3
3.05	CF23	Bag		26.9	20.2	37.8	17.6	CL	0.0	3.9	60.7	35.4					

Remarks:

Approved by:

Clifton Associates Ltd.
engineering science technology

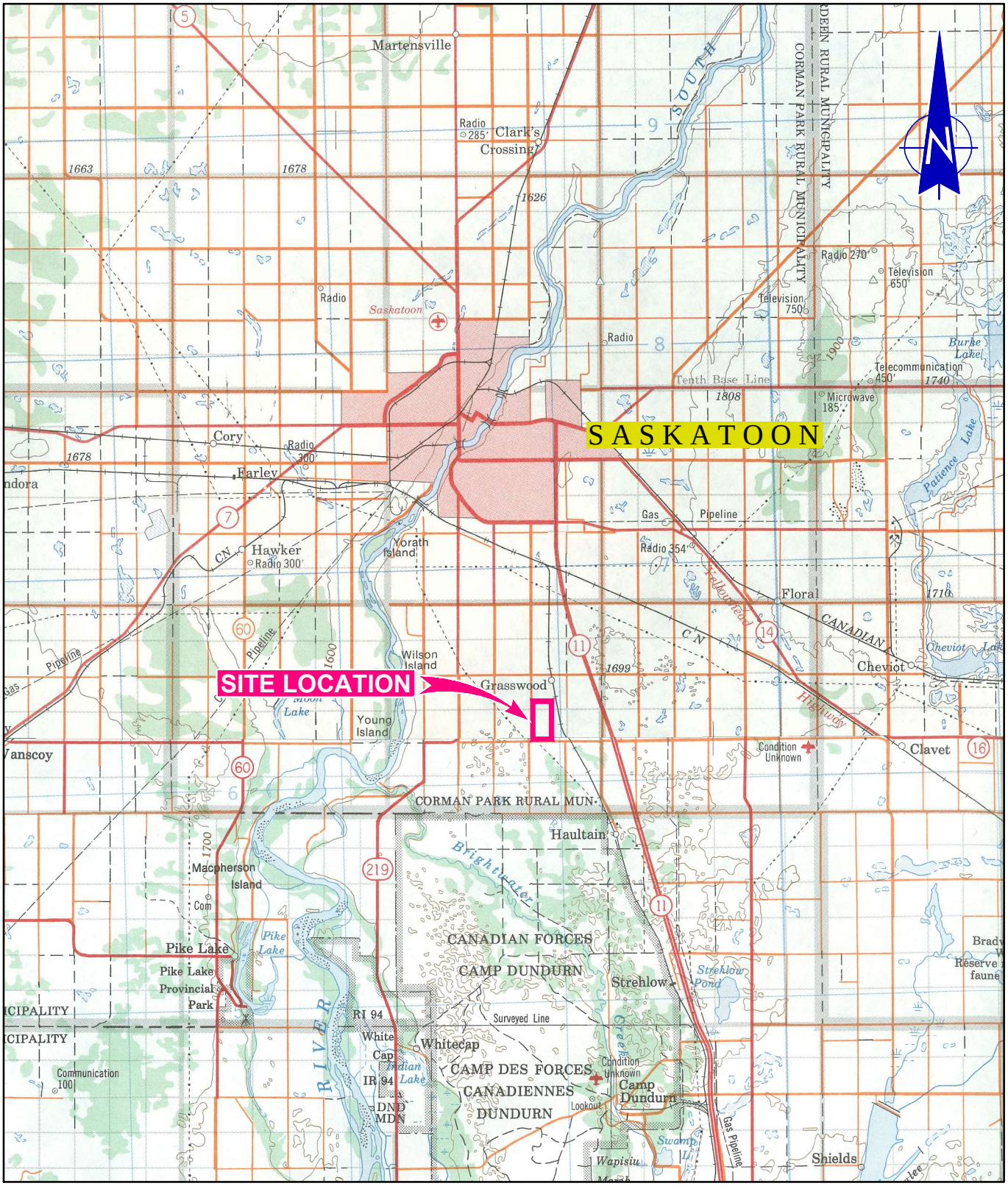
Project	Hydrogeology Investigation
Location	Grasswood Area, near Saskatoon, SK
Project No.	S1607.7

Borehole No.

213

Clifton Associates Ltd.
engineering science technology

Drawings



DRAWING REVISIONS				SCALE	PROJECT NO.	LAND LOCATION
				N.T.S	S1607.7	W1/2 26–35–S W3
				CLIENT	URBAN ELEMENTS DEVELOPMENTS CORP.	
REV	DESCRIPTION	BY	DATE	PROJECT	GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION	
DATE 2012–07–17	DESIGN BY C.F	DRAWN BY Z.Y	CHECKED BY J.G			
Clifton Associates Ltd. engineering science technology				TITLE	SITE LOCATION	DWG. NO. 01

J:\SDSK\PROJ\S1607.4\!CURRENT DRAWINGS\HYDROGEOLOGICAL INVESTIGATION\S1607.7–01.dwg

PRESTON AVENUE

BAKER ROAD

RAILWAY TRACK

BH 101
BH 102
BH 117
BH 206
BH 107
BH 106
BH 213
BH 116
BH 207
BH 108
BH 109
BH 212
BH 209
BH 103
BH 205
BH 105
BH 104
BH 110
BH 204
BH 210
BH 115
BH 118
BH 208
BH 112
BH 113
BH 203
BH 202
BH 119
BH 201
BH 111
BH 114
BH 211

A
A'
B
B'
C
C'
D
D'
E
E'

513.0 m
512.0 m
511.0 m
510.0 m
509.0 m
508.0 m
507.0 m
506.0 m

LEGEND

BOREHOLE LOCATIONS

APPROXIMATE SEPTIC MOUND LOCATIONS

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT
URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT
GRASSWOOD ESTATES
HYDROGEOLOGICAL INVESTIGATION

TITLE
BORE HOLE LOCATION
AND SITE PLAN

DESIGN M.N	SCALE 1:5000	DATE 2012-07-17
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7	DWG. NO. 02
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3	

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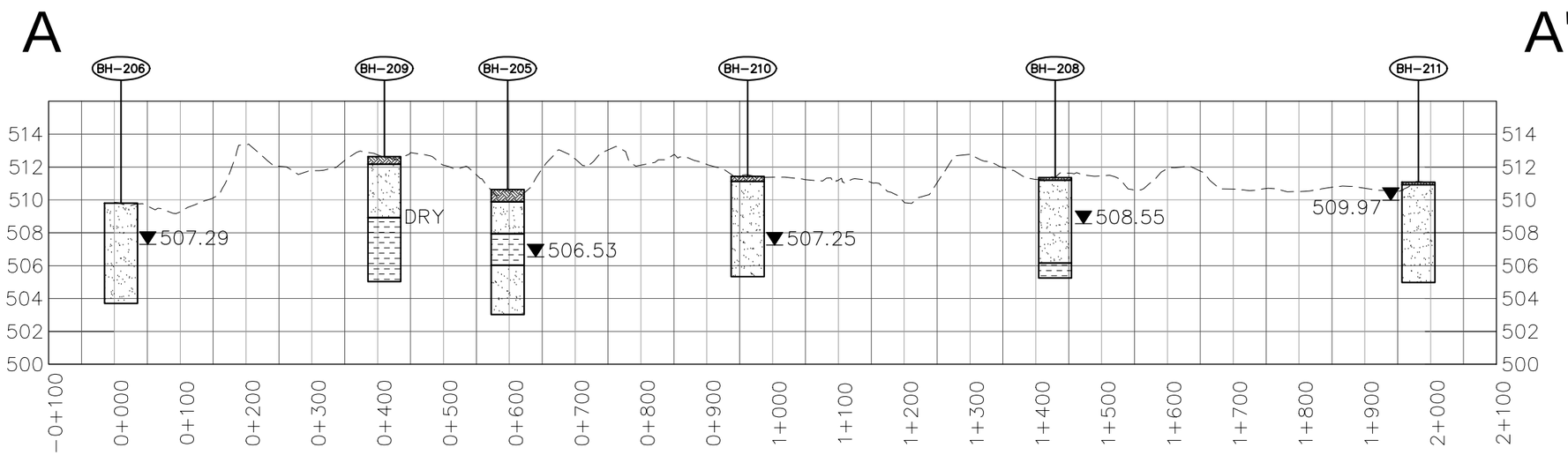

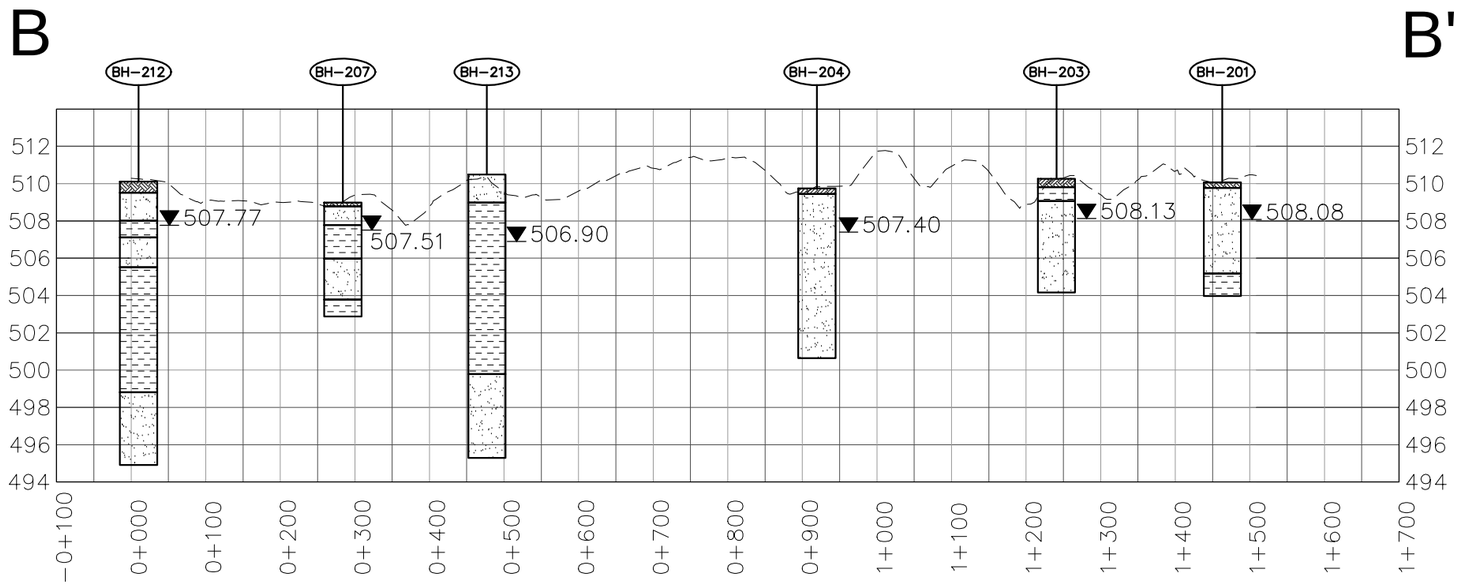

SCALE
HORIZ: 1:8000
VERT: 1:320

LEGEND

ORGANIC SOIL

SAND

CLAY

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT
URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT
GRASSWOOD ESTATES
HYDROGEOLOGICAL INVESTIGATION

TITLE
CROSS SECTION A-A'
CROSS SECTION B-B'

DESIGN	SCALE AS SHOWN	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 03
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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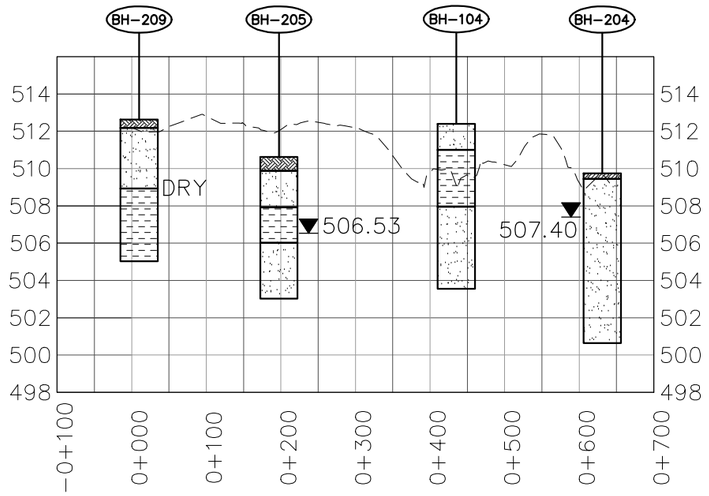
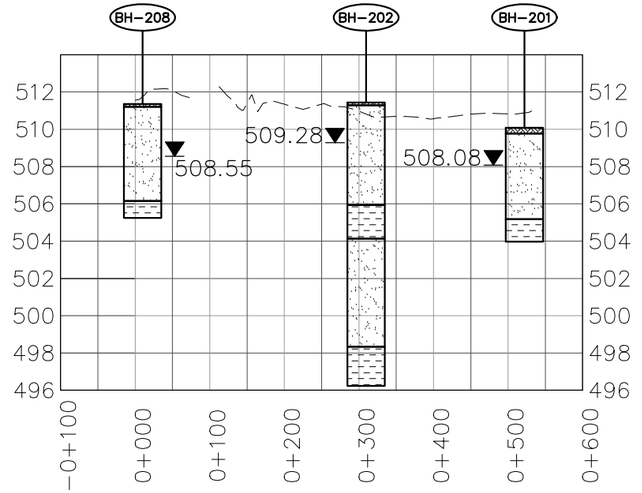
C



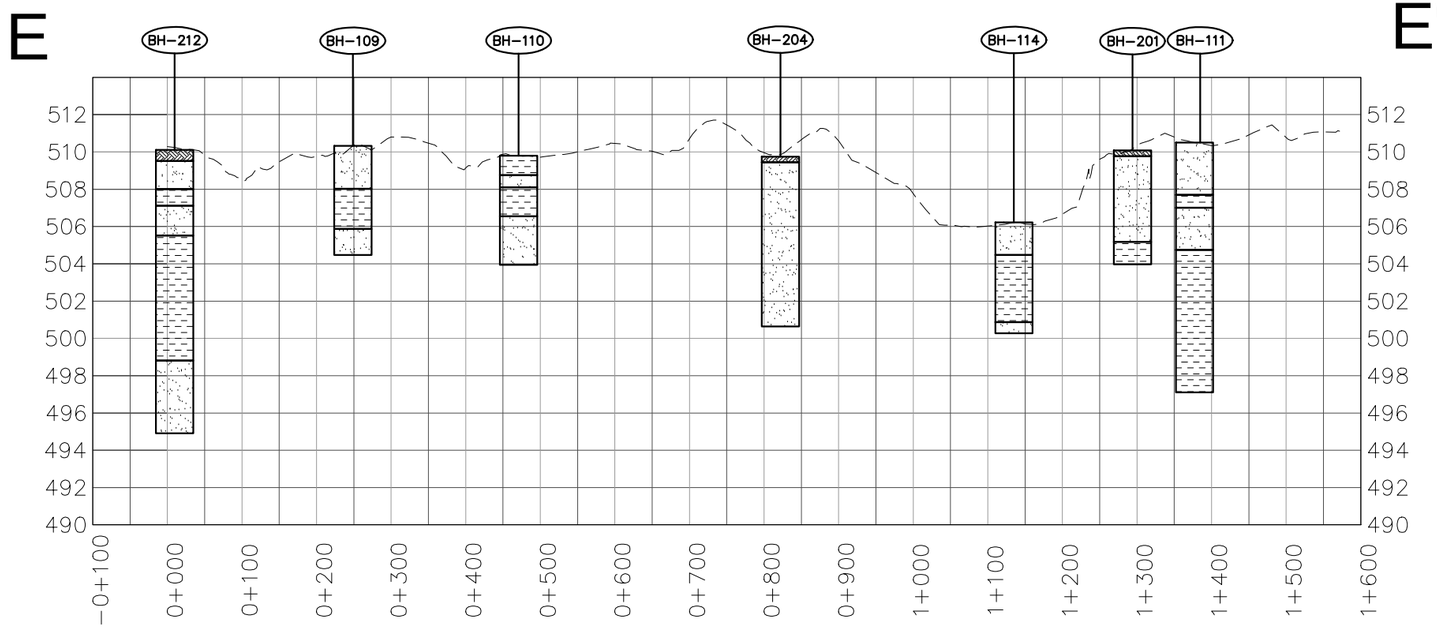
C'

D



D'

E



E'

SCALE
HORIZ: 1:8000
VERT: 1:320

LEGEND

ORGANIC SOIL

SAND

CLAY

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT
URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT
GRASSWOOD ESTATES
HYDROGEOLOGICAL INVESTIGATION

TITLE
CROSS SECTION D-D'
CROSS SECTION E-E'

DESIGN	SCALE AS SHOWN	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 04
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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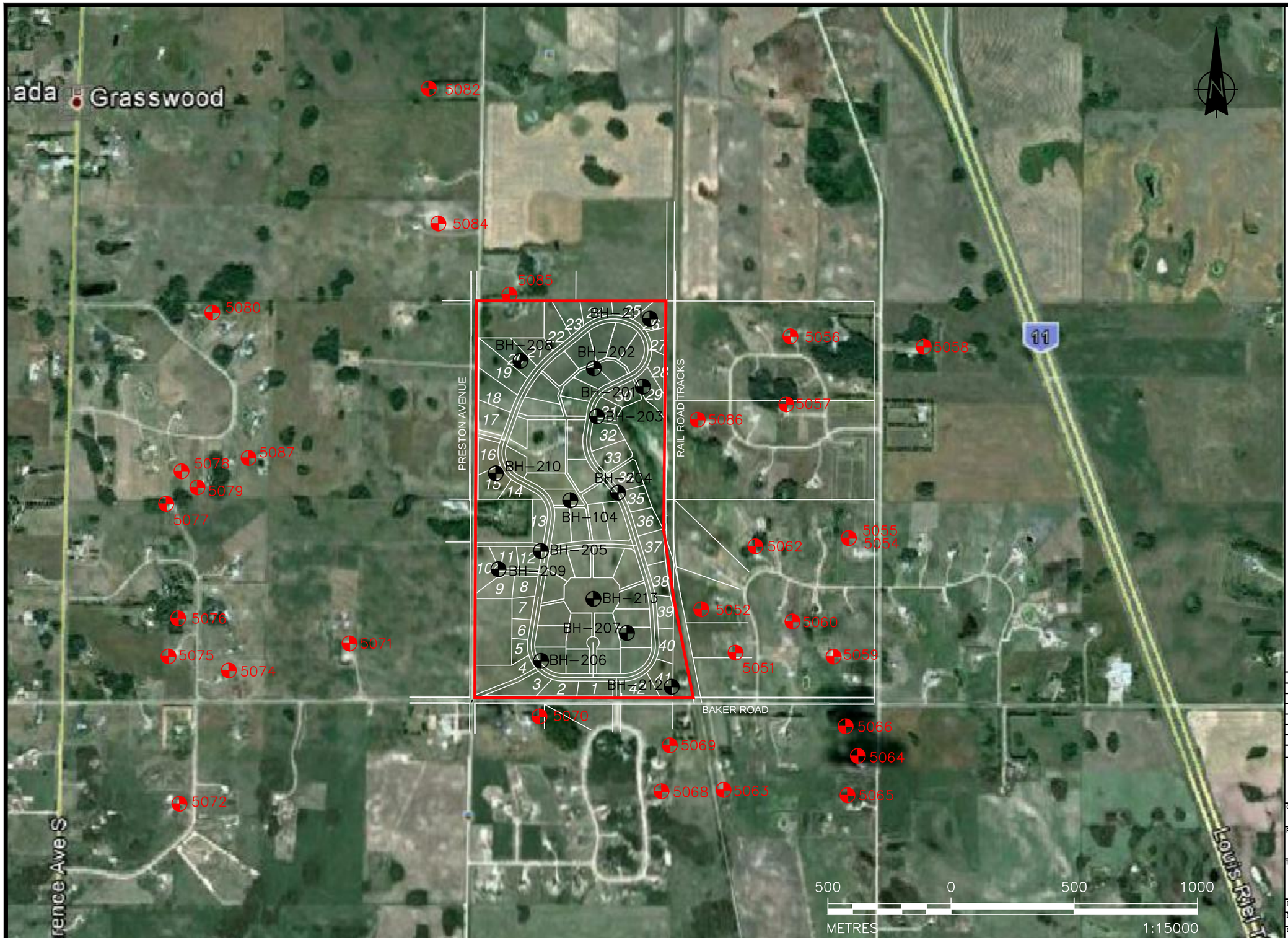

LEGEND

DOMESTIC WATER WELL

ON-SITE PIEZOMETER

APPROXIMATE SITE BOUNDARY

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE
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Clifton Associates Ltd. engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: 1 KM RADIUS WATER WELL LOCATION PLAN

DESIGN J.O.	SCALE 1:15000	DATE 2012-07-17	
DWN. BY Z.Y.	PROJECT NO. S1607.4		DWG. NO. 05
CHECKED J.G.	LAND LOCATION W1/2 26-35-5 W3		

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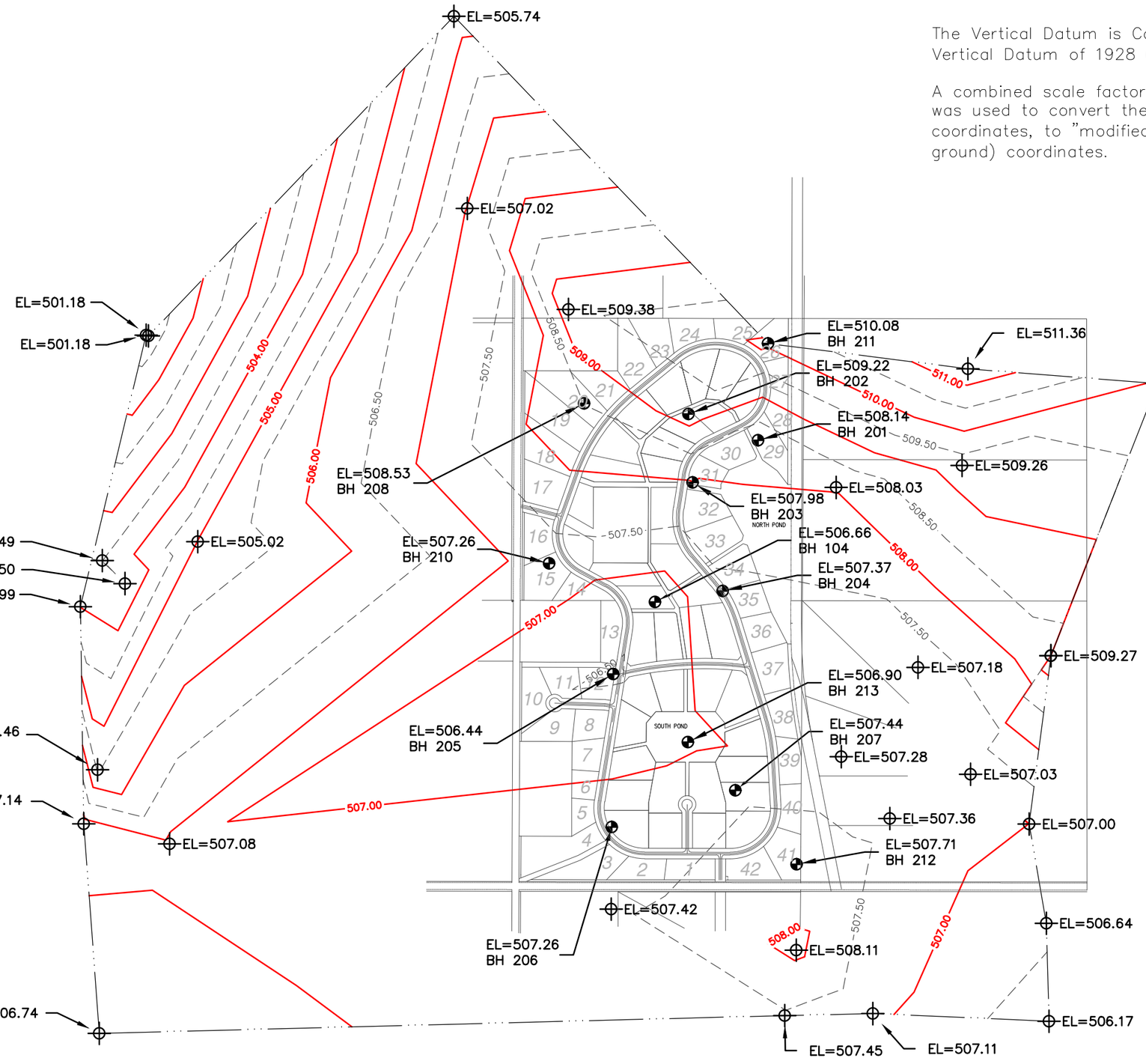
A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.



LEGEND

- BOREHOLE
- WATER WELLS
- MAJOR CONTOUR
- MINOR CONTOUR

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: GROUND WATER PIEZOMETRIC SURFACE

DESIGN J.G.	SCALE N.T.S.	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 06
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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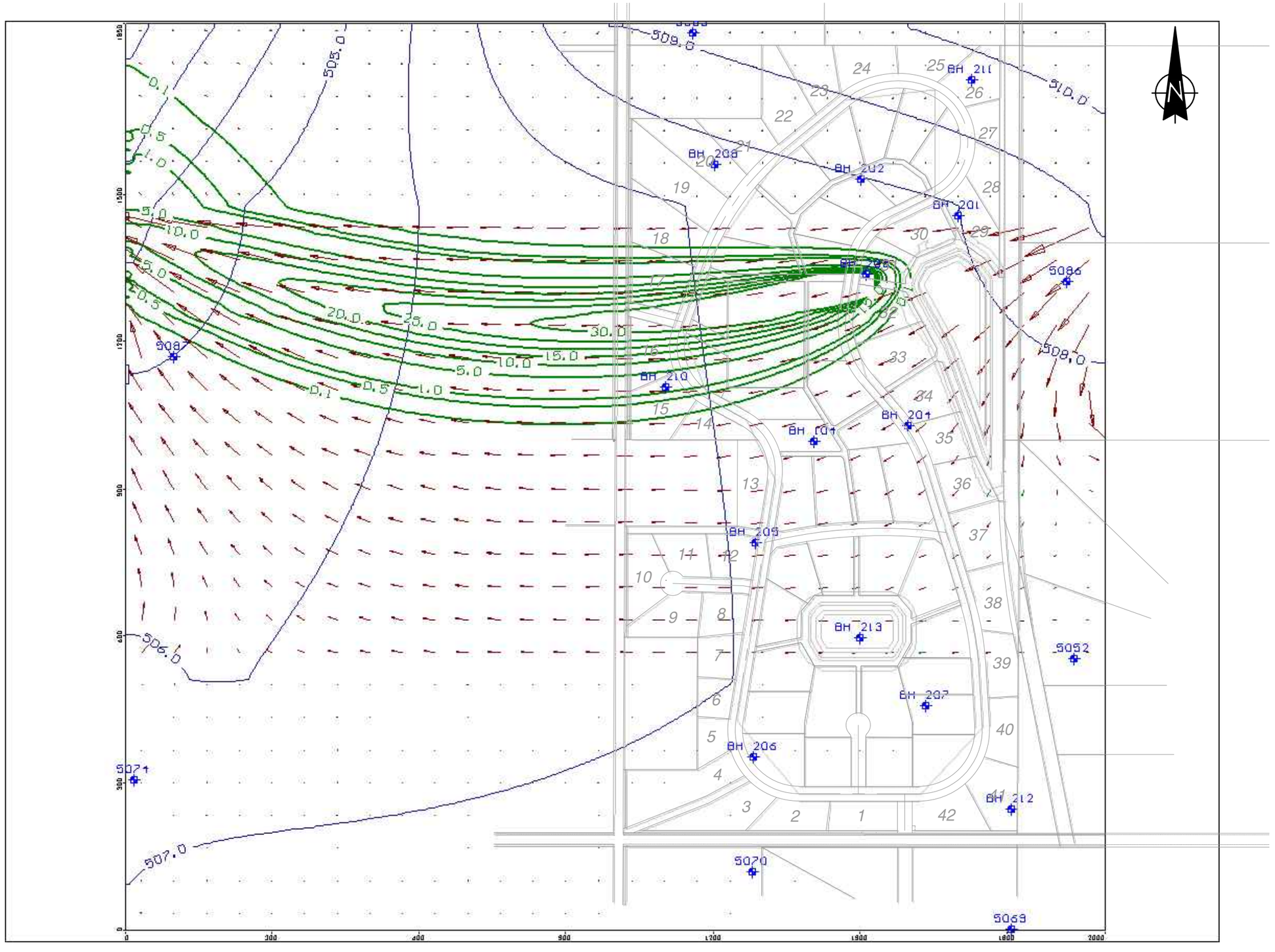

LEGEND

- PIEZOMETRIC SURFACE CONTOUR
- CONTAMINANT CONTOUR
- GROUND WATER FLOW DIRECTION
- PIEZOMETER/WELL LOCATION
- MOUND LOCATION

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: CURRENT CONDITIONS

DESIGN C.F	SCALE 1:8000	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO.
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		07

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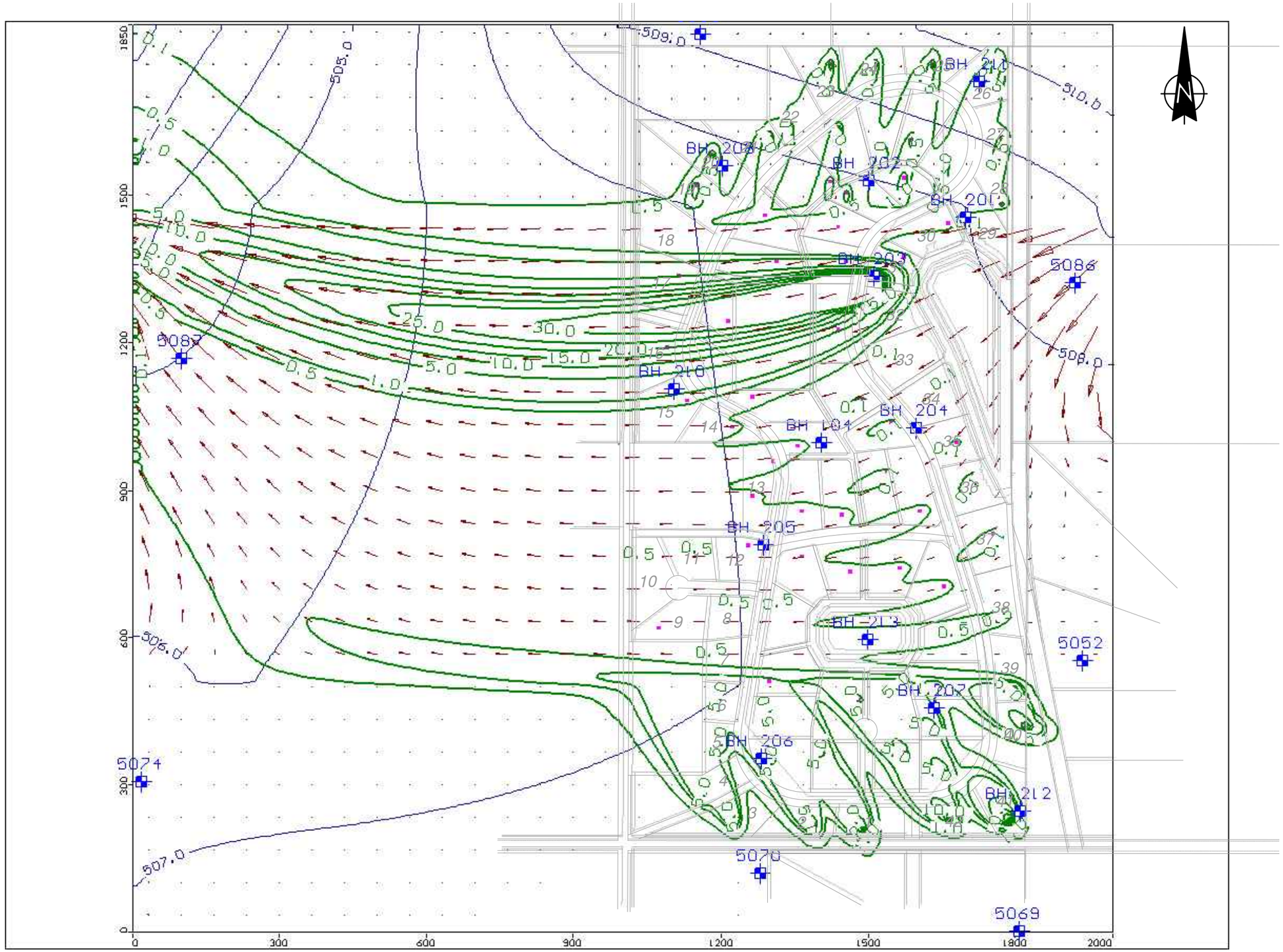

LEGEND

- PIEZOMETRIC SURFACE CONTOUR
- CONTAMINANT CONTOUR
- GROUND WATER FLOW DIRECTION
- PIEZOMETER/WELL LOCATION
- MOUND LOCATION

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: DEVELOPMENT CONDITION–40mg/L LOADING SOURCE AT BH203

DESIGN C.F	SCALE 1:8000	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 08
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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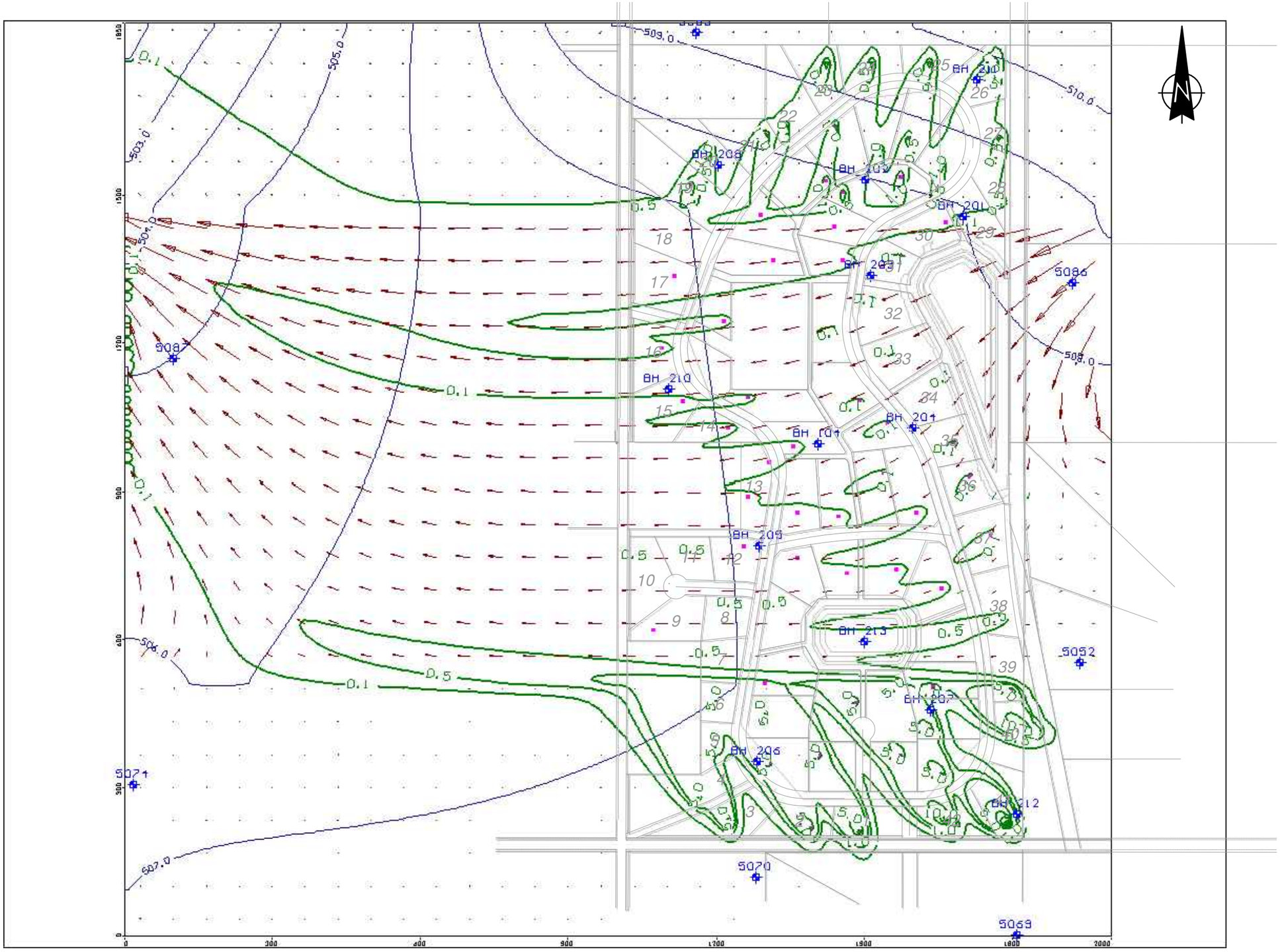

LEGEND

- PIEZOMETRIC SURFACE CONTOUR
- CONTAMINANT CONTOUR
- GROUND WATER FLOW DIRECTION
- PIEZOMETER/WELL LOCATION
- MOUND LOCATION

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: DEVELOPMENT CONDITIONS– 40mg/L LOADING WITHOUT SOURCE AT BH203

DESIGN C.F	SCALE 1:8000	DATE 2012–07–17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 09
CHECKED J.G	LAND LOCATION W1/2 26–35–5 W3		

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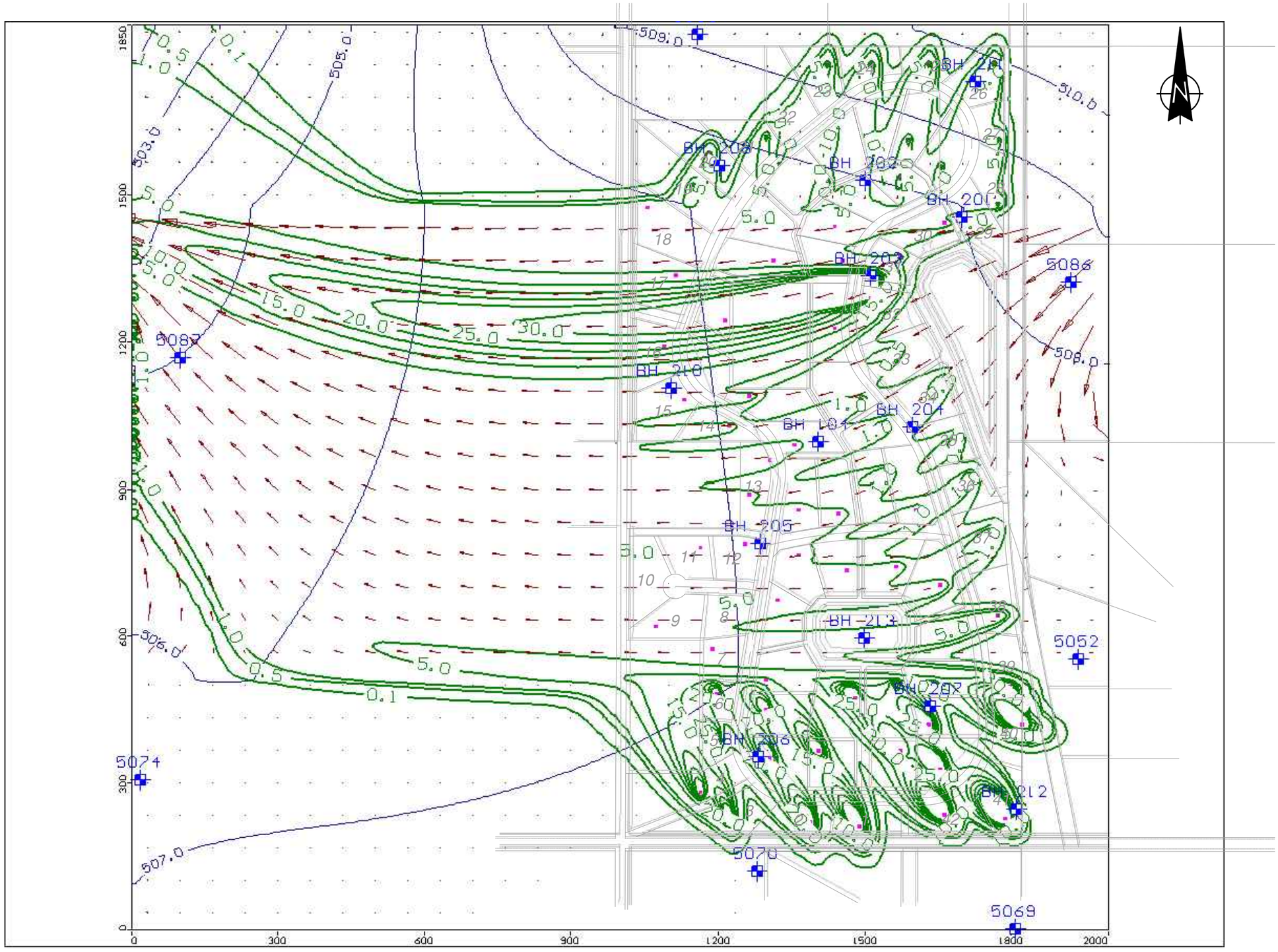

LEGEND

- PIEZOMETRIC SURFACE CONTOUR
- CONTAMINANT CONTOUR
- GROUND WATER FLOW DIRECTION
- PIEZOMETER/WELL LOCATION
- MOUND LOCATION

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: CONVENTIONAL–350mg/L LOADING SOURCE AT BH203

DESIGN C.F	SCALE 1:8000	DATE 2012–07–17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 10
CHECKED J.G	LAND LOCATION W1/2 26–35–5 W3		

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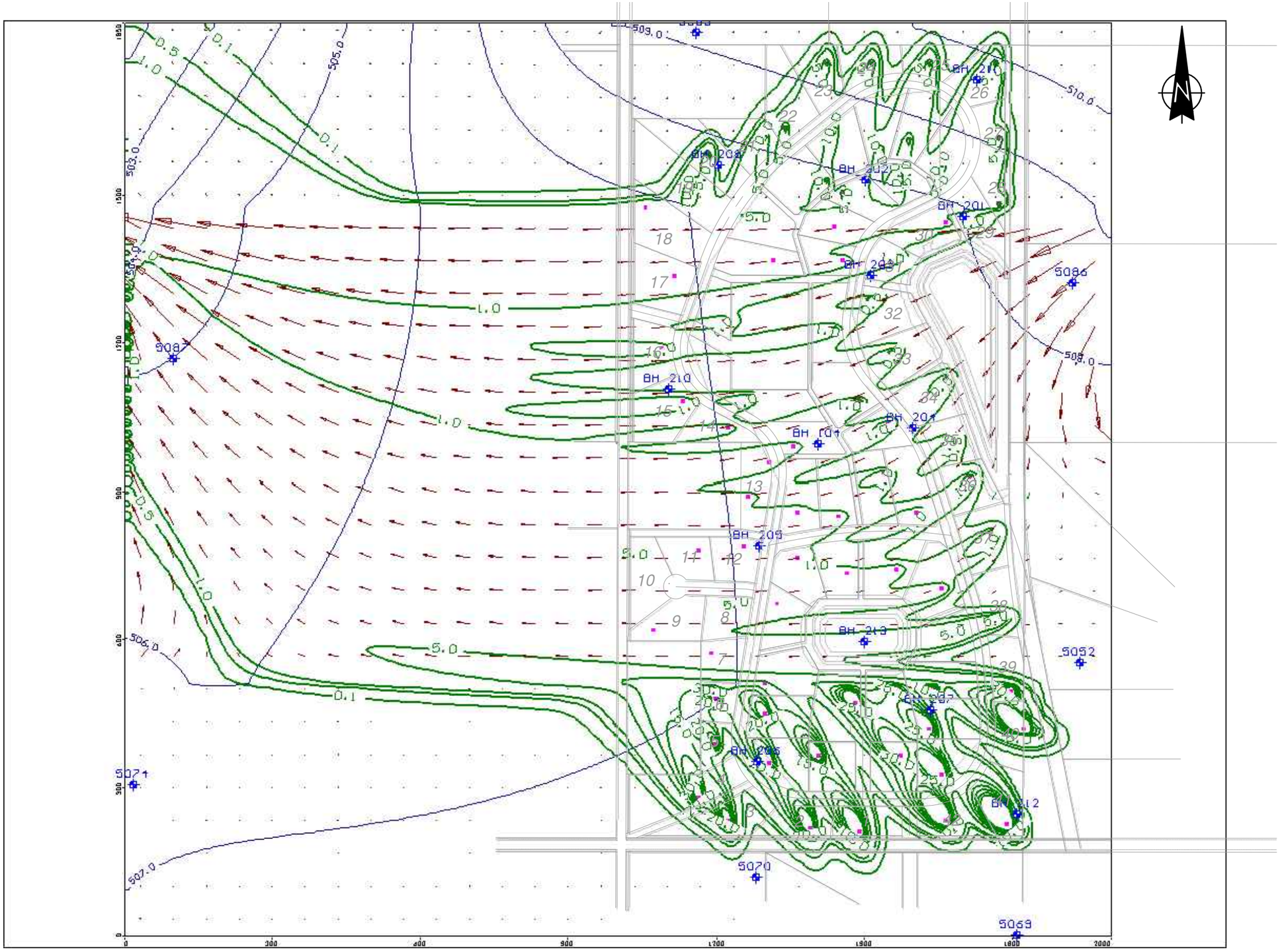

LEGEND

- PIEZOMETRIC SURFACE CONTOUR
- CONTAMINANT CONTOUR
- GROUND WATER FLOW DIRECTION
- PIEZOMETER/WELL LOCATION
- MOUND LOCATION

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT
URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT
GRASSWOOD ESTATES
HYDROGEOLOGICAL INVESTIGATION

TITLE
CONVENTIONAL–350mg/L LOADING WITHOUT SOURCE AT BH203

DESIGN C.F	SCALE 1:8000	DATE 2012–07–17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 11
CHECKED J.G	LAND LOCATION W1/2 26–35–5 W3		

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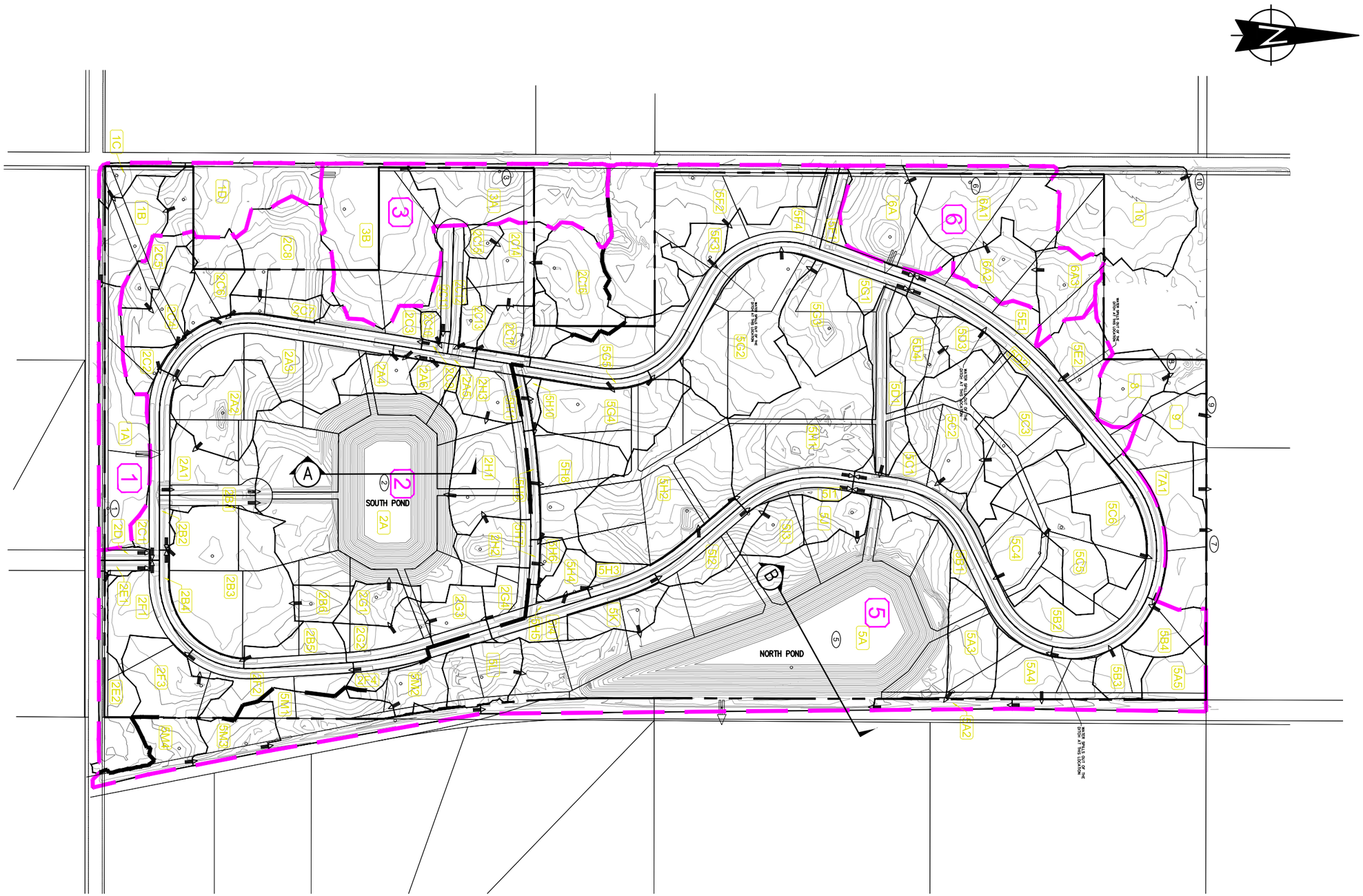

LEGEND

- PROJECT BOUNDARY
- CATCHMENT BASIN BOUNDARY
- SITE DIVIDE LINE
- CATCHMENT SUB-BASIN BOUNDARY
- CATCHMENT BASIN DESIGNATION — 4
- CATCHMENT SUB-BASIN DESIGNATION — 5B
- CONCENTRATION POINT — 2
- CATCHMENT BASIN OVERFLOW DIRECTION
- CATCHMENT SUB-BASIN OVERFLOW DIRECTION
- SOUTH POND CROSS SECTION — A
- NORTH POND CROSS SECTION — B

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

50 0 50 100 150
METERS 1:2500

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT
URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT
GRASSWOOD ESTATES
HYDROGEOLOGICAL INVESTIGATION

TITLE
PROPOSED CONCEPTUAL CONDITIONS DRAINAGE ANALYSIS

DESIGN J.G.	SCALE N.T.S.	DATE 2012-07-17
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7	DWG. NO. 12
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3	

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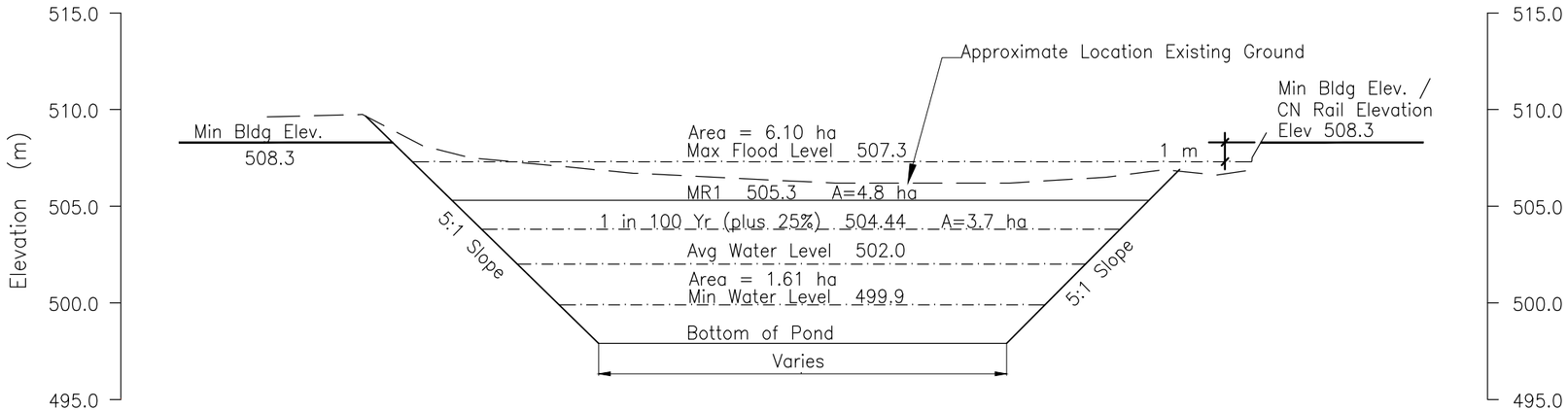

TYPICAL NORTH POND SECTION

NOT TO SCALE

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: TYPICAL NORTH POND CROSS SECTION

DESIGN J.G.	SCALE N.T.S.	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 13
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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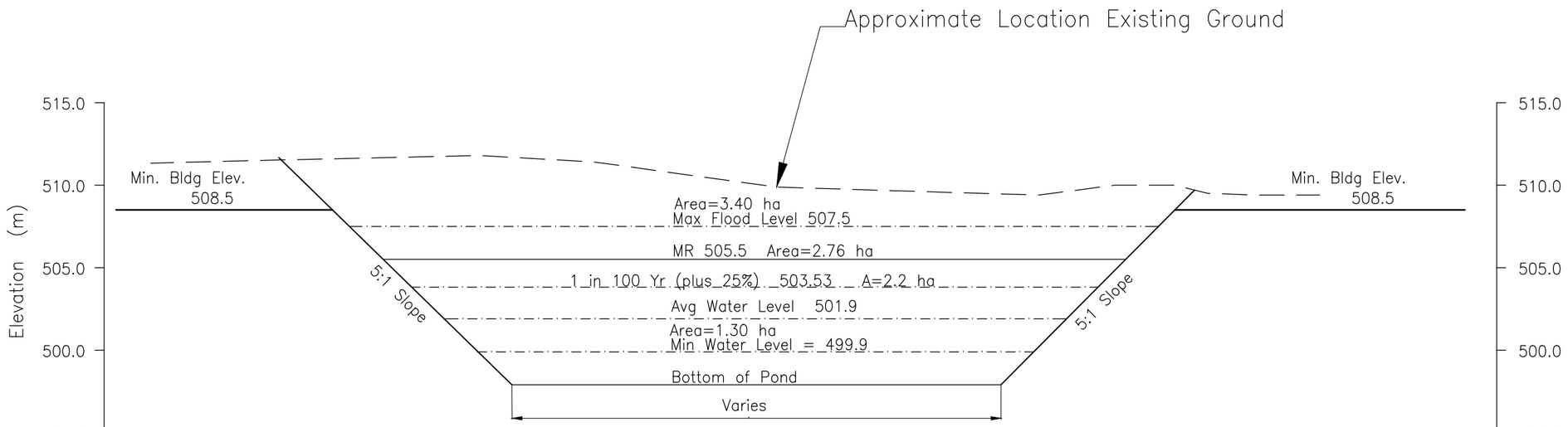

TYPICAL SOUTH POND SECTION

NOT TO SCALE

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd.
engineering science technology

CLIENT
URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT
GRASSWOOD ESTATES
HYDROGEOLOGICAL INVESTIGATION

TITLE
TYPICAL SOUTH
POND CROSS SECTION

DESIGN J.G.	SCALE N.T.S.	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 14
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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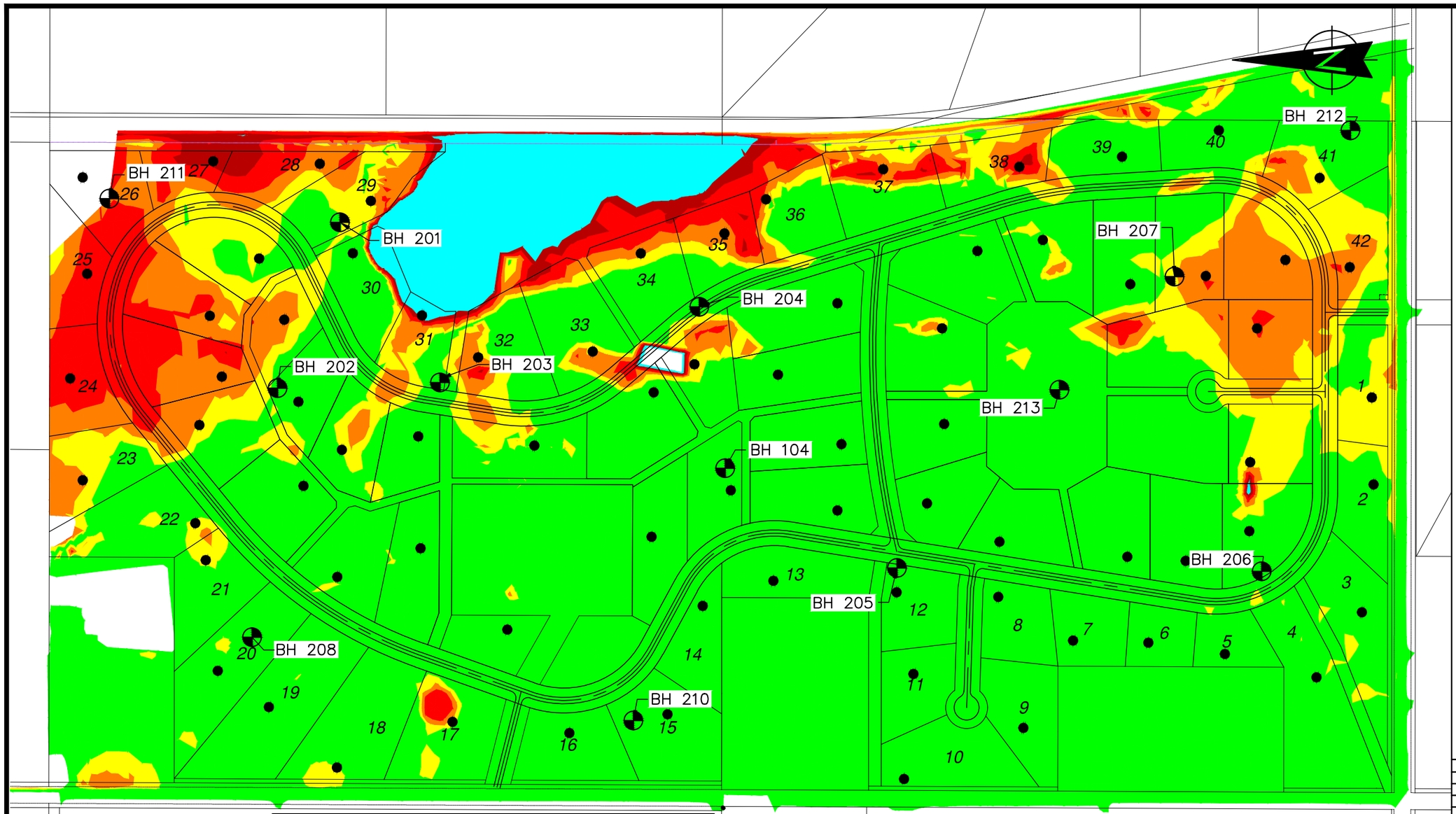

LEGEND

- APPROXIMATE SEPTIC MOUND LOCATIONS
- BOREHOLE LOCATIONS

GROUND WATER DEPTH:

- < 0m
- 0m~0.5m
- 1.5m~2m
- 1m~1.5m
- 1.5m~2m
- > 2m

NOTE

WATER LEVEL LOCATIONS KNOWN AT THE BOREHOLE LOCATION ONLY. GROUNDWATER DEPTH AT OTHER LOCATIONS ARE INTERPRETED.

The Vertical Datum is Canadian Geodetic Vertical Datum of 1928 (CGVD28).

A combined scale factor of 1.000324575 was used to convert the UTM grid coordinates, to "modified grid" (or ground) coordinates.

BORE HOLE TABLE

BH	GROUND WATER DEPTH	NORTHING	EASTING
BH 104	5.77	9995.59	5404.76
BH 201	2.03	10456.70	5699.24
BH 202	2.19	10531.52	5500.57
BH 203	2.35	10336.18	5512.29
BH 204	2.48	10026.54	5597.99
BH 205	4.27	9789.90	5285.50
BH 206	2.50	9353.17	5281.36
BH 207	1.59	9457.63	5634.26
BH 208	2.84	10561.86	5202.47
BH 210	4.26	10105.39	5102.67
BH 211	1.04	10732.78	5727.47
BH 212	2.55	9247.06	5809.27
BH 213	3.47	9595.47	5498.80

DRAWING REVISIONS

REV	DESCRIPTION	BY	DATE

Clifton Associates Ltd. engineering science technology

CLIENT: URBAN ELEMENTS DEVELOPMENT CORP.

PROJECT: GRASSWOOD ESTATES HYDROGEOLOGICAL INVESTIGATION

TITLE: WATER TABLE DEPTH PLAN

DESIGN J.G.	SCALE 1:5000	DATE 2012-07-17	
DWN. BY O.Z&Z.Y	PROJECT NO. S1607.7		DWG. NO. 15
CHECKED J.G	LAND LOCATION W1/2 26-35-5 W3		

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Clifton Associates Ltd.
engineering science technology

Tables

Table 3.2-1
Site Groundwater Elevations & Field Measurements
Grasswood Hydrogeology

Piezometer #	Top Casing Elevation (m)	Ground Elevation (m)	Casing Height (m)	Water Elevation	July 4 Mbgs	July 31 Mbgs	Dissolved Oxygen Field Recordings July 31	Temp July 31	pH July 31
BH104	513.3	512.4	0.9	506.6	5.8	5.6	19.2	10.8	7.3
BH201	511.2	510.1	1.1	508.1	2.0	2.1	22.2	13.4	7.1
BH202	512.5	511.4	1.1	509.3	2.2	2.4	14.2	13.9	7.0
BH203	511.3	510.3	1.0	508.1	2.1	2.5	24.6	12.5	7.1
BH204	510.8	509.7	1.1	507.4	2.3	2.4	32.2	12.4	7.3
BH205	511.6	510.6	0.9	506.5	4.1	4.0	37.5	9.7	7.2
BH206	510.7	509.8	0.9	507.3	2.5	2.7	25.1	12.2	7.2
BH207	509.9	509.0	0.9	507.5	1.5	1.7	24.4	16.7	7.1
BH208	512.4	511.4	1.0	508.6	2.8	2.8	72.1	13.9	7.1
BH209	513.5	512.6	0.9	empty	-	-			
BH210	512.6	511.4	1.1	507.3	4.2	4.1	24.6	13.7	6.7
BH211	512.2	511.1	1.1	509.9	1.2	1.4	19.1	15.4	7.3
BH212	511.0	510.1	0.9	507.8	2.3	2.4	57.0	14.0	6.8
BH213	511.6	510.5	1.1	506.9	3.6	3.5	16.5	10.8	6.9

Table 3.4-1
Surrounding Water Well Elevations
Grasswood Hydrogeology

Point #'s	Northing	Easting	OG Elev.	Water Elev.	Notes
5051	9377.513	6075.313	510.182	507.362	15 South Point Road
5052	9553.765	5936.28	508.153	507.283	25 South Point Road
5053	9857.034	6431.537	510.213	N/A	N/A
5054	9842.159	6534.961	509.977	508.307	65 South Point Road (Bitz)
5055	9842.105	6535.021	510.599	509.269	GA3-P Pizo
5056	10660.71	6297.974	513.732	511.357	85 Ashwood Drive
5057	10385.191	6281.368	511.445	509.255	98 Ashwood Drive
5058	10618.674	6838.906	514.752	509.932	25-35-5W3
5059	9361.743	6472.99	510.128	506.998	(North of lot 35404)
5060	9503.665	6305.784	508.493	507.028	58 South Point Lane
5062	9808.879	6155.499	508.827	507.177	45 Ashwood Drive
5063	8820.795	6026.795	509.993	507.113	NE35-35-5W3
5064	8958.519	6571.47	508.088	505.208 when pump is running	505.788 when pump is off
5065	8799.128	6529.506	507.022	506.172	Lot 35362
5066	9078.634	6521.865	508.366	506.636	35362 Along TWP 3051
5068	8815.114	5774.974	510.736	507.446	19 Mandalay Drive
5069	9002.033	5808.279	508.646	508.106	25 Mandalay Drive
5070	9118.833	5279.528	510.405	507.415	Howard Butlers
5071	9414.796	4508.94	510.194	506.536	1751 Baker Road (Water was measured by farmer not witnessed)
5072	8764.306	3818.562	513.27	506.74	1450 Baker Road
5074	9305.192	4019.07	511.884	507.084	60 Casa Rio Road
5075	9362.539	3773.915	509.906	507.136	47 Casa Rio Road
5076	9516.415	3813.345	507.577	505.457	N/A
5077	9981.731	3764.573	508.464	503.994	22 Casa Rio Road
5078	10113.704	3827.195	508.923	503.493	75 Casa Rio Road
5079	10047.932	3891.604	509.475	503.505	65 Casa Rio Road
5080	10756.979	3952.047	503.823	501.183	15 Casa Rio Road
5081	10754.451	3958.523	503.809	501.183	Right Beside Point 5080
5082	11666.533	4830.799	508.237	505.737	Lot North 5044 Preston Drive
5084	11118.486	4869.115	513.176	507.016	N/A
5085	10830.083	5157.474	511.476	509.376	5196 Preston Drive
5086	10322.118	5921.655	510.823	508.028	45 Ashwood Drive
5087	10167.566	4099.522	506.781	505.016	55 Eldorado Lane

Table 4.2.1
Water and Soil Lab Results
Grasswood Hydrogeology

Parameter	Units	Sample ID ALS ID Date Sampled Detection Limit	Criteria Saskatchewan Drinking Water Standards & Objectives	CAL104 L1172891-8 7/4/2012 Water	BH201 L1172891-3 7/4/2012 Water	BH202 L1172891-2 7/4/2012 Water	BH203 L1172891-5 7/4/2012 Water	BH204 L1172891-7 7/4/2012 Water	BH205 L1172891-9 7/4/2012 Water	BH206 L1172891-11 7/4/2012 Water	BH207 L1172891-12 7/4/2012 Water	BH208 L1172891-4 7/4/2012 Water	BH210 L1172891-6 7/4/2012 Water	BH211 L1172891-1 7/4/2012 Water	BH213 L1172891-10 7/4/2012 Water	BH212 L1172891-13 7/4/2012 Water	DUP 1 L1172891-15 7/4/2012 Water	DUP 2 L1172891-14 7/4/2012 Water	DUP 3 L1172891-16 7/4/2012 Water
Health and Toxicity Metals																			
Total Mercury in Water by CRC ICPMS																			
Mercury (Hg)-Total	mg/L	0.00005	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	<0.000050	-
Total Metals in Water by CRC ICPMS			-																
Aluminum (Al)-Total	mg/L	0.01	-	37.4 *	10.5 *	1.24 *	150 *	8.21 *	72.6 *	88.0 *	0.76 *	8.33 *	58.9 *	4.64 *	0.586 *	79.6 *	-	89.5 *	-
Arsenic (As)-Total	mg/L	0.0002	0.025	**0.0516 ***	0.0103 *	0.00346 *	**0.268 ***	0.0164 *	**0.0629 ***	**0.0756 ***	0.0023 *	0.0119 *	**0.0779 ***	0.00444 *	0.00213 *	**0.0811 ***	-	**0.0881 ***	-
Barium (Ba)-Total	mg/L	0.0002	1	**2.75 ***	0.709 *	0.0686 *	**23.1 ***	0.683 *	**3.20 ***	**4.93 ***	0.0412 *	0.834 *	**4.80 ***	0.352 *	0.136 *	**2.64 ***	-	**3.04 ***	-
Boron (B)-Total	mg/L	0.02	5	<0.10 *	0.060 *	0.188 *	0.23 *	0.052 *	<0.20 *	<0.20 *	0.43 *	0.025 *	<0.10 *	0.035 *	0.038 *	<0.20 *	-	<0.20 *	-
Cadmium (Cd)-Total	mg/L	0.00002	-	0.00138 *	0.000302 *	0.000081 *	0.0108 *	0.000624 *	0.00179 *	0.00491 *	<0.00020 *	0.000332 *	0.00282 *	0.000332 *	0.000025 *	0.00247 *	-	0.00273 *	-
Chromium (Cr)-Total	mg/L	0.0002	-	0.0615 *	0.0155 *	0.00205 *	0.265 *	0.0131 *	0.115 *	0.147 *	<0.0020 *	0.0125 *	0.0978 *	0.00745 *	0.00127 *	0.132 *	-	**0.147 ***	-
Copper (Cu)-Total	mg/L	0.001	1	0.0629 *	0.0278 *	0.0032 *	0.319 *	0.0172 *	0.149 *	0.200 *	<0.010 *	0.0158 *	0.160 *	0.0060 *	0.0021 *	0.178 *	-	0.201 *	-
Iron (Fe)-Total	mg/L	0.02	0.3	**89.0 ***	**16.4 ***	**2.45 ***	**430 ***	**21.1 ***	**160 ***	**207 ***	**1.47 ***	**17.7 ***	**175 ***	**6.69 ***	**1.25 ***	**178 ***	-	**203 ***	-
Lead (Pb)-Total	mg/L	0.0001	0.01	**0.0727 ***	**0.0257 ***	0.00150 *	**0.383 ***	**0.0190 ***	**0.118 ***	**0.177 ***	0.0013 *	**0.0134 ***	**0.162 ***	0.00416 *	0.00085 *	**0.115 ***	-	**0.138 ***	-
Manganese (Mn)-Total	mg/L	0.0006	0.05	**1.29 ***	**0.998 ***	**0.695 ***	**29.6 ***	**1.12 ***	**2.78 ***	**5.50 ***	**0.247 ***	**1.89 ***	**4.12 ***	**0.826 ***	**0.617 ***	**4.37 ***	-	**4.95 ***	-
Selenium (Se)-Total	mg/L	0.0002	0.01	0.0023 *	0.00072 *	<0.00020 *	0.0069 *	0.00034 *	0.0096 *	<0.0020 *	<0.0020 *	0.00800 *	**0.0195 ***	<0.00020 *	<0.00020 *	0.0099 *	-	0.0098 *	-
Uranium (U)-Total	mg/L	0.00002	0.02	0.0134 *	**0.0276 ***	**0.0270 ***	**0.0256 ***	0.00163 *	**0.0265 ***	**0.0300 ***	**0.195 ***	0.00397 *	0.00942 *	0.00520 *	0.00284 *	0.0159 *	-	0.0181 *	-
Zinc (Zn)-Total	mg/L	0.006	5	0.401 *	0.0910 *	0.0134 *	1.78 *	0.0736 *	0.667 *	0.974 *	<0.060 *	0.0691 *	0.631 *	0.0311 *	0.0080 *	0.685 *	-	0.771 *	-
Miscellaneous Parameters																			
Turbidity	NTU	0.1	-	1740	424	55.8	>4000	>4000	613	>4000	134	1340	>4000	372	13.5	>4000	927	-	-
Routine Potable Water																			
Alkalinity, Total																			
Alkalinity, Total (as CaCO3)	mg/L	5	500	227	296	383	314	282	294	423	**508**	341	224	294	190	374	**512**	-	-
Bicarbonate (HCO3)	mg/L	5	-	277	361	467	383	344	359	516	620	417	274	359	231	456	625	-	-
Hydroxide (OH)	mg/L	5	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	-
Carbonate (CO3)	mg/L	5	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	-
Chloride (Cl)																			
Chloride (Cl)	mg/L	1	250	7.4	6.7	5	40.6	3.4	5.2	1.8	98 *	7.9	5.2	1.9	2.3	9.1	101 *	-	-
Fluoride (F)																			
Fluoride (F)	mg/L	0.1	-	0.23	0.2	0.22	0.2	<0.10	0.22	0.14	0.32	<0.10	<0.10	0.3	0.2	0.21	0.31	-	-
ICP Cations																			
Calcium (Ca) Dissolved	mg/L	1	-	73.4	88.8	127	173	89.9	106	110	467 *	140	63.4	84.2	76.2	109	459 *	-	-
Magnesium (Mg) Dissolved	mg/L	1	200	28.8	25.7	54.2	53.7	35.8	30.9	41.7	**817 ***	32.5	14.9	26.1	21.3	35.2	**815 ***	-	-
Potassium (K) Dissolved	mg/L	1	-	4	3.4	6.9	7.2	10.5	2.9	3.4	51 *	4.7	2.3	2.5	3.1	5.5	51 *	-	-
Sodium (Na) Dissolved	mg/L	2	300	29.2	15.8	66	44.7	9.4	7.7	7.6	**1180 ***	16.5	5.4	7.2	8.6	27.5	**1160 ***	-	-
Sulfur (as SO4) Dissolved	mg/L	3	500	112	35.9	263	186	104	95.3	18.3	**6240 ***	139	18	30.2	95.5	87.7	**6400 ***	-	-
Iron (Fe) & Manganese (Mn) - Dissolved																			
Iron (Fe)-Dissolved	mg/L	0.03	-	<0.030	<0.030	0.082	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	0.035	<0.030	<0.030	0.07	<0.030	-	-
Manganese (Mn)-Dissolved	mg/L	0.001	-	0.0309	0.602	0.574	0.0895	0.297	0.163	0.184	0.254	0.0057	0.113	0.538	0.526	0.386	0.244	-	-
Nitrate, Nitrite and Nitrate+Nitrite-N																			
Nitrate+Nitrite-N	mg/L	0.5		<0.50	<0.50	<0.50	51.3	<0.50	0.83	<0.50	<0.50	7.12	0.67	<0.50	<0.50	<0.50	<0.50	-	-
Nitrate-N	mg/L	0.5	10	<0.50	<0.50	<0.50	**51.0**	<0.50	0.72	<0.50	<0.50	7.1	0.61	<0.50	<0.50	<0.50	<0.50	-	-
Nitrite-N	mg/L	0.05	3.2	<0.050	<0.050	<0.050	0.276	<0.050	0.11	<0.050	0.058	<0.050	0.065	<0.050	<0.050	<0.050	0.08	-	-
pH and Conductivity																			
pH	pH	0.1	-	7.46 *	7.28 *	7.19 *	7.51 *	7.59 *	7.66 *	7.49 *	7.39 *	7.24 *	7.33 *	7.37 *	7.52 *	7.58 *	7.42 *	-	-
Conductivity (EC)	uS/cm	10	-	651	639	1150	1420	711	721	786	8800	920	443	588	550	834	8800	-	-
Total Coliform, Ecoli Mcoli Blue & HPC																			
Escherichia Coli mcoli blue MF																			
E. Coli	CFU/100mL	1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	<1	<1	**10**	-	-	<1
Heterotrophic Plate Count																			
Heterotrophic Plate Count	CFU/mL	10	-	>3000	>3000	>3000	>3000	>3000	>3000	>3000	>3000	>3000	-	>3000	>3000	>3000	-	-	>3000
Total Coliforms																			
Total Coliforms	CFU/100mL	1	0 , no OVERGROWN	**190**	**890**	**OVERGROWN**	<1	**30**	**70**	**40**	**210**	<1	-	**OVERGROWN**	**OVERGROWN**	**10**	-	-	**OVERGROWN**
Miscellaneous																			
Biochemical Oxygen Demand	mg/L	2	-	23	6	8	10	26	7	7	5	7	-	12	55	4	-	-	-
TDS (Calculated)	mg/L	n/a	1500	391	354	752	921	422	428	437	**9160**	577	247	329	321	499	**9290**	-	-
Cation - Anion Balance	%	n/a	-	2.2	3.2	2.1	0.7	1.3	1	2.4	0.1	0.2	-3.9	1.1	1.3	0.6	-1.6	-	-
Hardness (as CaCO3)	mg/L	n/a	800	302	328	540	653	372	392	446	**4530**	483	220	318	278	417	4500	-	-
Soils																			
Total Available Nitrogen	mg/kg	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen by LECO	%	0.02	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-
Available Ammonium-N	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate+Nitrite-N	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate-N	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite-N	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* = Result Qualified **Bold**-Exceeds Guidelines

Table 4.2.1
Water and Soil Lab Results
Grasswood Hydrogeology

		Sample ID	DUP 4	BH207-CF07	BH208-CF25
		ALS ID	L1172891-17	L1171379-2	L1171379-1
		Date Sampled	7/4/2012	6/26/2012	6/28/2012
			Water	Soil	Soil
Parameter	**Units**	**Detection Limit**			
Health and Toxicity Metals					
Total Mercury in Water by CRC ICPMS					
Mercury (Hg)-Total	mg/L	0.00005	-	-	-
Total Metals in Water by CRC ICPMS					
Aluminum (Al)-Total	mg/L	0.01	-	-	-
Arsenic (As)-Total	mg/L	0.0002	-	-	-
Barium (Ba)-Total	mg/L	0.0002	-	-	-
Boron (B)-Total	mg/L	0.02	-	-	-
Cadmium (Cd)-Total	mg/L	0.00002	-	-	-
Chromium (Cr)-Total	mg/L	0.0002	-	-	-
Copper (Cu)-Total	mg/L	0.001	-	-	-
Iron (Fe)-Total	mg/L	0.02	-	-	-
Lead (Pb)-Total	mg/L	0.0001	-	-	-
Manganese (Mn)-Total	mg/L	0.0006	-	-	-
Selenium (Se)-Total	mg/L	0.0002	-	-	-
Uranium (U)-Total	mg/L	0.00002	-	-	-
Zinc (Zn)-Total	mg/L	0.006	-	-	-
Miscellaneous Parameters					
Turbidity	NTU	0.1	-	-	-
Routine Potable Water				-	-
Alkalinity, Total					
Alkalinity, Total (as CaCO3)	mg/L	5	-	-	-
Bicarbonate (HCO3)	mg/L	5	-	-	-
Hydroxide (OH)	mg/L	5	-	-	-
Carbonate (CO3)	mg/L	5	-	-	-
Chloride (Cl)					
Chloride (Cl)	mg/L	1	-	-	-
Fluoride (F)					
Fluoride (F)	mg/L	0.1	-	-	-
ICP Cations					
Calcium (Ca) Dissolved	mg/L	1	-	-	-
Magnesium (Mg) Dissolved	mg/L	1	-	-	-
Potassium (K) Dissolved	mg/L	1	-	-	-
Sodium (Na) Dissolved	mg/L	2	-	-	-
Sulfur (as SO4) Dissolved	mg/L	3	-	-	-
Iron (Fe) & Manganese (Mn) - Dissolved					
Iron (Fe)-Dissolved	mg/L	0.03	-	-	-
Manganese (Mn)-Dissolved	mg/L	0.001	-	-	-
Nitrate, Nitrite and Nitrate+Nitrite-N					
Nitrate+Nitrite-N	mg/L	0.5	-	-	-
Nitrate-N	mg/L	0.5	-	-	-
Nitrite-N	mg/L	0.05	-	-	-
pH and Conductivity					
pH	pH	0.1	-	-	-
Conductivity (EC)	uS/cm	10	-	-	-
Total Coliform, Ecoli Mcoli Blue & HPC				-	-
Escherichia Coli mcoli blue MF					
E. Coli	CFU/100mL	1	-	-	-
Heterotrophic Plate Count					
Heterotrophic Plate Count	CFU/mL	10	-	-	-
Total Coliforms					
Total Coliforms	CFU/100mL	1	-	-	-
Miscellaneous				-	-
Biochemical Oxygen Demand	mg/L	2	5	-	-
TDS (Calculated)	mg/L	n/a	-	-	-
Cation - Anion Balance	%	n/a	-	-	-
Hardness (as CaCO3)	mg/L	n/a	-	-	-
Soils					
Total Available Nitrogen	mg/kg	2.2	-	5.2	4.6
Total Nitrogen by LECO	%	0.02	-	0.051	0.033
Available Ammonium-N	mg/kg	1	-	5.2	4.6
Nitrate+Nitrite-N	mg/kg	2	-	<2.0	<2.0
Nitrate-N	mg/kg	2	-	<2.0	<2.0
Nitrite-N	mg/kg	0.4	-	<0.40	<0.40

* = Result Qualified **Bold**-Exceeds Guidelines

Table 6.0-2
Soil Classification
Grasswood Hydrogeology

Borehole	Visual Soil Classification	Laboratory Tests		Field Tests	Suitability	
	Upper 3 m	USC Classification	USDA Classification	Depth to Water (m)	Soil Texture	Depth to Groundwater
101	Sand fine grained, silty, clay layer from 1.5 to 2.0 m	SM / CH	Sandy Loam*	>2**	Further Testing	
102	Sand, fine grained, silty		Sandy Loam	>2**	Suitable	
103	Sand over silt at 1.8 m		Sandy Loam*	>2**	Suitable	
104	Sand to 1.4 m over silty clay to 4.5 m	SM / CL	Sandy Loam*	6.8	Further Testing	
105	Clay, silty to 1.2 m over sand		Silty Loam	>2**	Suitable	
106	Sand to 2.2 m over clay		Sandy Loam*	>2**	Suitable	
107	Sand, fine grained silty		Sandy Loam*	>2**	Suitable	
108	Sand, fine grained silty over clay at 2.7 to 3.0 m	SM	Sandy Loam*	<2**	Suitable	Potential Limitation
109	Sand, fine, silty to 2.4 m over clay		Sandy Loam*	>2**	Suitable	
110	Clay with sand layer to 3 m		Clay Loam	>2**	Further Testing	
111	Sand, some silt to 2. m over clay to 3.5 m		Sandy Loam	<2**	Suitable	Potential Limitation
112	Sand to 2.2 m over clay		Sandy Loam*	>2**	Suitable	
113	Clay to 1.5 m over sand to 2.6 m		Loam	>2**	Suitable	
114	Sand to 1.8 m over clay		Silty Clay Loam*	<2**	Further Testing	Potential Limitation
115	Sand to 1.4 m over clay		Silty Clay Loam*	>2**	Further Testing	
116	Sand to 0.8 m over clay		Silty Clay Loam*	<2**	Further Testing	Potential Limitation
117	Sand to 2 m over clay		Sandy Loam*	>2**	Suitable	
118	Sand to 0.9 m over clay		Silty Clay Loam*	>2**	Further Testing	
119	Sand, fine grained silty		Sandy Loam*	>2**	Suitable	
201	Sand, fine to med	SM	Sandy Loam	2.0	Suitable	
202	Sand, fine to med	SM	Sandy Loam*	2.1	Suitable	
203	Clay to 1.2 over sand	SC	Clay Loam	2.1	Suitable	
203	Fine to medium grained sand	SM	Sandy Loam*	2.1	Suitable	
204	Sand, fine to med.	SM	Silty Loam	2.3	Suitable	
205	Sand to 2.6 m over clay	SM	Sandy Loam*	4.1	Suitable	
206	Sand, fine to med	SM	Sandy Loam*	2.4	Suitable	
207	Sand to 1.2m over clay to 3 m	SM	Sandy Loam*	1.5	Further Testing	Limitation
208	Sand, fine to med		Sandy Loam*	2.7	Suitable	
209	Sand, fine to med	SM	Sandy Loam*	>3.0	Suitable	
210	Sand, fine to med	SM	Sandy Loam*	4.2	Suitable	
211	Sand, fine to med	SM	Sandy Loam*	1.3	Suitable	Limitation
212	Sand to 2.1 m over 1 m of clay	SM	Sandy Loam*	2.4	Suitable	
213	Sand to 1.5 m over clay	CL	Silty Clay Loam	3.6	Further Testing	

Notes:
USC and USDA Classifications without (*) indicate testing confirmed via field, seive or hydrometer testing
Suitablity by soil texture conisders most restrictive soil in upper 2 m.
Suitability for groundwater based on 1.5m depth to groundwater below tile plus 0.5 m tile burial depth for total of 2.0 m depth to groundwater
Soil Texture Suitability based on Appendix 15 Soil Tests- Saskatchewan OnSite Waste Water Disposal Guideline 2009
* Soil Textures based on visual classifications, and assume all fines being silt, or sandy loam where visual classification as sand
**Values based on interpolated groundwater elevation data acquired from Drawing 15

Clifton Associates Ltd.
engineering science technology

Appendix A

BIO-MICROBICS® INCORPORATED

8450 Cole Parkway ▪ Shawnee, KS 66227 ▪ Phone: 913-422-0707 ▪ Fax: 913-422-0808
E-mail: onsite@biomicrobics.com ▪ www.biomicrobics.com ▪ 800-753-FAST (3278)

FAST® Wastewater Treatment Systems Data Catalog

1. **Residential Applications (MicroFAST®/ModularFAST®)**
    a. Small Units (500 – 1500 GPD)
        i. NSF Std. 40 Certification – Executive Summary
        ii. Florida OWNRS Demo Project – Phase I & II
        iii. Buzzard's Bay - Massachusetts Alternative Septic System Test Center
    b. Large Units (3000+)
        i. Halifax, Massachusetts
        ii. Sandwich, Massachusetts
        iii. Sherborn, Massachusetts
        iv. Sudbury, Massachusetts

2. **High Strength Applications (HighStrengthFAST®/ModularFAST®)**
    a. Coonamesett Inn, Coonamesett, Massachusetts
    b. Fuego, Washington
    c. Littleton, Massachusetts
    d. Mashpee 99 Restaurant, Mashpee, Massachusetts
    e. Plymouth, Massachusetts
    f. Richmond, Rhode Island

3. **RetroFAST® Data – EPA Environmental Technology Verification (ETV)**
    a. ETV Joint Verification Statement
    b. RetroFAST® Data Summary

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EXECUTIVE SUMMARY

Testing of the Bio-Microbics, Inc. (formerly Scienco/FAST®) Single Home FAST Treatment Plant Model 23-001-750 was conducted under the provisions of NSF Standard 40 for Individual Aerobic Wastewater Treatment Plants (July 1990). NSF Standard 40 was developed by the NSF Joint Committee on Wastewater Technology.

The performance evaluation was conducted at the NSF Wastewater Technology Test Facility in Chelsea, Michigan, using wastewater diverted from the Chelsea municipal wastewater collection system. The evaluation consisted of six months of testing, during which a seven week stress test was conducted. The evaluation consisted of three weeks of dosing without sampling to allow for plant start-up, sixteen weeks of dosing at design flow, seven weeks of stress test and five weeks of dosing at design flow. Sampling started in the fall and continued through the winter and into spring, covering a full range of operating temperatures.

Standard 40, in Section H. (3) of Appendix A, provides for exclusion of up to ten percent of the effluent sample days, not to exceed one during stress testing, in completing the pass/fail determination. No sample days were excluded in this evaluation. Over the course of the evaluation, the average effluent BOD_5 was 9 mg/L, ranging between <5 and 24 mg/L, and the average effluent suspended solids was 7 mg/L, ranging between <5 and 27 mg/L. The pH ranged from 7.5 to 8.2.

The Single Home FAST Treatment Plant Model 23-011-750 produced an effluent that successfully met the performance requirements established by NSF Standard 40 for Class I effluent:

> The maximum arithmetic mean of seven consecutive sample days was 14 mg/L for BOD_5 and 12 mg/L for suspended solids, both well below the allowed maximum of 45 mg/L. The maximum arithmetic mean of 30 consecutive sample days was 12 mg/L for BOD_5 and 8 mg/L for suspended solids, both well below the allowed maximum of 30 mg/L. Removal rates ranged from 92 to 95 percent for BOD_5 and 95 to 97 percent for suspended solids, consistently above the requirement of 85 percent.

The effluent pH during the entire evaluation ranged between 7.5 and 8.2, within the required range of 6.0 to 9.0. The plant also met the requirements for noise levels (less than 60 dbA at a distance of 20 feet) and color, threshold odor, oily film and foam.

Prepared 8/28/96

P.O. Box 130140 Ann Arbor, Michigan 48113-0140 USA
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E-Mail: info@nsf.org Web: http://www.nsf.org

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NITROGEN SERIES TEST RESULTS

(All results reported as mg/L as N)

Plant: Bio-Microbics, Inc. (formerly Scienco/FAST®) Model 23-001-0750

Sample Date	Ammonia - N		Nitrate - N		Total Kjeldahl - N	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
9/17	22	3.3	<0.5	0.7	32	6.1
9/20	29	2.2	0.8	4.1	36	4.7
9/24	34	4.0	<0.5	4.6	39	6.2
9/27	25	3.5	<0.5	3.9	33	5.4
10/1	28	4.7	<0.5	1.5	35	8.0
10/4	21	6.0	<0.5	1.4	31	9.4

Prepared 8/26/96

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OFFICIAL LISTING

NSF International Certifies that the products appearing on this Listing conform to the requirements of NSF/ANSI Standard 40 - Residential Wastewater Treatment Systems

This is the Official Listing recorded on April 25, 2005.

BIO-MICROBICS, INC.
8450 COLE PARKWAY
SHAWNEE, KS 66227
800-753-FAST
913-422-0707

Facility : SHAWNEE, KS

Model Number	Rated Capacity Gallons/Day	Classification
MicroFast 0.5[1]	500	Class I
MicroFast 0.75[2]	750	Class I
MicroFast 0.9[3]	900	Class I
MicroFast 1.5[4]	1500	Class I

[1] Beginning with serial number MCF2265B
[2] Beginning with serial number MCF4000B
[3] Beginning with serial number MCF3026B
[4] Beginning with serial number MCF6006B

NOTE: Units accepted with either concrete or fiberglass tanks.

This company may sell products complying with all applicable requirements for Certification nationally and internationally, but has advised NSF of authorized representatives physically located in the following:

Alaska	Arizona	British Columbia	California	Colorado
Florida	Georgia	Hawaii	Idaho	Illinois
Iowa	Kansas	Maryland	Massachusetts	Michigan
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Onsite Wastewater Nutrient Reduction Systems (OWNRS) For Nutrient Sensitive Environments

Damann L. Anderson*
Mark B. Tyl
Richard J. Otis
Timothy G. Mayer
Kevin M. Sherman

ABSTRACT

Negative impacts to the Florida Keys coral reef ecology have been documented in recent years, and water quality degradation from nutrient overloading is a suspected cause. To protect the waters of the Florida Keys from further degradation, the Florida Keys National Marine Sanctuary (FKNMS) was established by the federal government in 1990. In 1993 the U.S. Environmental Protection Agency (EPA) identified domestic wastewater as a major source of nutrient loading to FKNMS waters. Many dwellings and commercial establishments in the Keys use onsite wastewater treatment systems (OWTS), so the Florida Keys Onsite Wastewater Nutrient Reduction Systems (OWNRS) Demonstration Project was initiated in 1995 to demonstrate the use of OWTS which could significantly improve treatment and reduce the concentrations of nutrients discharged to the near-shore environment of the Keys.

To meet this objective, a unique test facility was designed and constructed to evaluate various OWNRS processes simultaneously, under controlled conditions, using a common wastewater source. Five principle wastewater treatment process streams were operated concurrently at the test facility, with several unit processes in each stream. Unit processes evaluated included attached growth and suspended growth biological processes (both aerobic and anaerobic), physical/chemical processes (adsorption, precipitation, ion exchange) and natural systems utilizing drip irrigation for plant uptake and evapo-transpiration. Influent and effluent quality were monitored monthly with 24-hour flow-composite samples. Results after the first year of operation indicate that OWNRS effluent concentrations of 5 mg/L $CBOD_5$, 5 mg/L TSS, 10 mg/L total nitrogen, and 1 mg/L total phosphorus are achievable without chemical addition using combinations of the processes tested. Although excellent treatment was achieved with OWNRS, significant additional construction, operation, and maintenance was required for these systems in comparison with conventional OWTS.

Keywords: Onsite wastewater treatment, Nutrient removal, Nitrogen removal, Phosphorus removal, Advanced wastewater treatment

INTRODUCTION

The Florida Keys are an environmentally sensitive chain of islands extending from the southern tip of Florida southwestward to Key West and the Dry Tortugas. The clear waters surrounding this area contain the only living coral reefs in the continental United States. Over 80,000 people make their homes in the Florida Keys and more than 3 million tourists visit the Keys annually.

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Background

In 1990, the United States Congress recognized the national and international significance of resources in the Florida Keys with the passage of The Florida Keys National Marine Sanctuary and Protection Act (Public Law 101-605). The sanctuary established by this legislation consists of approximately 9,500 km^2 of coastal and oceanic waters and the submerged land beneath them. The shoreward boundary of the sanctuary is the mean high-water mark.

Under the sanctuary designation, the National Oceanic and Atmospheric Administration (NOAA) is charged with developing a comprehensive management plan and implementation regulations. The U.S. Environmental Protection Agency (EPA), in conjunction with the State of Florida and NOAA, must develop and implement a water quality protection program.

The water quality protection program has identified nutrient loading from wastewater sources as one of the major water quality concerns in the Keys. Onsite wastewater treatment systems (OWTS) have been targeted as one of the primary wastewater sources of nitrogen and phosphorus. The Water Quality Protection Program Report (Continental Shelf Associates, 1993) to the EPA documented the need for a demonstration of nutrient-reducing OWTS in the Florida Keys. The Florida Department of Health initiated the Florida Keys Onsite Wastewater Nutrient Reduction System (OWNRS) Demonstration Project in response to this need.

Project Objectives

The Florida Keys OWNRS Demonstration Project was designed to demonstrate the capability and use of alternative OWTS technologies for the Florida Keys. Wastewater treatment processes which provide a level of treatment superior to conventional OWTS were tested to evaluate their potential to reduce organic, solids, and nutrient loading to near-shore waters of the Keys. An additional goal of the project was to determine if Florida advanced wastewater treatment (AWT) standards of 5 milligrams per liter (mg/L) for Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS), 3 mg/L for Total Nitrogen, and 1 mg/L for Total Phosphorus, are feasible for OWTS.

MATERIALS AND METHODS

Central Test Facility

A central test facility was constructed at a minimum security correctional institution in the Florida Keys to test various processes for onsite wastewater treatment removal. The central test facility was designed to allow comparative testing of numerous onsite wastewater treatment processes simultaneously, under controlled conditions, with a common wastewater source. Use of a common source eliminated the difficulty of making valid comparisons of technology performance based on a limited number of installations with widely varying wastewater characteristics. The test facility allows accurate monitoring of influent wastewater quality and flow, and the capability for flow-composited effluent sampling to determine treatment performance.

The test facility was initially set up to evaluate five principle wastewater treatment process streams. Electronically activated dose systems provide each of the process streams with influent wastewater, diverted from the correctional institution's wastewater collection systems. The dosing schedule is shown in Figure 1 and mimics the typical wastewater flow from a home, with peaks in the morning and early evening. Under normal operating conditions, each of the treatment streams receives 200 gallons per day. The facility is designed so this volume can be adjusted for stress testing and other special purpose research. The central test facility was activated in October of 1996.

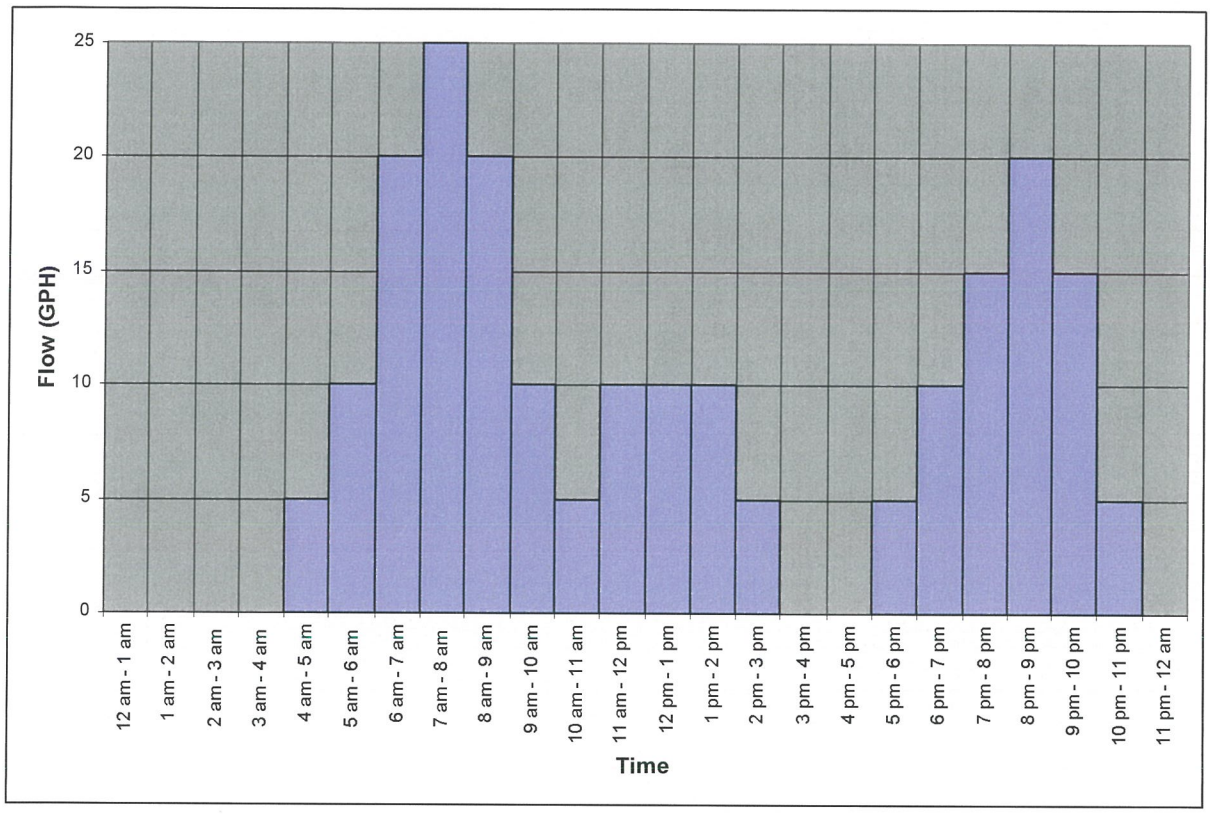


Figure 1: Daily Dose Schedule to Treatment Systems (5 gallons per dose)

Treatment Processes

The principle treatment technologies currently under evaluation are physical, chemical, and aerobic and anaerobic biological treatment processes. One "passive" technology stream and four "active" technology process streams are currently under evaluation. A description of the five principle process streams follows. Figure 2 provides a schematic of the test facility and process streams currently in operation.

Process Stream 1 consists of a septic tank (ST-1) followed by a recirculating sand filter (RSF) and an anoxic bio-filter (ABF). Effluent from the system is discharged to an unlined drip irrigation bed. Treatment occurs through digestion and settling in the septic tank and physical, chemical, and attached growth aerobic biological processes in the RSF. Adsorption by the RSF media removes limited quantities of phosphorus. The nitrified RSF effluent is mixed with anoxic septic tank effluent in the recirculation chamber (RC) to encourage denitrification. The effluent also undergoes further nutrient reduction in an anoxic bio-filter and by plant uptake in the drip bed as well as adsorption on the drip field media.

Process Stream 2 is a relatively passive technology consisting of a septic tank (ST-2) with effluent discharged to a lined drip irrigation field. A commercially available subsurface drip irrigation (SDI) system by Aztex™ Products is used for effluent distribution to the root zone. This process stream represents the most "low tech" of the systems. Reduction of nutrients and other parameters is accomplished by preliminary digestion and settling in the septic tank with additional

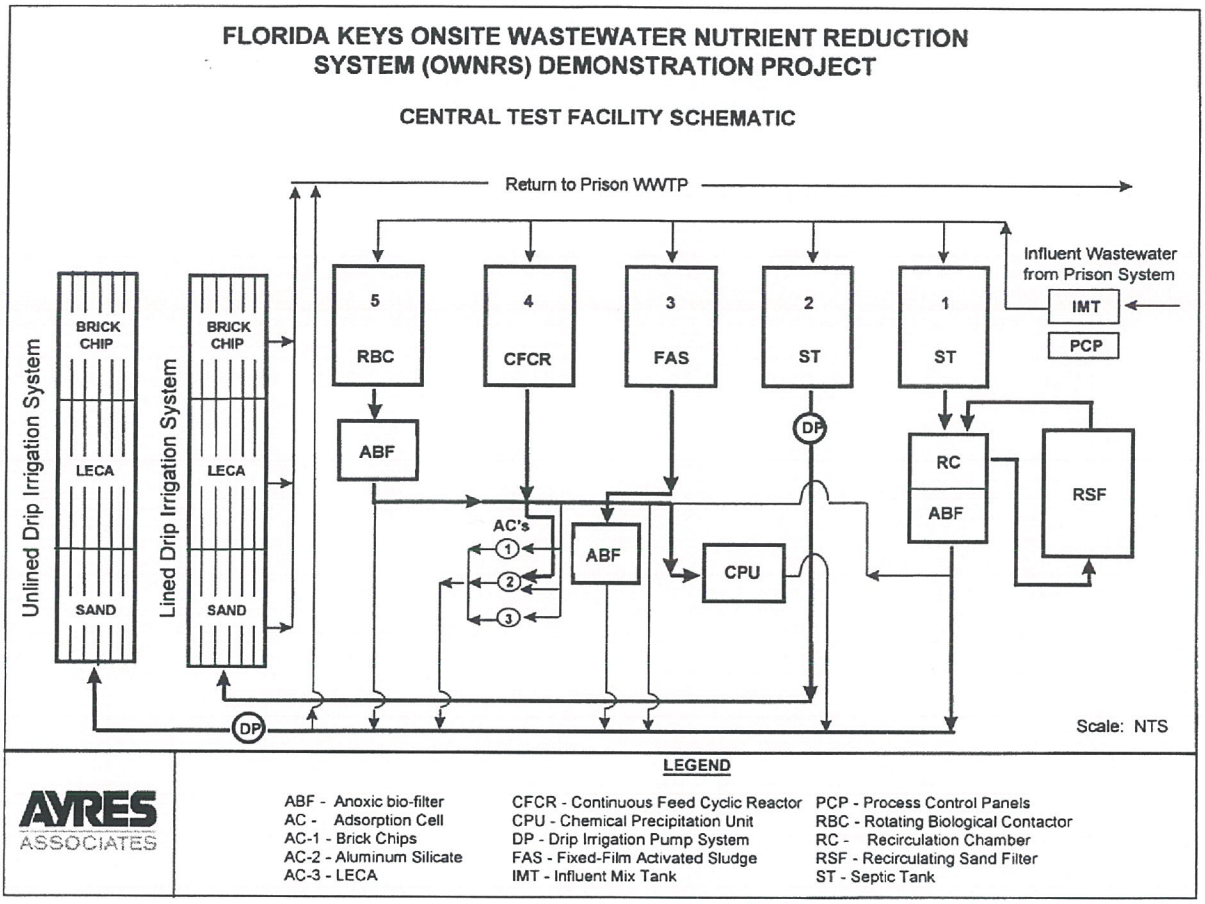


Figure 2: Central Test Facility Schematic

physical, chemical, and biological treatment processes occurring in the lined bed underlying the drip field and by plant uptake. The lined bed contains a one foot thickness of saturated media under 1.5 feet of unsaturated media. The effluent undergoes nitrification in the upper unsaturated (aerobic) portion of the drip bed and limited denitrification in the saturated (anaerobic) lower portion of the drip bed. Three treatment media (crushed red brick, silica sand, and an expanded clay aggregate from Norway, commercially known as LECA™) underlie distinct zones of the drip field. Two of these, the bricks and LECA, were selected for their phosphorus adsorption potential. Because these media beds have been built over an impermeable liner, the program includes an assessment of the effectiveness of evapo-transpiration in reducing effluent volumes.

The principle treatment unit in *process stream 3* is a proprietary unit known as the Bio-Microbics FAST™ aerobic unit. This unit uses fixed-film activated sludge (FAS) treatment. The treatment is a combination suspended growth and attached growth aerobic biological process. This system provides nitrification of the effluent before discharge, and also provides denitrification by mixing anaerobic conditions that favor the growth of denitrifying microorganisms and conversion of nitrate to nitrous oxide or nitrogen gas. Additional processes would be required for phosphorus removal following this system.

Process stream 4 consists of proprietary treatment unit known as the AES BESTEP- IDEA™ system. This system is a suspended growth biological treatment process that operates as a continuous feed cyclic reactor (CFCR). The process is similar to a sequencing batch reactor (SBR), but is unique in that it allows continuous flow while using only one process tank. Aeration to the tank is cyclical, which causes alternating aerobic and anaerobic conditions. This fluctuating environment results in nitrification followed by denitrification and also luxury uptake of phosphorus by the activated sludge biomass.

Process stream 5 consists of a proprietary treatment unit known as the Klargester Biodisc™. It is a rotating biological contactor (RBC), followed by an anoxic bio-filter (ABF). The RBC is an attached growth, aerobic biological treatment process that provides internal recycle for nitrification and denitrification. It produces a nitrified effluent that then undergoes further denitrification in the ABF. Additional processes would be required for phosphorus removal following this system.

Additional unit processes are available for testing at the facility. These include chemical precipitation, supplemental carbon addition for denitrification, and additional phosphorus adsorption media. The test facility was designed so that the effluent from the principle treatment process streams described above can be routed to any of these additional processes for further treatment and evaluation. These additional processes are currently under evaluation and are not included in this paper. Effluents from the various process streams are discharged to a sump tank after water quality sampling and returned to the correctional institution's wastewater treatment plant.

Treatment Performance Monitoring

Twenty-four hour flow composited samples were collected from the influent mix tank and from each of the five treatment process effluents from November 1996 through August 1997. Samples were analyzed according to Standard Methods (APHA, 1992) for biochemical oxygen demand (BOD_5), carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS), total kjeldahl nitrogen (TKN), nitrate + nitrite-nitrogen (NO_2NO_3-N), and total phosphorus (TP). Total nitrogen (TN) was obtained by summation.

RESULTS

Results of the water quality analyses for the influent and five process stream effluents are provided in Table 1. For the lined bed drip irrigation system (Process Stream 2), only the results of the crushed brick media (LBRICK) are reported here.

Influent wastewater quality was typical of that reported in the literature for domestic wastewater (Metcalf and Eddy, 1991) with mean $CBOD_5$, TSS, TN, and TP values of 137.8, 117.5, 38.4, and 8.4 mg/L, respectively. Significant variations about these mean values were measured over the 12 sampling events, also typical of domestic wastewater from individual homes.

Effluent quality for all treatment processes was excellent in terms of traditional wastewater treatment parameters, $CBOD_5$, and TSS.

$CBOD_5$: All five process streams met the AWT $CBOD_5$ effluent standard of 5 mg/L. Figure 3 shows the 95% confidence intervals about the mean for the five processes. These data illustrate the stability of fixed-film attached growth biological processes such as the RSF and RBC.

TSS: Only the CFR and the RBC systems did not meet the AWT effluent TSS standard of 5 mg/L, but they were within 2 mg/L of the standard. Figure 4 shows the 95% confidence intervals for TSS. These data indicate the stability of biological filter type processes such as the RSF for TSS removal. The crushed brick media also indicated stable TSS removals later in the study period, once the fine media particles stabilized and grass growth took hold.

Effluent quality for the nutrients, nitrogen and phosphorus, showed significantly more variation between processes, and typically did not meet AWT effluent standards.

Table 1: Summary of Influent and Effluent Water Quality Data

Parameter	Statistic	Influent (IMT)	System 1 (RSF-ABF)	System 2 (LBRICK)	System 3 (FAS)	System 4 (CFCR)	System 5 (RBC-ABF)
BOD_5	mean	170.90	2.27	4.17	5.58	4.16	2.42
	Std. Dev.	73.85	2.51	6.29	3.90	5.45	1.38
	min	62.00	1.00	1.00	1.00	1.00	1.00
	max	299.00	9.70	21.30	14.00	17.20	5.00
	n	10	12	11	11	8	11
$CBOD_5$	mean	137.80	1.50	2.81	2.70	3.19	1.68
	Std. Dev.	60.13	0.90	4.04	3.11	5.18	1.24
	min	59.00	1.00	1.00	1.00	1.00	1.00
	max	220.00	4.00	14.40	9.01	15.90	5.00
	n	10	12	11	11	8	11
TSS	mean	117.50	2.25	4.09	4.63	6.85	5.75
	Std. Dev.	92.09	1.76	3.83	3.93	6.62	4.47
	min	17.00	1.00	1.00	1.00	2.00	1.00
	max	345.00	6.00	11.00	14.00	20.00	16.00
	n	12	12	11	12	10	12
TKN	mean	38.58	1.01	1.75	1.55	1.16	2.75
	Std. Dev.	10.67	1.44	2.10	0.82	0.52	2.62
	min	19.20	0.26	0.34	0.49	0.56	0.42
	max	62.50	5.30	8.19	3.40,	2.20	7.40
	n	12	11	12	12	9	11
NO_2NO_3-N	mean	0.03	21.09	18.3.6	9.42	14.30	9.77
	Std. Dev.	0.02	6.76	10.56	4.06	6.49	3.69
	min	0.01	14.00	1.60	3.90	2.54	3.60
	max	0.05	35.20	36.60	19.70	23.00	17.00
	n	10	11	11	12	9	11
TN	mean	38.61	20.76	20.24	10.97	15.46	12.52
	Std. Dev.	10.67	5.61	11.64	4.05	6.60	5.98
	min	19.25	14.46	3.00	4.55	3.53	4.05
	max	62.55	30.23	44.79	20.19	24.20	23.00
	n	12	10	11	12	9	11
TP	mean	8.39	1.76	0.60	5.38	6.24	4.67
	Std. Dev.	5.79	0.48	0.23	1.44	1.59	1.05
	min	4.32	0.92	0.34	3.22	4.80	2.50
	max	26.00	2.40	1.20	8.70	9.90	5.90
	n	12	10	11	12	10	12

Nitrogen: None of the five process streams met the AWT nitrogen standard of 3 mg/L. The FAS and RBC-ABF systems performed best for nitrogen removal, with mean effluent TN values of 11.0 and 12.5 mg/L, respectively. Figure 5 shows the 95% confidence intervals for TN.

These results are excellent considering they were obtained without supplemental carbon addition to enhance denitrification. In fact, the RBC-ABF effluent was not significantly different from the RBC effluent alone, indicating insufficient residual carbon for denitrification in the ABF tank following the RBC.

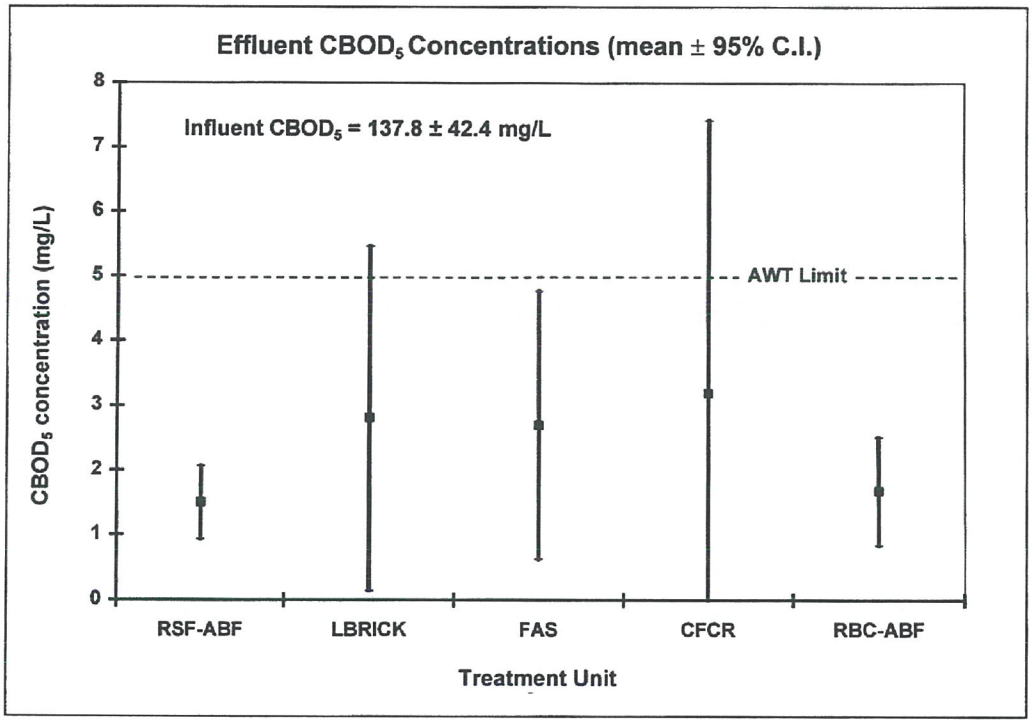


Figure 3: Effluent $CBOD_5$ Concentrations (mean ± 95% C.I.)

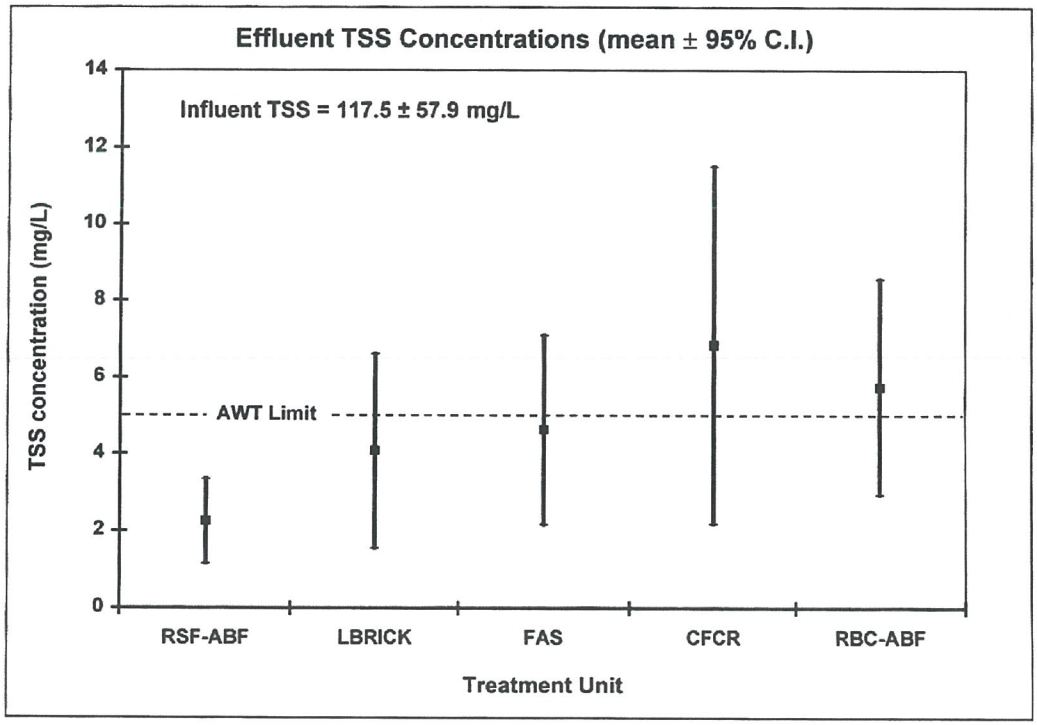


Figure 4: Effluent TSS Concentrations (mean ± 95% C.I.)

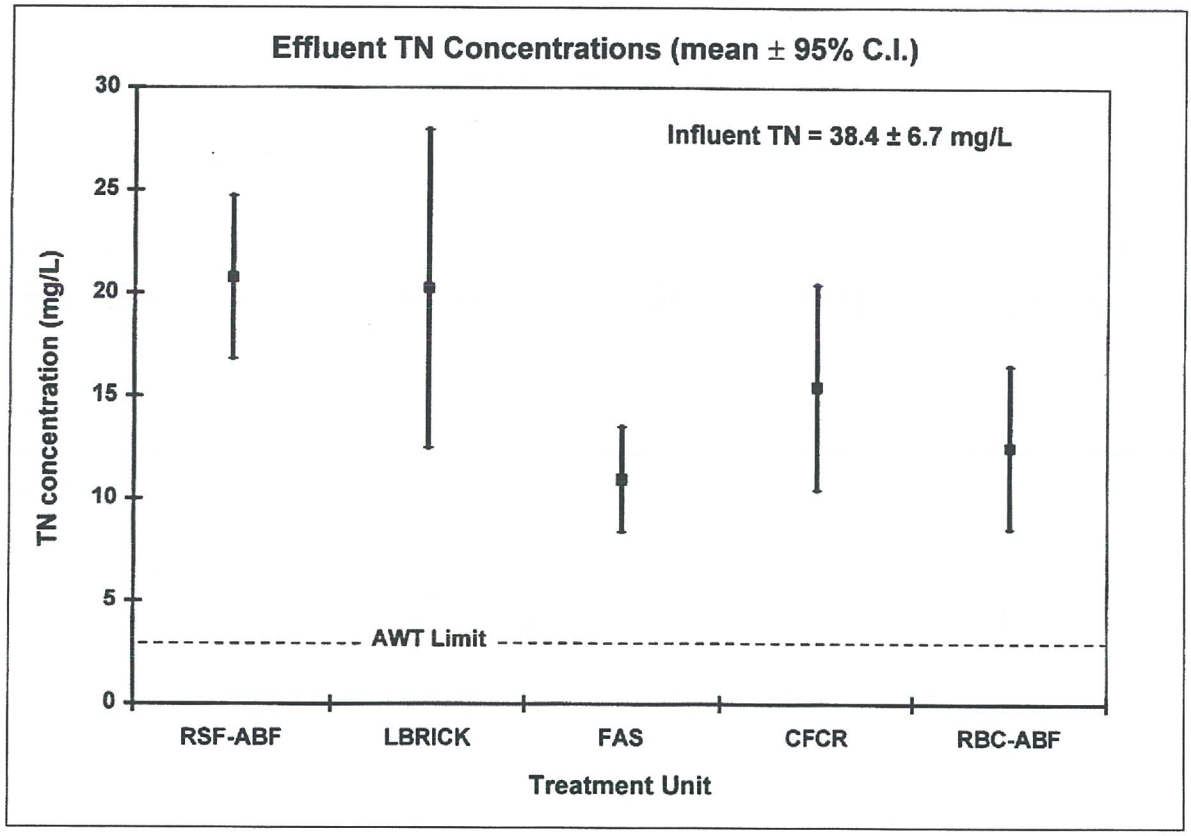


Figure 5: Effluent Total Nitrogen Concentrations (mean ± 95% C.I.)

Supplemental carbon addition is currently being evaluated at the Keys test facility, and preliminary results indicate that an effluent TN value of 5 mg/L may be achievable by adding carbon to an ABF unit following the FAS or RBC.

Phosphorus: Only the lined drip irrigation system with crushed brick (LBRICK) media met the AWT effluent standard for phosphorus. The LBRICK and RSF-ABF systems both provided excellent TP removals with mean effluent TP values of 0.60 and 1.8 mg/L, respectively. Figure 6 shows the 95% confidence intervals for TP. These data suggest that adsorption of phosphorus on the RSF sand and drip field crushed brick media are also the most stable phosphorus removal mechanisms tested. It remains to be seen, however, how long these removal efficiencies will last. Once the media adsorption sites reach capacity, breakthrough of phosphorus at higher concentrations may occur.

SUMMARY AND CONCLUSIONS

A field evaluation of several onsite wastewater nutrient reduction systems (OWNRS) was conducted to evaluate the potential for improved treatment effectiveness of onsite wastewater treatment systems (OWTS) in the Florida Keys. Results indicated that the systems tested provided excellent treatment performance ($CBOD_5$ and TSS <5 mg/L), but no individual system was capable of meeting the Florida advanced waste treatment (AWT) effluent standards of 5 mg/L $CBOD_5$, 5 mg/L TSS, 3 mg/L TN, and 1 mg/L of TP.

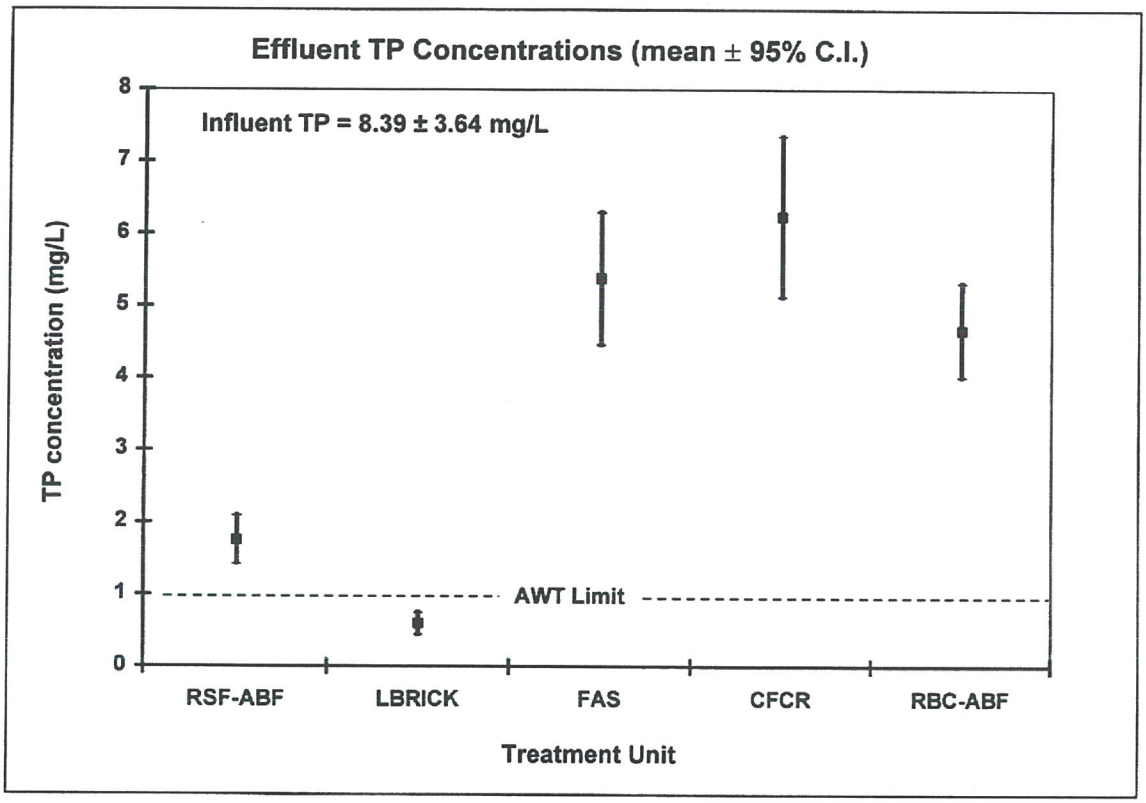


Figure 6: Effluent Total Phosphorus- Concentrations (mean ± 95% C.I.)

It appeared that a combination of processes, such as an aerobic biological treatment unit followed by an anoxic bio-filter (ABF) with supplemental carbon addition, discharging to an engineered media drip irrigation bed could meet the AWT standards for $CBOD_5$, TSS, and TP and come very close to the standard for TN. The duration of the TP removals by the drip irrigation bed is unknown; however, continued monitoring of these systems is recommended to address longevity issues and solids handling requirements. Based on the evaluation conducted to date, following conclusions are drawn:

- AWT effluent standards for $CBOD_5$, TSS, and TP can be consistently met with combinations of the technologies tested;
- TN reductions of >70% are achievable without supplemental carbon addition and 90% with carbon addition;
- Continued monitoring of the OWNRS are required to quantify phosphorus removal duration and treatment performance longevity, solids handling requirements, and maintenance requirements;
- Construction of the OWNRS and operation for one year has indicated that OWNRS will require considerably greater capital, operation and maintenance expenditures in comparison to conventional OWTS.

ACKNOWLEDGEMENTS

This project was funded by the Florida Department of Health (Contract #LP988) under a grant from the US Environmental Protection Agency (Cooperative Agreement #X994394-93-0), and this financial support is acknowledged. The Florida Department of Corrections, and specifically the staff of the Big Pine Key Road Prison, are gratefully acknowledged for the cooperation and assistance on the OWNRS Demonstration Project. Finally, the time and material provided by the numerous equipment manufacturers made this study possible, and their support is acknowledged.

REFERENCES

1. APHA, 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed., American Public Health Association, Washington DC.
2. Continental Shelf Associates, Inc., Batelle Ocean Services, Lindahl, Browning, Ferrari & Hellstrom, Inc., Batelle Pacific Northwest Division and Batelle Seattle Research Center, 1993. Water Quality Protection Program, Florida Keys National Marine Sanctuary, Phase II Report. Report to the US Environmental Protection Agency, Oceans and Coastal Protection Division under Contract 68-C2-0134.
3. Metcalf & Eddy, Inc. Wastewater Engineering: Treatment Disposal, and Reuse. 3rd ed., McGraw-Hill, New York, 1991.

FLORIDA OWNRS PROJECT PHASE 1 - TEST DATA

PARAMETER		UNITS	SAMPLE DATES												AVG	% RED
			11/20/96	12/18/96	1/29/97	2/26/97	4/2/97	4/23/97	[1]5/8/97	5/21/97	[2]5/29/97	6/11/97	7/17/97	8/28/97		
BOD (5-Day@20°C)																
	INFLUENT	mg/L	137.00	148.00	299.00	139.00	170.00	210.00	230.00	62.00	240.00	100.00	150.00	100.00	165.42	
	FAST	mg/L	3.26	7.75	8.02	6.00	4.30	9.00	5.70	2.60	14.00	4.80	1.00	1.00	5.62	96.6
	FAST-ABF	mg/L	NO DATA	NO DATA	10.00	10.00	2.20	1.40	1.70	2.70	1.00	1.40	1.00	1.00	3.24	98.0
BOD (Carbonaceous)																
	INFLUENT	mg/L	176.00	136.00	215.00	183.00	150.00	200.00	220.00	59.00	130.00	67.00	130.00	71.00	144.75	
	FAST	mg/L	2.48	8.85	9.01	6.00	1.20	1.40	1.00	1.00	1.00	1.00	1.00	1.00	2.91	98.0
	FAST-ABF	mg/L	NO DATA	NO DATA	16.10	10.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.41	97.6
Ammonia Nitrogen																
	INFLUENT	mg/L N	18.90	34.90	50.80	26.80	23.00	37.00	29.00	26.00	36.00	30.00	27.00	27.00	30.53	
	FAST	mg/L N	0.32	1.24	1.73	0.58	0.75	1.40	0.10	0.07	1.90	0.30	0.15	0.04	0.72	97.7
	FAST-ABF	mg/L N	NO DATA	NO DATA	2.50	0.34	0.61	0.37	0.29	0.67	0.63	0.04	NO DATA	NO DATA	0.68	97.8
Nitrate-Nitrite Nitrogen																
	INFLUENT	mg/L N	0.05	0.05	0.05	0.05	0.04	0.02	0.02	0.01	0.01	0.04	NO DATA	NO DATA	0.03	
	FAST	mg/L N	9.23	9.39	8.47	19.70	9.20	7.00	3.90	12.00	11.00	9.40	9.80	4.00	9.42	NA
	FAST-ABF	mg/L N	NO DATA	NO DATA	18.81	19.00	8.60	6.40	2.40	7.40	11.00	10.00	10.00	2.40	9.60	NA
Total Kjeldahl Nitrogen																
	INFLUENT	mg/L N	19.20	46.90	62.50	37.40	32.00	46.00	39.00	33.00	44.00	36.00	33.00	32.00	38.42	
	FAST	mg/L N	1.23	1.77	1.82	0.49	1.90	2.50	1.10	1.00	3.40	1.30	1.50	0.55	1.55	96.0
	FAST-ABF	mg/L N	NO DATA	NO DATA	2.39	0.64	1.60	1.10	1.10	1.60	1.60	0.83	1.10	0.81	1.28	96.7
Total Nitrogen(TKN+Nitrates)																
	INFLUENT	mg/L N	19.25	46.95	62.55	37.45	32.04	46.02	39.02	33.01	44.01	36.04	NO DATA	NO DATA	39.63	
	FAST	mg/L N	10.46	11.16	10.29	20.19	11.10	9.50	5.00	13.00	14.40	10.70	11.30	4.55	10.97	72.3
	FAST-ABF	mg/L N	NO DATA	NO DATA	21.20	19.64	10.20	7.50	3.50	9.00	12.60	10.83	11.10	3.21	10.88	72.6
Total Phosphorus																
	INFLUENT	mg/L P	4.32	7.09	11.00	7.07	6.60	7.80	7.10	5.80	26.00	5.80	7.10	5.00	8.39	
	FAST	mg/L P	3.22	4.21	5.19	5.64	5.80	6.40	6.10	5.30	8.70	5.90	3.70	4.40	5.38	35.9
	FAST-ABF	mg/L P	NO DATA	NO DATA	4.52	5.22	5.60	5.60	5.40	5.30	5.80	7.10	4.50	4.20	5.32	36.5
Total Suspended Solids																
	INFLUENT	mg/L	60.00	86.00	345.00	70.00	17.00	203.00	170.00	162.00	80.00	123.00	74.00	20.00	117.50	
	FAST	mg/L	4.00	14.00	10.00	4.00	1.00	3.00	5.50	1.00	2.00	4.00	6.00	1.00	4.63	96.1
	FAST-ABF	mg/L	NO DATA	NO DATA	4.00	4.00	1.00	1.00	2.50	1.00	1.00	1.00	3.00	1.00	1.95	98.3

1 - sample collected following simulated vacation stress
2 - sample collected following simulated wash day stress

FLORIDA OWNRS PROJECT PHASE 2 - TEST DATA

PARAMETER		UNITS	SAMPLE DATES												AVG	% RED
			8/19/98	9/22/98	1/18/99	2/16/99	3/23/99	4/22/99	MAY	6/22/99	7/27/99	8/31/99	9/28/99	10/21/99		
BOD (5-Day@20°C)																
	INFLUENT	mg/L	160.00	120.00	NO DATA	120.00	140.00	56.00	N	160.00	160.00	160.00	110.00	150.00	133.60	
	FAST	mg/L	NO DATA	3.40	NO DATA	4.50	NO DATA	2.50	O	NO DATA	4.20	3.70	1.80	5.60	3.67	97.3
	FAST-ABF	mg/L	NO DATA	13.00	NO DATA	NO DATA	NO DATA	NO DATA		NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	13.00	90.3
BOD (Carbonaceous)									D							
	INFLUENT	mg/L	150.00	91.00	190.00	90.00	88.00	39.00	A	100.00	120.00	120.00	90.00	140.00	110.73	
	FAST	mg/L	1.00	1.70	1.00	2.00	1.00	1.00	T	1.00	1.00	1.10	1.00	1.00	1.16	98.9
	FAST-ABF	mg/L	NO DATA	NO DATA	3.80	1.50	1.00	1.00	A	1.00	1.00	6.70	36.00	1.00	5.89	94.7
Ammonia Nitrogen																
	INFLUENT	mg/L N	NO DATA	26.00	NO DATA	37.00	NO DATA	22.00	F	53.00	35.00	47.00	30.00	40.00	36.25	
	FAST	mg/L N	NO DATA	0.11	NO DATA	0.28	NO DATA	0.28	O	0.35	0.34	0.34	0.40	0.08	0.27	99.2
	FAST-ABF	mg/L N	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	R	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Nitrate-Nitrite Nitrogen																
	INFLUENT	mg/L N	0.02	0.01	0.01	0.26	0.28	0.01	M	0.01	0.01	0.05	0.12	0.01	0.07	
	FAST	mg/L N	15.00	8.20	13.00	12.00	12.00	9.70	O	12.00	9.50	5.90	4.70	2.40	9.49	N.A.
	FAST-ABF	mg/L N	NO DATA	7.20	3.90	9.60	11.00	6.10	N	8.10	10.00	0.01	0.01	2.00	5.79	N.A.
Total Kjeldahl Nitrogen									T							
	INFLUENT	mg/L N	38.00	32.00	62.00	44.00	37.00	29.00	H	56.00	48.00	65.00	46.00	46.00	45.73	
	FAST	mg/L N	1.20	0.89	1.20	1.20	0.99	1.20		0.77	1.20	1.50	1.20	0.35	1.06	97.7
	FAST-ABF	mg/L N	NO DATA	0.96	1.30	0.90	0.60	1.30	O	0.99	0.82	2.30	2.90	1.20	1.33	97.1
Total Nitrogen(TKN+Nitrates)									F							
	INFLUENT	mg/L N	38.02	32.01	62.01	44.26	37.28	29.01		56.01	48.01	65.05	46.12	46.01	45.80	
	FAST	mg/L N	16.20	9.09	14.20	13.20	12.99	10.90	M	12.77	10.70	7.40	5.90	2.75	10.55	77.0
	FAST-ABF	mg/L N	NO DATA	8.16	5.20	10.50	11.60	7.40	A	9.09	10.82	2.31	2.91	3.20	7.12	84.5
Total Phosphorus									Y							
	INFLUENT	mg/L P	6.50	7.80	8.00	12.00	9.40	5.80		9.50	5.70	11.00	8.70	7.90	8.39	
	FAST	mg/L P	6.40	7.00	6.20	6.10	6.00	7.20		5.70	5.70	7.70	6.90	6.00	6.45	23.2
	FAST-ABF	mg/L P	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA		NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Total Suspended Solids																
	INFLUENT	mg/L	68.00	48.00	68.00	90.00	108.00	66.00		70.00	114.00	100.00	133.00	92.00	87.00	
	FAST	mg/L	1.00	3.00	5.00	3.00	6.00	6.00		16.00	1.00	1.00	1.00	3.00	4.18	95.2
	FAST-ABF	mg/L	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA		NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Fecal Coliforms																
	INFLUENT	cts/100 ml	NO DATA	600,000 Q,Z	600,000 V	600,000 Z	600,000	630,000		600,000	21,000	600,000	600,000	600,000	604,375	
	FAST	cts/100 ml	NO DATA	460.00	200.00	450.00	63.00	140.00		1500.00	200.00	>600	270.00	3600.00	764.78	99.9
	FAST-ABF	cts/100 ml	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA		NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA

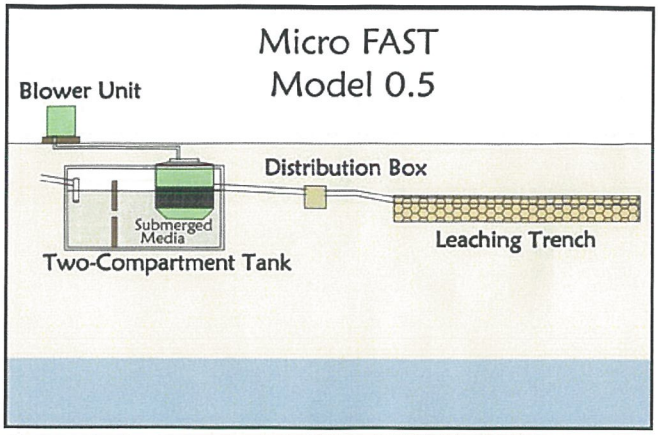
Q - Sample analyzed beyond the accepted holding limit. (Analyzed at client's request)
V - Greater than 6,000. Fecal coliforms exceeded 60 counts on lowest filtration volume (1ml).
Z - Greater than 60,000. Fecal coliforms exceeded 60 counts on lowest filtration volume (0.1ml).

Massachusetts Alternative Septic System Test Center
Technology Fact Sheet -*Interim Findings*

MicroFAST ®
Model 0.5

The Massachusetts Alternative Septic System Test Center is a collaborative project of the Buzzards Bay Project National Estuary Program, Massachusetts Office of Coastal Zone Management, Massachusetts Department of Environmental Protection, Barnstable County Department of Health and the Environment, and UMass Dartmouth School for Marine Science and Technology. The Test Center was established in recognition of the need in Massachusetts for cost-effective wastewater disposal systems suitable for sites with limited space, poor soils, high groundwater elevations, or where advanced pollutant removal is required. Its mission is twofold. First, to evaluate the performance and operation costs of new and innovative wastewater disposal technologies in a carefully controlled and unbiased manner, and provide this information to regulators and consumers. Second, to assist vendors in getting their technologies more quickly approved for use in Massachusetts, and at a lesser cost.

Technology Name:	MicroFAST®- residential unit, Model 0.5
Technology Type:	Fixed Activated Sludge Treatment System
Manufacturer:	Bio-Microbics Inc. 8450 Cole Parkway Shawnee, KS 66227 913-422-0707 or 1-800-753-3278 (FAST)
Contact:	Robert J. Rebori, President
Company Website:	www.biomicrobics.com
Performance & Permitting info at MA DEP and BCHED Websites:	www.state.ma.us/dep/brp/wwm/t5pubs.htm#it www.barnstablecountyhealth.org/AlternativeWebpage/
Testing Objectives:	Demonstrate N removal for use in N-sensitive watersheds. Obtain approval for reductions in SAS size or high groundwater elevation separation distance.
Testing Period:	Testing began 5/99 and is ongoing. Results shown for 7/99 to 7/00.
Test Loadings:	System loading was 330 gpd, (in 15 doses AM/PM), SAS was 0.74 gallons per sq. ft per day.



Generalized schematic of the MicroFAST Model 0.5.

MicroFAST during construction.

MicroFAST after installation.

Siting Considerations and Installation Notes
MicroFAST system component installation is similar to a standard Title 5 system. Installers should have training and oversight from the manufacturer. Above ground components include a blower with housing (approximately 2'x 2' x 2'), and an electrical control panel with an audio and visual alarm. Designer should consider situating the blower to minimize possibility for noise disturbance. Alternately, the blower can be installed in a belowground vault. Alarm and panel box should be accessible for inspection and maintenance.

Actual and Manufacturer's Estimated Costs (3-bedroom home) and Labor
Non-Title 5 Components: $2,995 suggested retail, this model (claim).
Components + Installation: $3,500 more than conventional (claim).
Electrical: $337 per year actual (local rates, annual KWh= 3,273).
O&M: Quarterly inspection of motors, air flow, effluent and sludge. A service contract is required in Massachusetts (Approximately $400 per year minimum, but varies). Septic tank pumping averages $60 per year.
Other Costs: Quarterly effluent quality monitoring is required for some permits ($300 or more annually). Design and permitting costs vary.
Replacement: Blowers ($300) have a 2-year warranty by Bio-Microbics, extended 10 year warranty available, UL-CE-CSA certified electrical parts. No corrodible parts claimed to be in the unit.

Theory of Operation
The MicroFAST consists of a modified two-compartment 1500-gallon septic tank, where the first compartment of 500-gallon capacity is used for primary settling of the household wastewater. The second compartment contains the submerged plastic media around which air, supplied by a blower, is diffused. This technology uses both attached and suspended growth in the second chamber to achieve the nitrification of wastewater (*i.e.*, conversion of ammonium to nitrate) entering from the primary settling chamber. The recycling of a portion of the nitrified effluent back to the anoxic settling chamber makes possible the denitrification step of the process (*i.e.*, conversion of nitrate to nitrogen gas).

Permitting and Use in Massachusetts (*as of June 2001)*
Certification for General Use: MicroFAST is Certified for General Use and can be installed wherever a conventional Title 5 system can be installed. Remedial Use Approval: MicroFAST has approval in remedial situations where a system is failed, failing or nonconforming where relief is sought to construct an SAS within two feet (or three feet for percolation rates exceeding two minutes per inch) of the high groundwater elevation, or to construct an SAS reduced in size by up to 50 percent or in areas where at least 2 feet of suitable material is available beneath the SAS. Model 0.5 is approved for up to 440 gpd or four bedrooms. Provisional Use Approval: MicroFAST is approved for use in nitrogen sensitive areas for new construction for systems designed for less than 2000 gpd. For residential systems up to 660 gpd per acre, for nonresidential systems up to 550 gpd per acre. Model 0.5 is only approved for up to 330 gpd or three bedrooms.

Note: In this study, the model tested employed a 1/3 hp blower that operated continuously. The manufacturer is currently testing a unit with the blower with an on-off cycle to reduce electrical consumption. These results will be reported in the 2-year performance summary. The manufacturer has other models available, and their performance may not be identical to the results reported here.

Operation and Maintenance Issues

[This information will be included in the final report findings.].

Explanation of the Graphs

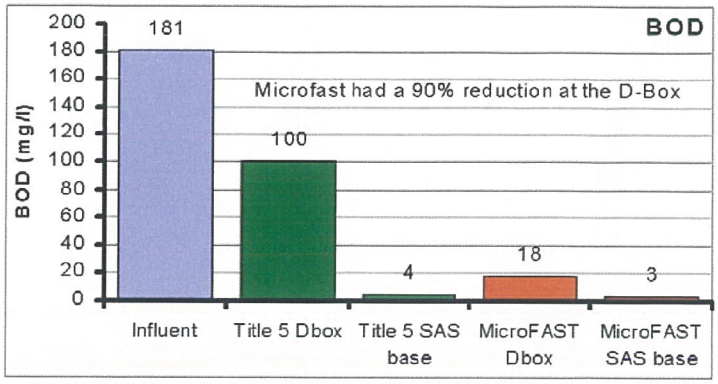
The graphs to the right show the mean of three replicates for each parameter over the testing period, compared to Title 5 performance and influent measured in parallel samples during the same period. Fecal coliform results are expressed as geometric means. In the nitrogen graph, NH4 represents ammonia, NOx represents nitrate + nitrite, DON is dissolved organic nitrogen, and PON is particulate organic nitrogen. Total nitrogen is the sum of these four parameters.

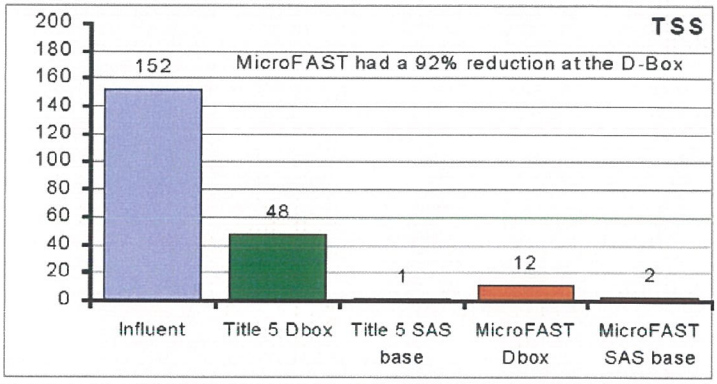
Soil absorption system samples include wastewater disposal system effluent and precipitation. The recharge of precipitation to groundwater is estimated to be between 8 and 16 percent of effluent discharge based on local rainfall, estimated groundwater recharge rates, SAS size and dosage rates. For all technologies, an interim dilution rate of 10 percent was employed based on precipitation and theoretical and measured dosage rates at the Test Center. The results for nitrogen removal include this estimated dilution factor (note bars labeled "SAS adj.") Results shown for biological oxygen demand (BOD), total suspended solids (TSS), and fecal coliforms were not adjusted for dilution by precipitation, because the adjustment was negligible in evaluating overall performance. This interim approach, is being compared to specific conductivity, chlorides, and bromide tracer to better refine this estimate, and develop system specific dilution factors. **Thus, the "SAS adjusted" values reported here for nitrogen discharge to groundwater should be considered preliminary.**

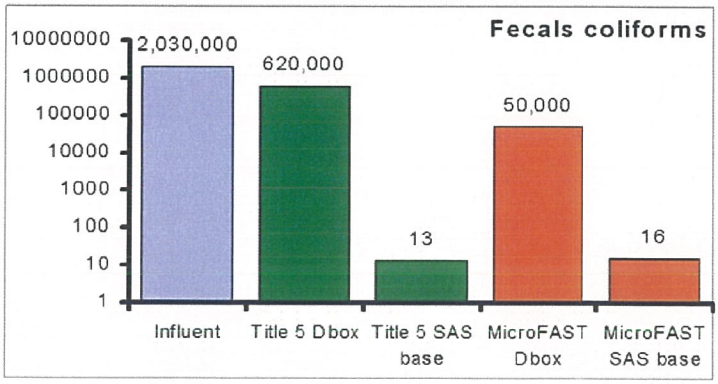
Summary of Interim Findings

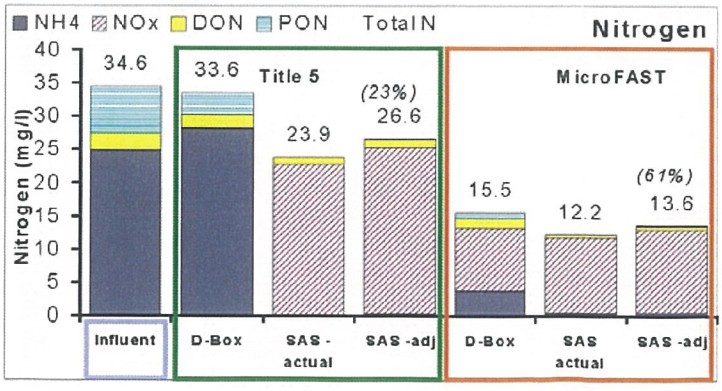
This technology exceeds secondary treatment (*i.e.*, TSS and BOD less than or equal to 30 mg per liter) to allow for the reduced separation to groundwater, or reduced soil absorption system size. BOD and TSS concentrations at the base of the SAS for this technology and the Title 5 system are similar. This technology discharged below the regulatory standard of 19 mg/l TN to allow for use in nitrogen sensitive areas. At the SAS base, this system was estimated to remove 60 percent of nitrogen inputs compared to 22 percent for a Title 5 system during the same period. This system was not tested at the Test Center for seasonal or intermittent use or for high hydraulic loading conditions.

The Technical Review Committee does not recommend adoption of nitrogen loading ratings for this technology until the two-year testing period is complete. Differences in nitrogen removal among technologies tested are not necessarily significant. Nitrogen removal performance may vary with soil types and other site differences. The Buzzards Bay Project will recommend nitrogen loading rates for this technology for planning purposes and watershed loading evaluations at a later date.









Funding for the Massachusetts Septic System Test Center was provided by the US EPA, through Cooperative Agreements x991657 and x981007, the Massachusetts Department of Environmental Protection (319-99-01, 319-00-02), Massachusetts Office of Coastal Zone Management, Massachusetts Environmental Trust, Barnstable County Department of Health and Environment, UMass Dartmouth SMAST, and other organizations. Other information on this initiative can be found at www.buzzardsbay.org. These fact sheets were reviewed by a multi-agency work group. The views or opinions expressed are not necessarily those of the Commonwealth of Massachusetts, the US EPA, or any of the funding organizations and agencies. The information presented here represents the technical findings of the Massachusetts Septic System Test Center after at least one year of system testing. Manufacturer claims of cost and longevity, warranties, or stated costs have not been verified. Modifications to system designs from those tested, or installation under other soil or climate conditions may result in different system performance. This fact sheet was prepared and printed by the Buzzards Bay Project.

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Jane Swift, Governor
Executive Office of Environmental Affairs
Bob Durand, Secretary
Buzzards Bay Project
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BIO-MICROBICS INCORPORATED

Bio-Microbics, Inc. • Ph: 913-422-0707 • Fax: 913-422-0808 • sales@biomicrobics.com

FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Halifax, Massachusetts
Unit Type: ModularFAST®
Application: Multi-Unit Residential Complex
Design Flow:

Date	BOD		TSS		FOG		NO3		NH3		TKN		TN	
	Influent	Effluent	Influent	Effluent	Influent	Effluent								
4/22/1998		7.3		12				16.2		2.04		4		20.2
5/19/1998		20.8		12.4				9.24		2.5		8		17.24
7/23/1998		13.5		8.6				14.6		0.37		2.5		17.1
9/15/1998		2.3		6				20		0.82		3.8		23.8
12/9/1998		9.1		8				16.8		0.61		3.3		20.1
3/4/1999	209	9	402	13.6			0.5	6.47	35.3	1.52	40	3.9	40.5	10.37
9/7/1999		8.3		7.6				1		1.25		3.5		4.5
11/27/2001	170	12.6	78.3	40	38.3	<1.2	0.16	7.12			46.9	2.8	47.15	9.92

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FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Sandwich, Massachusetts
Unit Type & Size: ModularFAST®
Application: Health Center
Design Flow: 2385 GPD

StartDate	Sample Date	Influent pH	Effluent pH	Influent BOD	Effluent BOD	Influent TSS	Effluent TSS	Influent TKN	Effluent TKN
11/21/00	2/27/01	8.9	7.5	28.1	4.2	24.2	11	38	7.8
	3/29/01		8.1	15.8	19.1	47.7	10.8	51	4.88
	4/26/01		8.4	140	5.6	81	<2	69	3.05
	5/24/01	8.5	8.2	123	12.2	44	7.5	92.7	6.4
	6/28/01		8	86	4.2	75.8	<2	47.9	13.5
	7/31/01		7.7	46.4	10.6	40.5	3	22.6	2.02
	10/2/01			78.6	9.7	34	3	24.5	1.9
	10/26/01			21	5.6	27.5	<2	19.1	1.87
	11/28/01		6.8	69	10	20.5	<2	18.8	1.3
	2/28/02	8.2	7.1	142	7.9	120	4.5	42.3	6.42
	5/31/02		6.3		5		<10		1.8

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FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Sherborn, Massachusetts
Unit Type & Size: ModularFAST®
Application: Clustered Residential
Design Flow: 4600 GPD

StartDate	Sample Date	Influent pH	Effluent pH	Influent BOD	Effluent BOD	Influent TSS	Effluent TSS	Influent TKN	Effluent TKN
2/8/00	5/22/00	7.7	7.20	162	22.9	344	11.20	36.6	10.70
	6/28/00	8.1	7.50	146	8.4	38.8	8.40	39	5.10
	8/17/00	7.3	7.50	140	<4.0	55.5	6.40	37.8	5.60
	9/26/00	7.1	7.60	261	10.2	89	6.00	46.1	8.50
	10/25/00	7.1	7.80	170	7.3	32.7	3.60	49.3	10.60
	2/16/01	7.3	7.80	255	11.2	668	5.60	65.3	30.60
	5/31/01	7.3	7.70	161	<4	31.3	<2	39.3	7.60
	8/9/01	7.3	7.80	147	6.6	34.7	2.50	37.2	5.72
	10/1/01				11		<10		13.00
	2/27/02	7.3	7.80	134	<4	54	2.00	46.3	25.90
	5/28/02	7.6	7.6	139	5.5	530	6.9	64	9

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FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Sudbury, Massachusetts
Unit Type & Size: ModularFAST®
Application: Clustered Residential
Design Flow: 6630 GPD

StartDate	Sample Date	Influent pH	Effluent pH	Influent BOD	Effluent BOD	Influent TSS	Effluent TSS	Influent TKN	Effluent TKN
12/3/01	12/27/01	7.3	7.8	160	9.2	40.7	4	47.4	35.7
	01/14/02	7.3	8.1	161	12	26	4.2	63.9	55
	02/28/02	7.4	7.3	234	31.6	280	21.3	44.3	10.8
	03/26/02	6.8	7.5	130	9	20	11	56	18
	04/23/02	7.5	7.5	210	8	67	<10	44	7
	05/22/02	7.1	7.1	28	3	16	<10	6.3	2.4
	06/26/02	7.2	7.5	29	27	27	18	11	8.4
	7/16/02	7.3	7.5	19	17	15	17	6.1	6

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FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Coonemesett Inn, Massachusetts
Unit Type & Size: 2 HighStrengthFAST® 9.0s
Application: Hotel & Restaurant
Design Flow: 15,000 GPD

Date	FOG		BOD		TSS		NO3		NH3		TKN		TN	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
8/9/1996		5		5.4		32		0.7		2.31		5.6		6.3
9/5/1996		5		<3.0		9		0.95		0.42		3.01		3.96
10/8/1996		5		25.5		8.4		1.14		<0.1		1.47		2.88
11/7/1996		5		14		18.8		0.92		<0.1		6.65		7.57
1/7/1997		5		10.2		24.2		2.05		0.42		2.94		4.99
2/5/1997		5		23.7		20		1.7		<0.1		7.91		9.61
3/5/1997		5		21.8		17		2.97		0.7		8.05		11
6/10/1997		5		18.1		13		0.8		1.09		4.86		5.68
9/10/1997		5		8.1		8.7		2.4		<0.1		1.6		4
7/29/1998		5		72		39.3		0.01		23.8		29.4		29.4
10/6/1998		5		7.5		29.4		1.3		0.87		3.77		5.07
1/12/1999		5		33		27.8		1.3		<0.2		9.4		10.7
4/27/1999		5		42.6		22.2		0.52		0.87		9.64		10.2
7/15/1999		5		44.2		46.7		<0.05		0.98		22.8		22.8
10/6/1999		5		58		154.3		1.38		1.47		11.8		13.2
Averages			600	29.13		31.39								

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FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Fuego, Washington
Unit Type & Size: HighStrengthFAST® 1.5
Application: Restaurant
Design Flow: 500 GPD

Date	BOD		TSS		FOG		NH3		TKN		TN	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
9/17/2003	700	19	80	19								
10/29/2003	1000	15	138	12	43.1	2.5						
11/21/2003	970	49	230	43	87	6.1						
12/27/2003	910	73	300	110	170	11						
Averages	895.00	39.00	187.00	46.00	100.03	6.53						

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FAST® Wastewater Treatment Systems - Field Data Summary

Installation Location: Littleton, Massachusetts
Unit Type & Size: ModularFAST®
Application: Grocery Store

		INFLUENT			EFFLUENT					
DATE	FLOW	BOD	TSS	TN	BOD	TSS	NO3-N	NH4-N	TN	TKN
	gpd	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
3/22/2000	12,570	433.0	550.0	92.0	6.0	5.0	1.0	0.8	1.6	0.6
4/19/2000	12,250	426.0	398.0	79.0	6.0	5.0	1.3	1.1	3.0	1.7
5/26/2000	11,150	345.0	474.0	114.0	6.0	5.0	1.4	1.0	1.4	0.0
6/29/2000	12,170	840.0	504.0	78.2	6.0	5.0	1.0	0.7	1.5	0.5
7/20/2000	10,740	555.0	592.0	93.2	6.0	5.0	1.0	0.8	1.5	0.5
8/24/2000	10,610	375	486	76.7	5.1	5.0	1	0.64	1.82	0.8
9/29/2000	9,920	450.0	650.0	104.0	6.0	5.0	1.0	<0.5	1.8	0.8
10/20/2000	9,570	540.0	568.0	108.5	6.0	5.0	1.9	0.6	4.2	2.3
11/21/2000	11,210	335	508	75.4	4.8	5.0	1	1.06	2.1	1.1
12/28/2000	12,210	401	400	83	6.0	5.0	1	1.2	1.92	0.9
1/30/2001	10,320	360	594	108	6.0	5.0	6.98	0.92	9.22	2.2
2/21/2001	10,100	198	584	104	6.0	5.0	1.13	1	3.26	2.1
3/23/2001	12,400	209	356	72.5	8.4	6.0	1	0.62	1.78	0.8
4/24/2001	9,190	237	520	96.3	6.2	5.0	1	0.72	2.14	1.1
5/18/2001	9,500	480	500	103	6.0	5.0	1	2.2	2.2	1.2
6/13/2001	9,510	215	524	101.8	6.6	5.0	1	0.92	3.1	2.1
7/12/2001	9,080	344	510	89	6.0	5.0	1	1.48	2	1.0
8/8/2001	7,770	372	376	95.8	11.3	5.0	1	1.32	2.55	1.6
9/5/2001	5,800	285	484	87.3	6.0	5.0	2.52	0.5	4.85	2.3
10/5/2001	6,900	390	582	122	6.0	5.0	1	1.8	2.3	1.3
11/7/2001	9,550	369	644	123	5.9	5.0	1	0.58	3.49	2.5
12/4/2001	9,820	452	539	90.4	6.0	5.0	1.14	1.06	2.2	1.1
1/9/2002	12,780	464	593	116	6.0	5.0	1	0.58	2.17	1.2
2/8/2002	12,550	273	496	104	6.0	5.0	1.71	1	3.94	2.2
3/7/2002	10,700	540	590	108	7.3	5.0	1	1.32	2.42	1.4
4/10/2002	11,570	353	592	116	9.9	5.0	1	1.4	2.32	1.3
5/8/2002	11,620	409	678	175	8.1	5.0	1	1	2.52	1.5
6/5/2002	11,840	216	448	103	6.0	5.0	1.28	1.04	4.23	3.0
7/17/2002	10,000	320	436	75.7	6.0	5.0	2.19	0.58	3.66	1.5
8/8/2002	10,030	327	514	66.8	6.0	5.0	1	0.5	2.15	1.2
9/11/2002	10,550	510	572	106.6	14.1	5.0	1	0.74	2	1.0
10/4/2002	8,160	434	474	81.4	6.0	5.0	2.21	0.66	4.18	2.0
11/8/2002	19,960	395	610	93.3	7.8	5.0	1	0.5	1.82	1.82
12/12/2002	8,250	342	506	101	6.0	5.0	1.41	1.47	3.33	
1/10/2003	15,190	401	572	123	6.0	8.0	1.11	0.5	2.86	1.75
2/5/2003	10,620	300	506	121	6.0	5.0	1	1.04	2.4	2.46
3/14/2003	11,390	352	704	135	7.2	5.0	1	0.5	1.85	1.85
4/9/2003	11,080	286	578	120	6.0	5.0	1	0.5	2.03	2.03
6/6/2003	12,670	358	442	105	6	5	1	1.58	2.01	2.01

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FAST® Wastewater Treatment Systems
Field Data Summary

Installation Location: Mashpee, MA
Unit Type & Size: 2 HSF 9.0
Application: Mashpee 99 Restaurant
Design Flow: 15,000 GPD

Date	BOD		TSS		NO3		NH3		TKN		TN	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
2/21/2003	890	55.8	800	18	<0.5	1.01			51.1	22.3	51.6	23.31
8/28/2001		19.4		6.5								
2/27/2001		91.5		15								
9/9/1999	11500	75	7820	87.5	1.46	1.04	71.3	26	132	40.8	133.46	41.84
2/12/1999	8010	41.7	9450	48	<0.5	<0.5	34.9	10.1	128	22.5	128.5	23
10/26/1998	2540	123	3320	256	0.5	<0.5	30.6	18.2	92.4	62	92.9	62.5
1/5/1998	5034	67.2	5470	104	<1.0	<1.0	33.3	14	188	28	189	29
3/18/1997	1500	68.3	667	18.5	2.74	11	56	8.25	90	24	92.74	35
Averages	4912	68	4588	69								

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FAST® Wastewater Treatment Systems - Field Data Summary

Installation Location: Plymouth, Massachusetts
Unit Type & Size: ModularFAST®
Application: Grocery Store
Design Flow: 4000 GPD

Date	BOD		TSS		FOG	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
10/5/1999	510	20	260	29	62	10
11/2/1999	780	11	65	38	54	9
11/11/1999	521	23	362	21		
12/6/1999	570	3	460	8	68	12
1/4/2000	930	34	520	24	51	9

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FAST® Wastewater Treatment Systems - Field Data Summary

Installation Location: Richmond, Rhode Island
Unit Type & Size: ModularFAST®
Application: Grocery Store
Design Flow: 4000 GPD

Date	BOD		TSS		FOG	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
11/11/1999	415	23	144	18		<0.1
11/17/1999	630	11	200	23	62	49
12/7/1999	590	32	180	56	55	29
1/3/2000	550	59	140	26	70	11

September 2003
03/08/WQPC-SWP

Environmental Technology Verification Report

Reduction of Nitrogen in Domestic Wastewater from Individual Residential Homes

Bio-Microbics, Inc.
RetroFAST® 0.375 System

Prepared by

NSF International

Under a Cooperative Agreement with

U.S. Environmental Protection Agency

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**BIOLOGICAL WASTEWATER TREATMENT – NITRIFICATION AND DENITRIFICATION FOR NITROGEN REDUCTION**	
APPLICATION:	**REDUCTION OF NITROGEN IN DOMESTIC WASTEWATER FROM INDIVIDUAL RESIDENTIAL HOMES**	
TECHNOLOGY NAME:	**RETROFAST® 0.375 SYSTEM**	
COMPANY:	**BIO-MICROBICS**	
ADDRESS:	**8450 COLE PARKWAY** **SHAWNEE, KS 66227**	**PHONE: (913) 422-0707** **FAX: (913) 422 0808**
WEB SITE:	http://www.biomicrobics.com	
EMAIL:	onsite@biomicrobics.com	

NSF International (NSF) operates the Water Quality Protection Center (WQPC) under the U.S. Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) Program. The WQPC evaluated the performance of a submerged attached-growth biological treatment system for nitrogen removal for residential applications. This verification statement provides a summary of the test results for the Bio-Microbics, Inc. RetroFAST® 0.375 System (RetroFAST®). NovaTec Consultants, Inc. (NovaTec) performed the verification testing.

EPA created the ETV Program to facilitate deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups consisting of buyers, vendor organizations, and permitters; and the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and verifiable quality are generated, and that the results are defensible.

NSF International
Ann Arbor, MI · Sacramento, CA · Washington, D.C. · Brussels, Belgium

Data Summary for BioMicrobics, Inc. RetroFAST 0.375 Under the EPA ETV Water Quality Protection Center

The following is a preliminary summary of the test results obtained for the BioMicrobics, Inc. RetroFAST 0.375 system for nutrient reduction under the ETV Water Quality Protection Center. These results have been QA reviewed, but will not be considered final until all EPA reviews have been completed. The testing was completed at the Mamquam Wastewater Technology Test Facility (British Columbia) during the period of September 2001 through October 2002. The data summarized below does not include data for November 2001 because of errors in testing. A full report for this testing will be completed soon and posted on the EPA (www.epa.gov/etv) and NSF (www.nsf.org/etv) web sites.

Table 1. BOD_5/$CBOD_5$ and TSS Data Summary

	BOD_5 Influent (mg/L)	$CBOD_5$ Effluent (mg/L)	Removal Percent	TSS Influent (mg/L)	TSS Effluent (mg/L)	Removal Percent
No. Samples	61	61		61	61	
Average	150	12	92	190	28	84
Median	140	12	92	170	23	88
Max	210	28	98	440	170	98
Min	60	2.0	79	110	3	14
Std. Dev.	29	5.9	7.4	59	25	15

Table 2. Nitrogen Data Summary

	TKN (mg/L)		Ammonia (mg/L)		Total Nitrogen (mg/L)		Nitrate (mg/L)	Nitrite (mg/L)
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Effluent	Effluent
No. Samples	61	61	61	61	61	61	59	58
Average	39	11	28	6.0	39	19	7.9	< 0.002
Median	37	6.6	28	3.7	37	18	9.0	< 0.002
Maximum	64	44	42	30	64	44	18	0.006
Minimum	28	1.7	19	0.2	28	6.4	0.1	< 0.002
Std. Dev.	8.9	10	4.0	6.9	8.9	7.6	5.0	0.002

NSF Contact: Thomas Stevens
(734) 769-5347
stevenst@nsf.org

Clifton Associates Ltd.
engineering science technology

Appendix B

CLIFTON ASSOCIATES LTD
ATTN: CINDY / SUMITH
4 - 1925 1ST AVE. NORTH
SASKATOON SK S7K 6W1

Date Received: 04-JUL-12
Report Date: 10-JUL-12 08:27 (MT)
Version: DRAFT REV. 3

Client Phone: 306-975-0401

Certificate of Analysis

Lab Work Order #: L1172891

Project P.O. #: NOT SUBMITTED
Job Reference: S1607.7
C of C Numbers: 10-208196, 10-208197
Legal Site Desc:

Comments:

10-JUL-12: BOD results forthcoming (11-July).

Brian Morgan
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-1 BH211							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	4.64	DLA	0.010	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.00444	DLA	0.00020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.352	DLA	0.00020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.035	DLA	0.020	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.000332	DLA	0.000020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.00745	DLA	0.00020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0060	DLA	0.0010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	6.69	DLA	0.020	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.00416	DLA	0.00010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	0.826	DLA	0.00060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	<0.00020	DLA	0.00020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.00520	DLA	0.000020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.0311	DLA	0.0060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	372		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	294		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	359		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	1.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.30		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	84.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	2.5		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	26.1		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	7.2		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	30.2		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.538		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.37	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	588		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	OVERGROWN		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-2 BH202							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	1.24	DLA	0.010	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.00346	DLA	0.00020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.0686	DLA	0.00020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.188	DLA	0.020	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.000081	DLA	0.000020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.00205	DLA	0.00020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0032	DLA	0.0010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	2.45	DLA	0.020	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.00150	DLA	0.00010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	0.695	DLA	0.00060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	<0.00020	DLA	0.00020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0270	DLA	0.000020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.0134	DLA	0.0060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	55.8		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	383		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	467		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	5.0		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.22		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	127		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	6.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	54.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	66.0		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	263		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	0.082		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.574		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.19	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	1150		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	OVERGROWN		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-3 BH201							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	10.5	DLA	0.010	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0103	DLA	0.00020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.709	DLA	0.00020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.060	DLA	0.020	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.000302	DLA	0.000020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.0155	DLA	0.00020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0278	DLA	0.0010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	16.4	DLA	0.020	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.0257	DLA	0.00010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	0.998	DLA	0.00060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.00072	DLA	0.00020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0276	DLA	0.000020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.0910	DLA	0.0060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	424		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	296		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	361		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	6.7		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.20		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	88.8		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	3.4		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	25.7		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	15.8		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	35.9		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.602		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.28	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	639		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	890		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-4 BH208							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	8.33	DLA	0.010	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0119	DLA	0.00020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.834	DLA	0.00020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.025	DLA	0.020	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.000332	DLA	0.000020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.0125	DLA	0.00020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0158	DLA	0.0010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	17.7	DLA	0.020	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.0134	DLA	0.00010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	1.89	DLA	0.00060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.00800	DLA	0.00020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.00397	DLA	0.000020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.0691	DLA	0.0060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	1340		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	341		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	417		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	7.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	<0.10		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	140		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	4.7		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	32.5		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	16.5		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	139		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.0057		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	7.10		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	7.12		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.24	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	920		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-5 BH203							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	150	DLA	0.10	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.268	DLA	0.0020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	23.1	DLA	0.0050	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.23	DLA	0.20	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.0108	DLA	0.00020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.265	DLA	0.0020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.319	DLA	0.010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	430	DLA	0.20	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.383	DLA	0.0010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	29.6	DLA	0.0060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.0069	DLA	0.0020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0256	DLA	0.00020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	1.78	DLA	0.060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	>4000		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	314		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	383		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	40.6		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.20		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	173		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	7.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	53.7		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	44.7		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	186		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.0895		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	51.0		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	0.276		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	51.3		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.51	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	1420		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-6 BH210							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	58.9	DLA	0.050	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0779	DLA	0.0010	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	4.80	DLA	0.0010	mg/L		09-JUL-12	R2395195
Boron (B)-Total	<0.10	DLA	0.10	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.00282	DLA	0.00010	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.0978	DLA	0.0010	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.160	DLA	0.0050	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	175	DLA	0.10	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.162	DLA	0.00050	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	4.12	DLA	0.0030	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.0195	DLA	0.0010	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.00942	DLA	0.00010	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.631	DLA	0.030	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	>4000		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	224		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	274		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	5.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	<0.10		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	63.4		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	2.3		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	14.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	5.4		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	18.0		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	0.035		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.113		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	0.61		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	0.065		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	0.67		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.33	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	443		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
L1172891-7 BH204							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-7 BH204							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	8.21	DLA	0.010	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0164	DLA	0.00020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.683	DLA	0.00020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.052	DLA	0.020	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.000624	DLA	0.000020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.0131	DLA	0.00020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0172	DLA	0.0010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	21.1	DLA	0.020	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.0190	DLA	0.00010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	1.12	DLA	0.00060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.00034	DLA	0.00020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.00163	DLA	0.000020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.0736	DLA	0.0060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	>4000		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	282		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	344		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	3.4		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	<0.10		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	89.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	10.5		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	35.8		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	9.4		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	104		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.297		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.59	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	711		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	30		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
L1172891-8 CAL104							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-8 CAL104							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	37.4	DLA	0.050	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0516	DLA	0.0010	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	2.75	DLA	0.0010	mg/L		09-JUL-12	R2395195
Boron (B)-Total	<0.10	DLA	0.10	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.00138	DLA	0.00010	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.0615	DLA	0.0010	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0629	DLA	0.0050	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	89.0	DLA	0.10	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.0727	DLA	0.00050	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	1.29	DLA	0.0030	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.0023	DLA	0.0010	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0134	DLA	0.00010	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.401	DLA	0.030	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	1740		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	227		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	277		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	7.4		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.23		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	73.4		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	4.0		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	28.8		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	29.2		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	112		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.0309		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.46	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	651		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	190		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-9 BH205							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	72.6	DLA	0.10	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0629	DLA	0.0020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	3.20	DLA	0.0020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	<0.20	DLA	0.20	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.00179	DLA	0.00020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.115	DLA	0.0020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.149	DLA	0.010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	160	DLA	0.20	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.118	DLA	0.0010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	2.78	DLA	0.0060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.0096	DLA	0.0020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0265	DLA	0.00020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.667	DLA	0.060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	613		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	294		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	359		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	5.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.22		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	106		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	2.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	30.9		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	7.7		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	95.3		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.163		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	0.72		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	0.110		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	0.83		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.66	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	721		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	70		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-10 BH213							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	0.586	DLA	0.010	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.00213	DLA	0.00020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.136	DLA	0.00020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.038	DLA	0.020	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.000025	DLA	0.000020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.00127	DLA	0.00020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.0021	DLA	0.0010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	1.25	DLA	0.020	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.00085	DLA	0.00010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	0.617	DLA	0.00060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	<0.00020	DLA	0.00020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.00284	DLA	0.000020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.0080	DLA	0.0060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	13.5		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	190		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	231		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	2.3		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.20		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	76.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	3.1		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	21.3		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	8.6		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	95.5		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.526		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.52	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	550		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	OVERGROWN		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-11 BH206							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	88.0	DLA	0.10	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0756	DLA	0.0020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	4.93	DLA	0.0020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	<0.20	DLA	0.20	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.00491	DLA	0.00020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.147	DLA	0.0020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.200	DLA	0.010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	207	DLA	0.20	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.177	DLA	0.0010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	5.50	DLA	0.0060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	<0.0020	DLA	0.0020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0300	DLA	0.00020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.974	DLA	0.060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	>4000		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	423		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	516		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	1.8		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.14		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	110		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	3.4		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	41.7		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	7.6		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	18.3		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.184		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.49	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	786		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	40		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-12 BH207							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	0.76	DLA	0.10	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0023	DLA	0.0020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	0.0412	DLA	0.0020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	0.43	DLA	0.20	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	<0.00020	DLA	0.00020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	<0.0020	DLA	0.0020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	<0.010	DLA	0.010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	1.47	DLA	0.20	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.0013	DLA	0.0010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	0.247	DLA	0.0060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	<0.0020	DLA	0.0020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.195	DLA	0.00020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	<0.060	DLA	0.060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	134		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	508		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	620		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	98	DLA	20	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.32		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	467	DLA	10	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	51	DLA	10	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	817	DLA	10	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	1180	DLA	20	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	6240	DLA	30	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.254		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	0.058		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.39	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	8800		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	210		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-13 BH212							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	79.6	DLA	0.10	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0811	DLA	0.0020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	2.64	DLA	0.0020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	<0.20	DLA	0.20	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.00247	DLA	0.00020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.132	DLA	0.0020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.178	DLA	0.010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	178	DLA	0.20	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.115	DLA	0.0010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	4.37	DLA	0.0060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.0099	DLA	0.0020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0159	DLA	0.00020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.685	DLA	0.060	mg/L		09-JUL-12	R2395195
Miscellaneous Parameters							
Turbidity	>4000		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	374		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	456		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	9.1		1.0	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.21		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	109		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	5.5		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	35.2		1.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	27.5		2.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	87.7		3.0	mg/L	05-JUL-12	05-JUL-12	R2393328
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	0.070		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.386		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	<0.050		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.58	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	834		10	uS/cm	05-JUL-12	05-JUL-12	R2392988
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	10		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	10		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-14 DUP 2							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Health and Toxicity Metals							
Total Mercury in Water by CRC ICPMS							
Mercury (Hg)-Total	<0.000050		0.000050	mg/L		06-JUL-12	R2393822
Total Metals in Water by CRC ICPMS							
Aluminum (Al)-Total	89.5	DLA	0.10	mg/L		09-JUL-12	R2395195
Arsenic (As)-Total	0.0881	DLA	0.0020	mg/L		09-JUL-12	R2395195
Barium (Ba)-Total	3.04	DLA	0.0020	mg/L		09-JUL-12	R2395195
Boron (B)-Total	<0.20	DLA	0.20	mg/L		09-JUL-12	R2395195
Cadmium (Cd)-Total	0.00273	DLA	0.00020	mg/L		09-JUL-12	R2395195
Chromium (Cr)-Total	0.147	DLA	0.0020	mg/L		09-JUL-12	R2395195
Copper (Cu)-Total	0.201	DLA	0.010	mg/L		09-JUL-12	R2395195
Iron (Fe)-Total	203	DLA	0.20	mg/L		09-JUL-12	R2395195
Lead (Pb)-Total	0.138	DLA	0.0010	mg/L		09-JUL-12	R2395195
Manganese (Mn)-Total	4.95	DLA	0.0060	mg/L		09-JUL-12	R2395195
Selenium (Se)-Total	0.0098	DLA	0.0020	mg/L		09-JUL-12	R2395195
Uranium (U)-Total	0.0181	DLA	0.00020	mg/L		09-JUL-12	R2395195
Zinc (Zn)-Total	0.771	DLA	0.060	mg/L		09-JUL-12	R2395195
L1172891-15 DUP 1							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Miscellaneous Parameters							
Turbidity	927		0.10	NTU		06-JUL-12	R2393860
Routine Potable Water							
Alkalinity, Total							
Alkalinity, Total (as CaCO3)	512		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Bicarbonate (HCO3)	625		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Hydroxide (OH)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Carbonate (CO3)	<5.0		5.0	mg/L	05-JUL-12	05-JUL-12	R2393108
Chloride (Cl)							
Chloride (Cl)	101	DLA	20	mg/L	05-JUL-12	05-JUL-12	R2393031
Fluoride (F)							
Fluoride (F)	0.31		0.10	mg/L	05-JUL-12	05-JUL-12	R2393297
ICP Cations							
Calcium (Ca)	459	DLA	10	mg/L	05-JUL-12	05-JUL-12	R2393328
Potassium (K)	51	DLA	10	mg/L	05-JUL-12	05-JUL-12	R2393328
Magnesium (Mg)	815	DLA	10	mg/L	05-JUL-12	05-JUL-12	R2393328
Sodium (Na)	1160	DLA	20	mg/L	05-JUL-12	05-JUL-12	R2393328
Sulfur (as SO4)	6400	DLA	30	mg/L	05-JUL-12	05-JUL-12	R2393328
Ion Balance Calculation							
Cation - Anion Balance	-1.6			%		05-JUL-12	
TDS (Calculated)	9290			mg/L		05-JUL-12	
Hardness (as CaCO3)	4500			mg/L		05-JUL-12	
Iron (Fe) & Manganese (Mn) -Dissolved							
Iron (Fe)-Dissolved	<0.030		0.030	mg/L	05-JUL-12	05-JUL-12	R2393310
Manganese (Mn)-Dissolved	0.244		0.0010	mg/L	05-JUL-12	05-JUL-12	R2393310
Nitrate, Nitrite and Nitrate+Nitrite-N							
Nitrate-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrite-N	0.080		0.050	mg/L	05-JUL-12	05-JUL-12	R2393099
Nitrate+Nitrite-N	<0.50		0.50	mg/L	05-JUL-12	05-JUL-12	R2393099
pH and Conductivity							
pH	7.42	EHT	0.10	pH	05-JUL-12	05-JUL-12	R2392988
Conductivity (EC)	8800		10	uS/cm	05-JUL-12	05-JUL-12	R2392988

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1172891-15 DUP 1							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
L1172891-16 DUP 3							
Sampled By: CLIENT on 04-JUL-12							
Matrix: WATER							
Total Coliform, EColi Mcoli Blue & HPC							
Escherichia Coli mcoli blue MF							
E. Coli	<1		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258
Heterotrophic Plate Count							
Heterotrophic Plate Count	>3000		10	CFU/mL	06-JUL-12	08-JUL-12	R2394461
Total Coliform mcoli blue MF							
Total Coliforms	OVERGROWN		1	CFU/100mL	06-JUL-12	07-JUL-12	R2394258

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
EHT	Exceeded Recommended Holding Time Prior To Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TOT-SK	Water	Alkalinity, Total	APHA 2320 B-Auto-Pot. Titration

Alkalinity is determined by a titration of an aliquot with standardized acid solution to a pH of 4.5. Total alkalinity, bicarbonate, carbonate(if present) and hydroxide(if present) also reported.

Reference
Greenberg, Arnold E., Cleseri, Lenore S., Eaton, Andrew D., Standard Methods For The Examination of Water and Wastewater, 18th Edition, 1992, Method 2320B.

CL-SK	Water	Chloride (Cl)	APHA 4500-CL E

Chloride in aqueous matrices is determined colorimetrically by auto-analyzer.

EC-MCOLIMF-WP	Water	Escherichia Coli mcoli blue MF	APHA 9222B AND HACH 10029

This procedure is applicable to E. coli analysis for water samples. It is also used for Total Coliform analysis when only one 100 mL samples is submitted for both Total Coliforms and E. coli. If two sample bottles are submitted for these analyses, E. coli analysis is performed by this procedure, and Total Coliform analysis can be performed by A151.

A suitable sample volume is poured through a membrane filter and placed in a petri dish prepared with m-Coli Blue 24 broth. The inverted plates are incubated at 35C +/- 0.5C for 24hrs. Coliforms that are not E. coli turn red because they reduce TTC (2,3,5 triphenyltetrazolium chloride) in the medium. E. coli turn blue due to the reaction between the enzyme beta glucuronidase and BCIG (5-bromo-4 chloro-3 indolyl-beta-D-glucuronide) in the medium.

ETL-ROUTINE-ICP-SK	Water	ICP Cations	APHA 3120 B-ICP-OES-ROU

These ions are determined directly y ICP-OES.

Reference
Greenberg, Arnold E., Cleseri, Lenore S., Eaton, Andrew D., Standard Methods For The Examination of Water and Wastewater, 18th Edition, 1992, Method 3120B.

F-SK	Water	Fluoride (F)	APHA 4500-F C

The quantity of free fluoride is determined by inserting a fluoride ion selective electrode into solution and measuring the potential. Samples and standards are mixed beforehand at a 1:1 ratio with a low-level TICAB solution, which frees up any complexed fluoride ions.

Reference:
Greenberg, Arnold E., Cleseri, Lenore S., Eaton, Andrew D., Standard Methods For The Examination of Water and Wastewater, 18th Edition, 1992, Method 4500-F C

FE,MN-DIS-SK	Water	Iron (Fe) & Manganese (Mn) -Dissolved	APHA 3120 B-ICP-OES

Iron and Manganese are determined in a filtered and preserved sample by ICP-OES.

HG-T-CVAF-SK	Water	Total Mercury in Water by CRC ICPMS	APHA 3030E / EPA 245.7

This procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry

HPC-PP-WP	Water	Heterotrophic Plate Count	APHA 9215B, 2005

This is a procedure for estimating the number of live heterotrophic bacteria in water and measuring changes during water treatment and distribution or in swimming pools. In the pour plate method, samples are diluted and plated on to media. After incubation, the colonies are counted and reported as CFU/mL.

IONBALANCE-OP03-SK	Water	Ion Balance Calculation	APHA 1030-E
MET-T-CCMS-SK	Water	Total Metals in Water by CRC ICPMS	APHA 3030E / EPA 6020A

This procedure involves preliminary digestion with concentrated nitric acid followed by instrumental analysis using collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

N2/N3-SK	Water	Nitrate, Nitrite and Nitrate+Nitrite-N	APHA 4500 NO3F

Nitrate is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl)ethylenediamine dihydrochloride. The resulting

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

water-soluble dye has a magenta color, which is measured at 520nm. Original nitrite can also be determined by removing the cadmium column and following the same procedure. Nitrate-N, Nitrite-N and NO3+NO2-N are reported.

Reference
Greenberg, Arnold E., Cleseri, Lenore S., Eaton, Andrew D., Standard Methods For The Examination of Water and Wastewater, 18th Edition, 1992, Method 4500NO3-F.

PH/EC-SK	Water	pH and Conductivity	APHA 4500-H, 2510
TC-MCOLIMF-WP	Water	Total Coliform mcoli blue MF	APHA 9222B and HACH 10029

This procedure is applicable to E. coli analysis for water samples. It is also used for Total Coliform analysis when only one 100 mL samples is submitted for both Total Coliforms and E. coli. If two sample bottles are submitted for these analyses, E. coli analysis is performed by this procedure, and Total Coliform analysis is performed by A151.

A suitable sample volume is poured through a membrane filter and placed in a petri dish prepared with m-Coli Blue 24 broth. The inverted plates are incubated at 35C +/- 0.5C for 24hrs. Coliforms that are not E. coli turn red because they reduce TTC (2,3,5 triphenyltetrazolium chloride) in the medium. E. coli turn blue due to the reaction between the enzyme beta glucuronidase and BCIG (5-bromo-4 chloro-3 indolyl-beta-D-glucuronide) in the medium.

TURBIDITY-ED	Water	Turbidity	APHA 2130 B-Nephelometer

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
ED	ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

10-208196 10-208197

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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ALS Environmental

L1172891-COFC

Page ____ of ____

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company:	Clifton Associates Ltd.	Standard: ✓	Other (specify):	Regular (Standard Turnaround Times - Business Days)
Contact:	Sumith or Cindy	Select: PDF ✓	Excel Digital Fax	Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	4-1925 1st Avenue N	Email 1:	Sumith_kahanda@clifton.ca	✓ Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Saskatoon, SK, S7K 6W1	Email 2:	Cindy_Friesen@clifton.ca	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	975-0401 Fax: 975 1076			

Invoice To	Same as Report ? (circle) (Yes) or No (if No, provide details)	Client / Project Information	
	Copy of Invoice with Report? (circle) (Yes) or No	Job #:	51607-7
Company:		PO / AFE:	
Contact:		LSD:	
Address:			
Phone:	Fax:	Quote #:	

Lab Work Order # (lab use only)		ALS Contact:	Sampler:

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Routine - Portable/Lab	TC, EC/QSI	HPC - mF	BOD	Metal - Health - Par							Number of Containers
1	BH 211	July 04 12		Water	✓	✓	✓	✓	✓							4
2	BH 202	"		"	✓	✓	✓	✓	✓							4
3	BH 201	"		"	✓	✓	✓	✓	✓							4
4	BH 208	"		"	✓	✓	✓	✓	✓							4
5	BH 203	"		"	✓	✓	✓	✓	✓							4
6	BH 210	"		"	✓				✓							2
7	BH 204	"		"	✓	✓	✓	✓	✓							4
8	CAL 104	"		"	✓	✓	✓	✓	✓							4
9	BH 205	"		"	✓	✓	✓	✓	✓							4
10	BH 213	"		"	✓	✓	✓	✓	✓							4
11	BH 206	"		"	✓	✓	✓	✓	✓							4
12	BH 207	"		"	✓	✓	✓	✓	✓							4

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
K Smith	July 04, 2012		A. Brown	04-Jul-12	18:25	8 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION | WHITE - LABORATORY COPY | YELLOW - CLIENT COPY | GENF 18.01 Front

10- 208197

ALS Environmental

L1172891-COFC

Page ____ of ____

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company:	Clifton Associates Ltd	Standard: ✓	Other (specify):		Regular (Standard Turnaround Times - Business Days)
Contact:		Select: PDF ✓	Excel ____ Digital ____ Fax ____		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:		Email 1:	Symith_kahanda@clifton.ca	X	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	Cindy_friesen@clifton.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	Fax:			Analysis Request	
Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)	Client / Project Information		(Indicate Filtered or Preserved, F/P)	
	Copy of Invoice with Report? (circle) Yes or No	Job #:			
Company:		PO / AFE:			
Contact:		LSD:			
Address:					
Phone:	Fax:	Quote #:			
Lab Work Order # (lab use only)		ALS Contact:	Sampler:		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Routine - Potable	TC, EC/QSY	HPC-MF	BOD	Metal+Health+TDS	Number of Containers
13	BH 212	July04,201		Water	✓	✓	✓	✓	✓	4
14	Dup 2	"		"					✓	1
15	Dup 1	"		"	✓					1
16	Dup 3	"		"		✓	✓			1
17	Dup 04	"		"				✓		1

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
[signature]	July04 2012		A. Brown	04-Jul-12	18:25	8 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION | WHITE - LABORATORY COPY | YELLOW - CLIENT COPY | GENF 18.01 Front

Clifton Associates Ltd.
engineering science technology

Appendix C

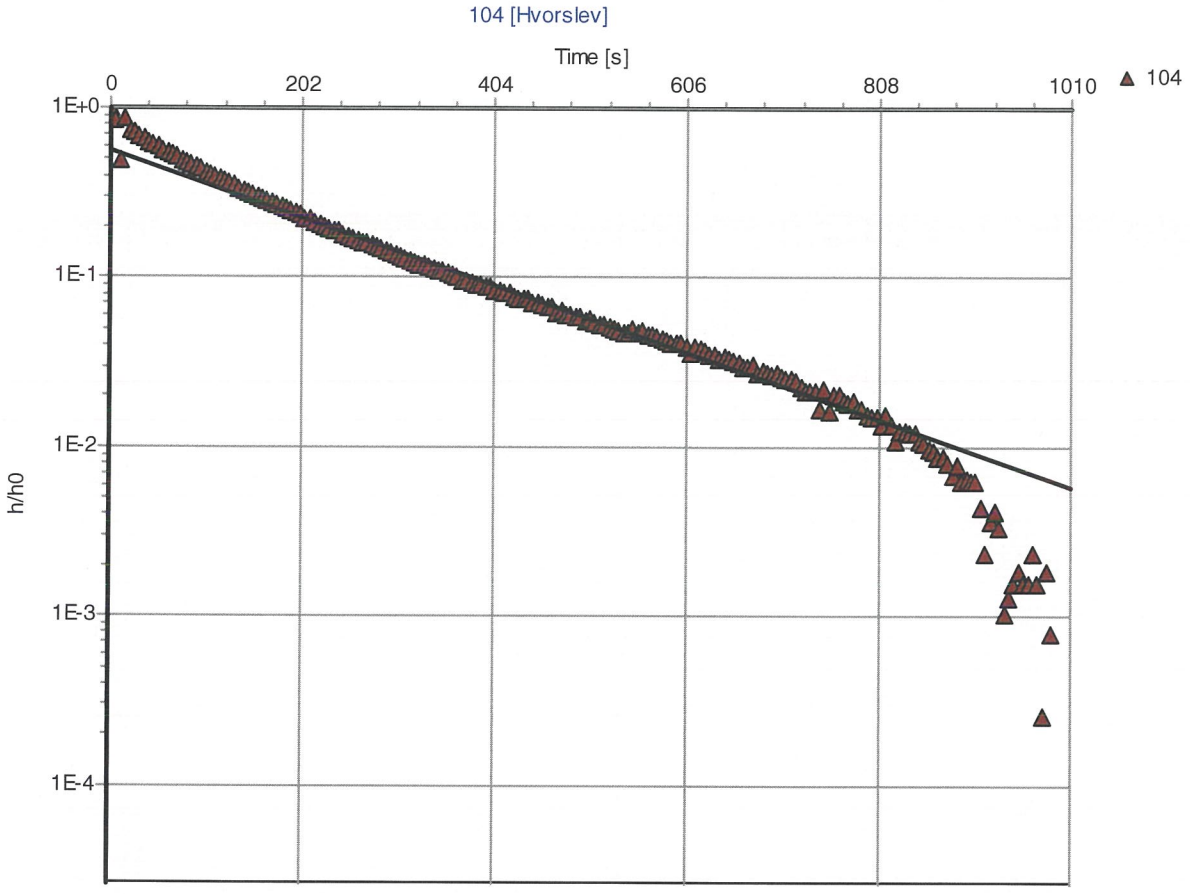
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **104**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 3.28E-6 [m/s]

Test parameters:

Test Well:	104	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	1.524 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by:

Evaluation Date: 16/07/2012

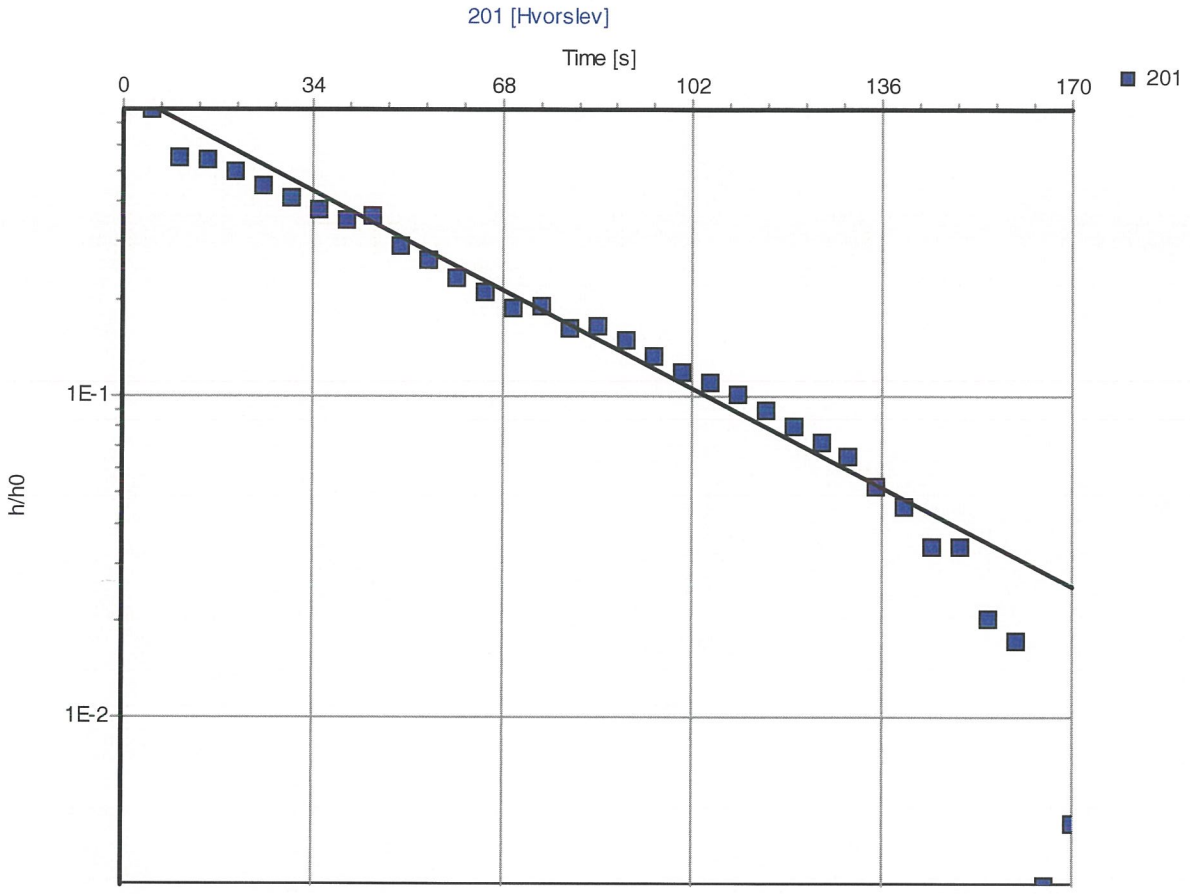
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **201**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.12E-5 [m/s]

Test parameters:

Test Well:	201	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	2.3 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 06/07/2012

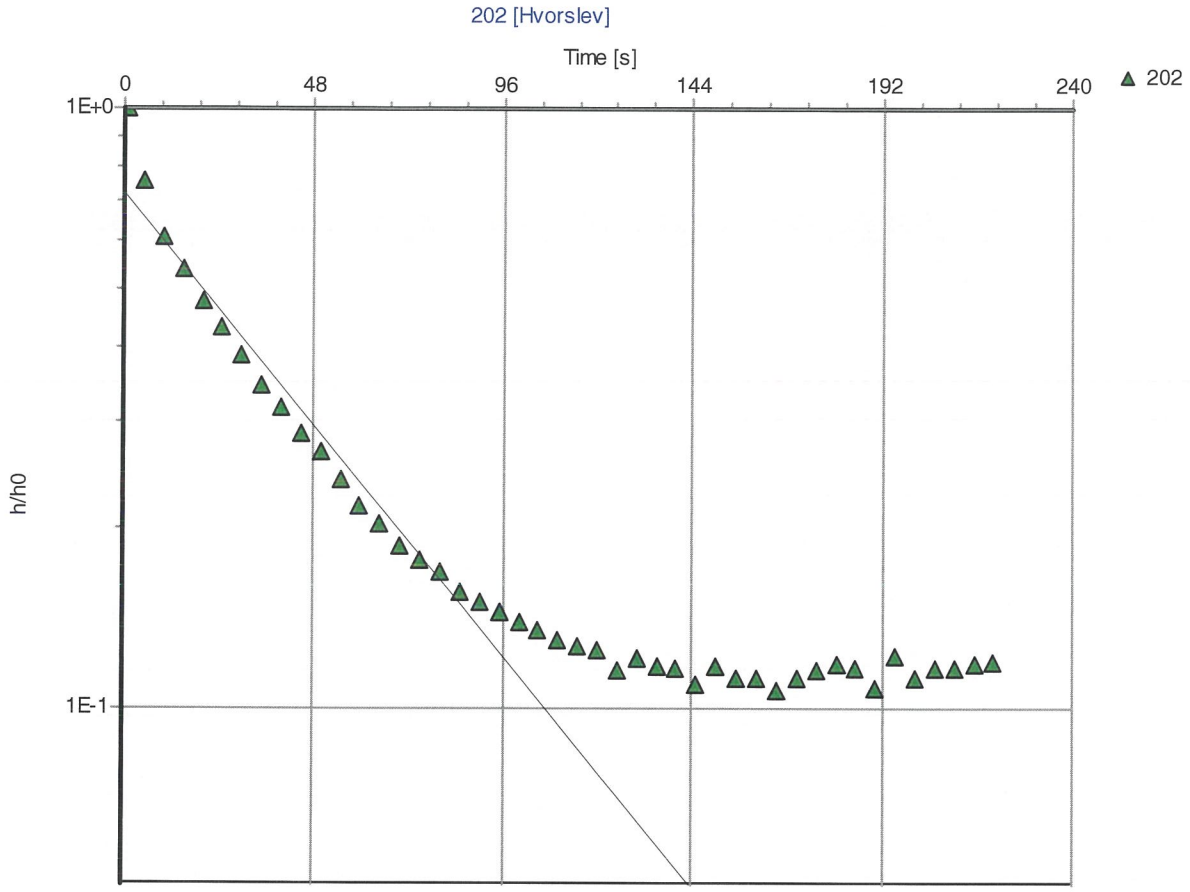
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **202**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 6.57E-6 [m/s]

Test parameters:

Test Well:	202	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	4 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 16/07/2012

Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
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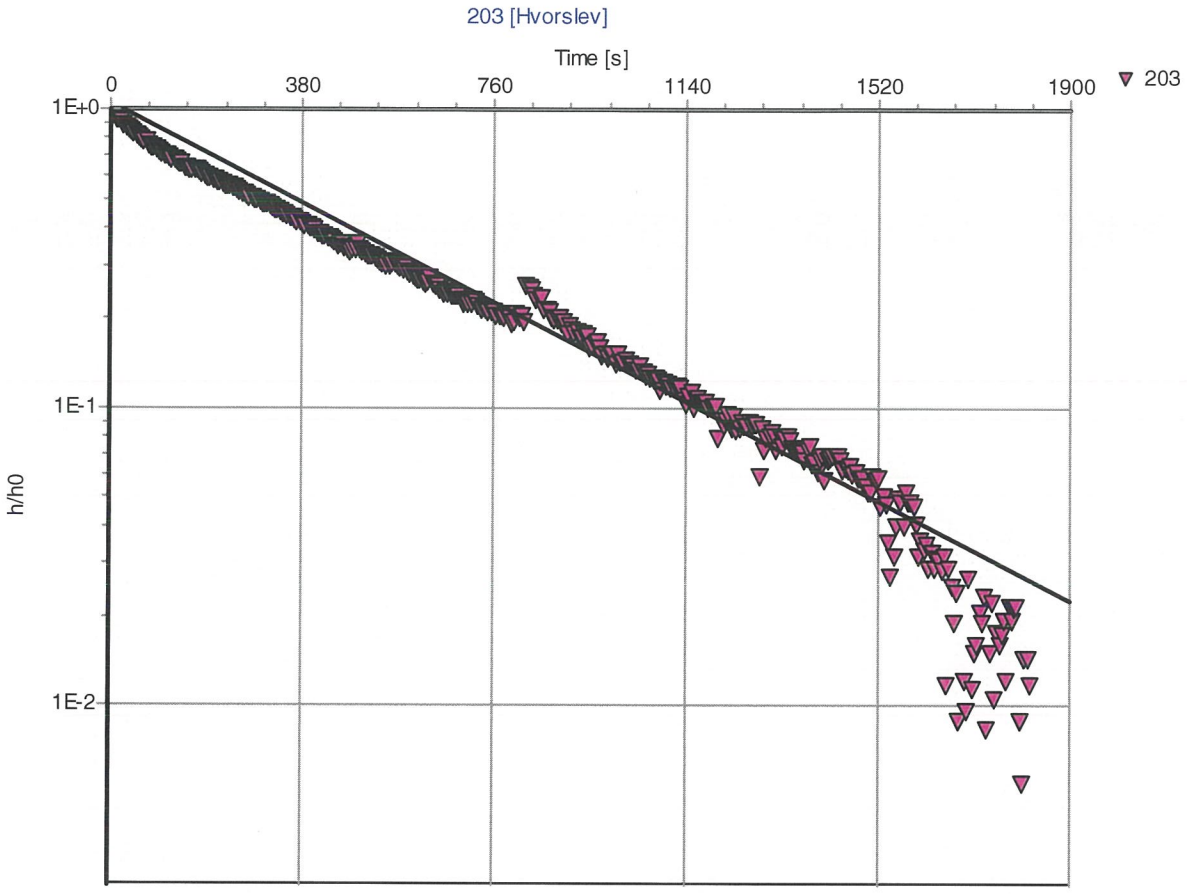
Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **203**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.21E-6 [m/s]

Test parameters:

Test Well:	203	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	2 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 16/07/2012

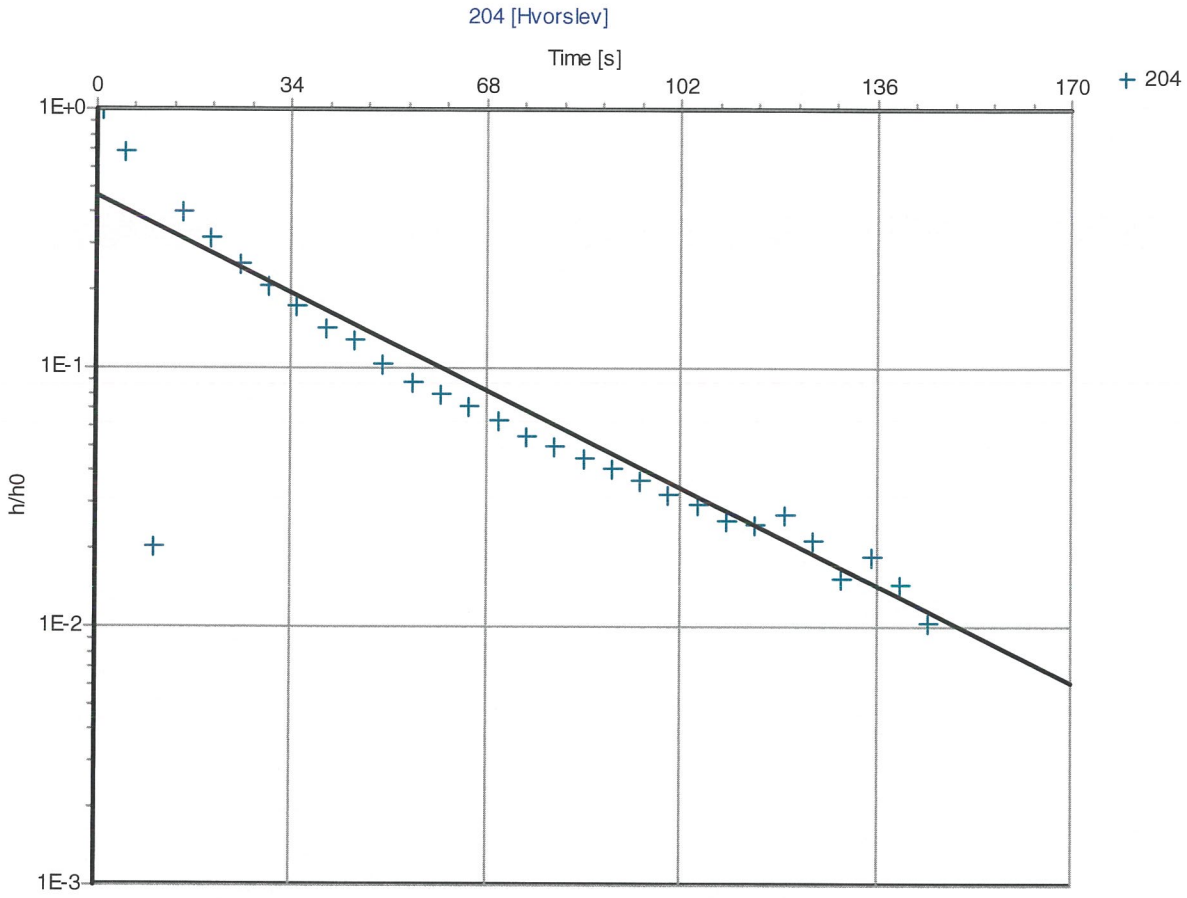
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **204**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.52E-5 [m/s]

Test parameters:

Test Well:	204	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	2 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 16/07/2012

Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
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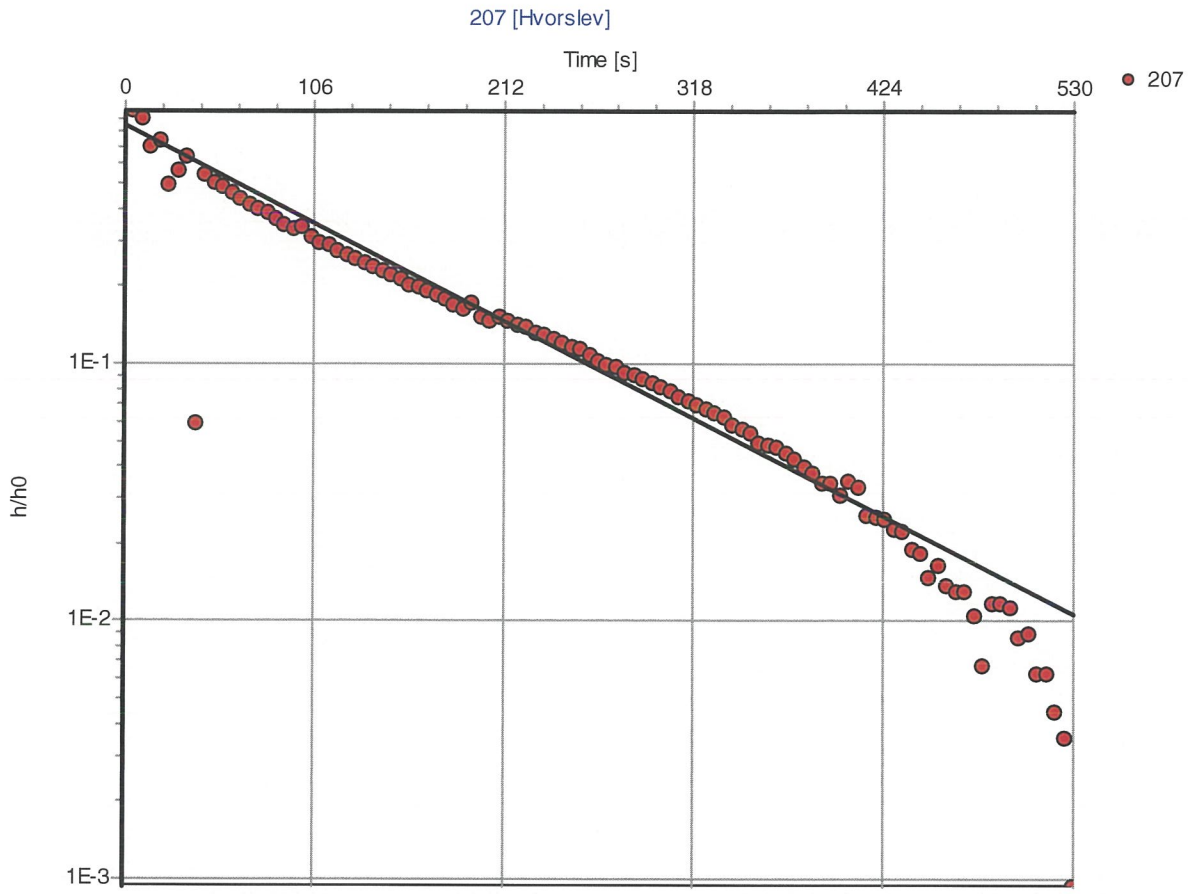
Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **207**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 4.53E-6 [m/s]

Test parameters:

Test Well:	207	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	1.9 [m]	
Boring radius:	0.0762 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 06/07/2012

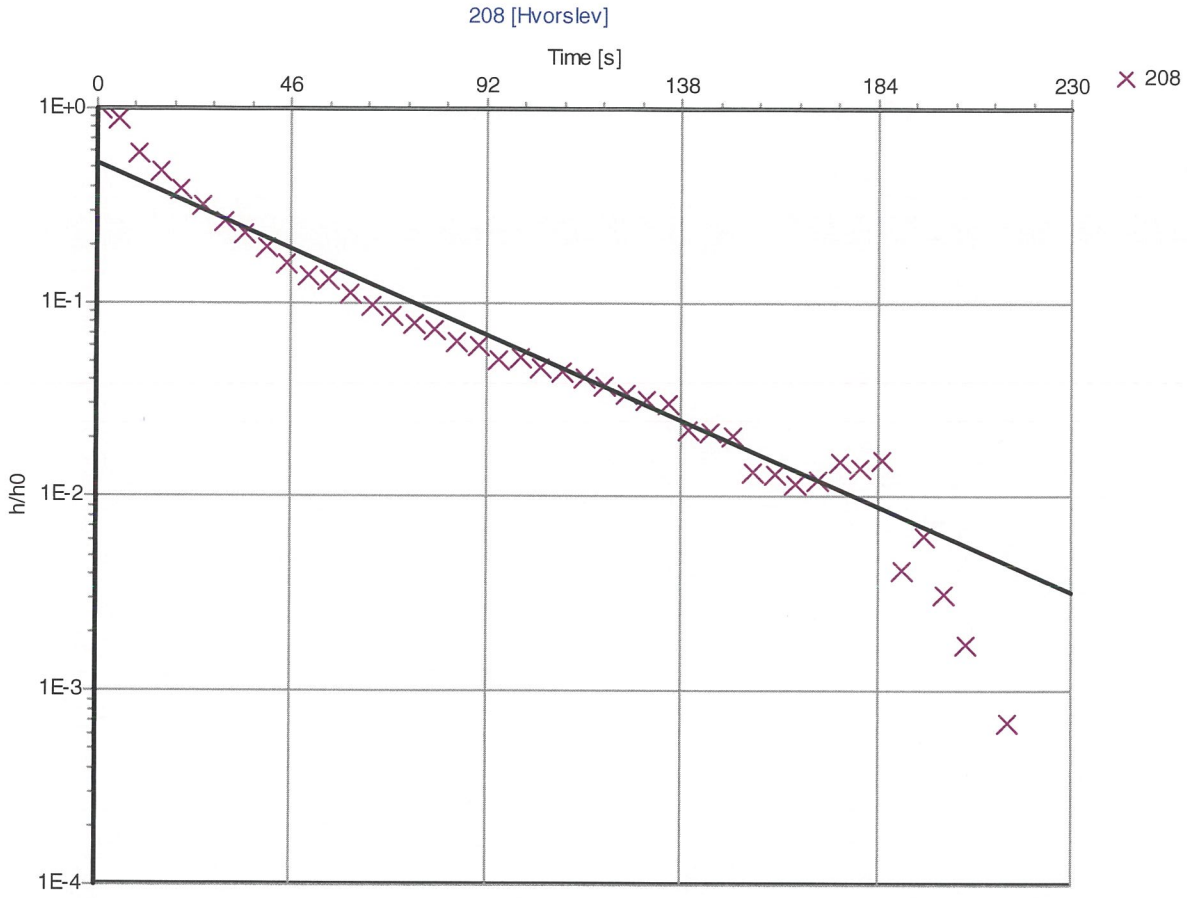
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **208**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.32E-5 [m/s]

Test parameters:

Test Well:	208	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	2 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 16/07/2012

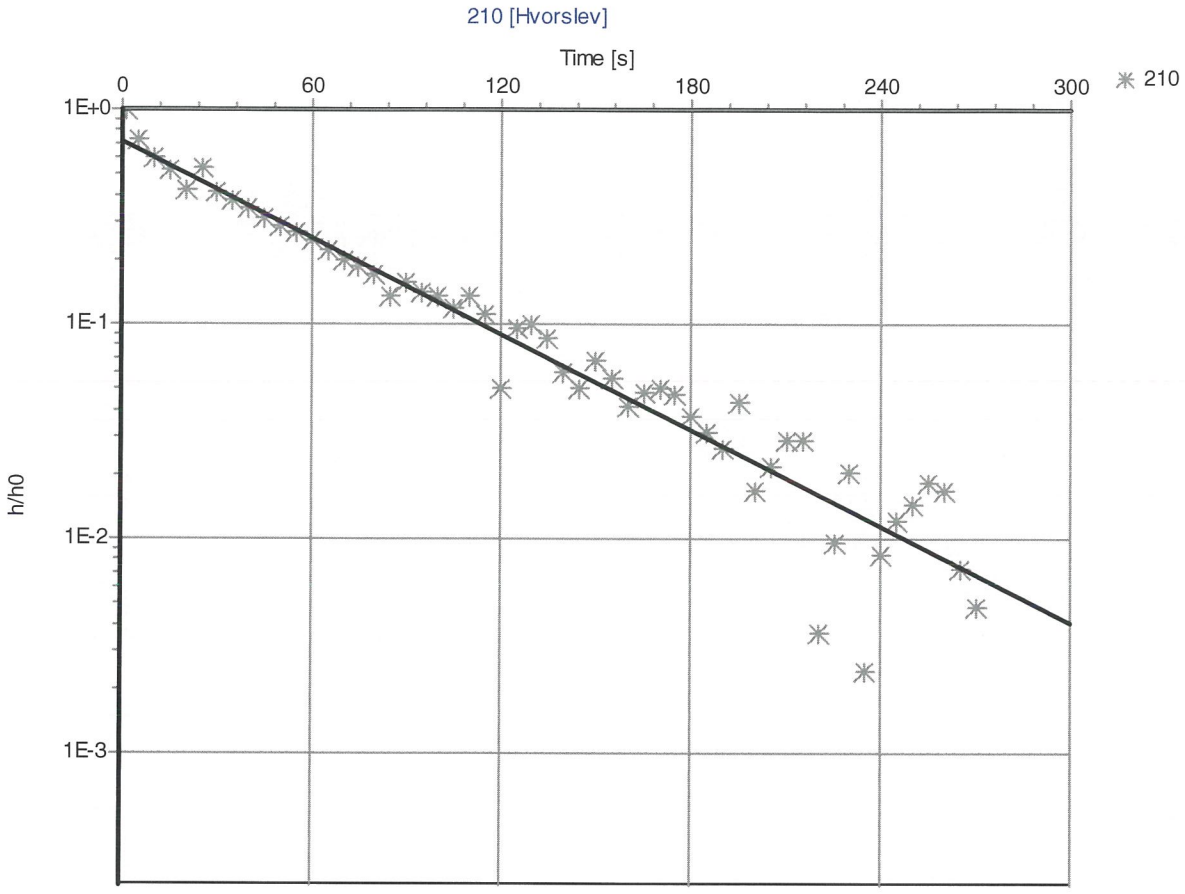
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **210**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.13E-5 [m/s]

Test parameters:

Test Well:	210	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	1.75 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 16/07/2012

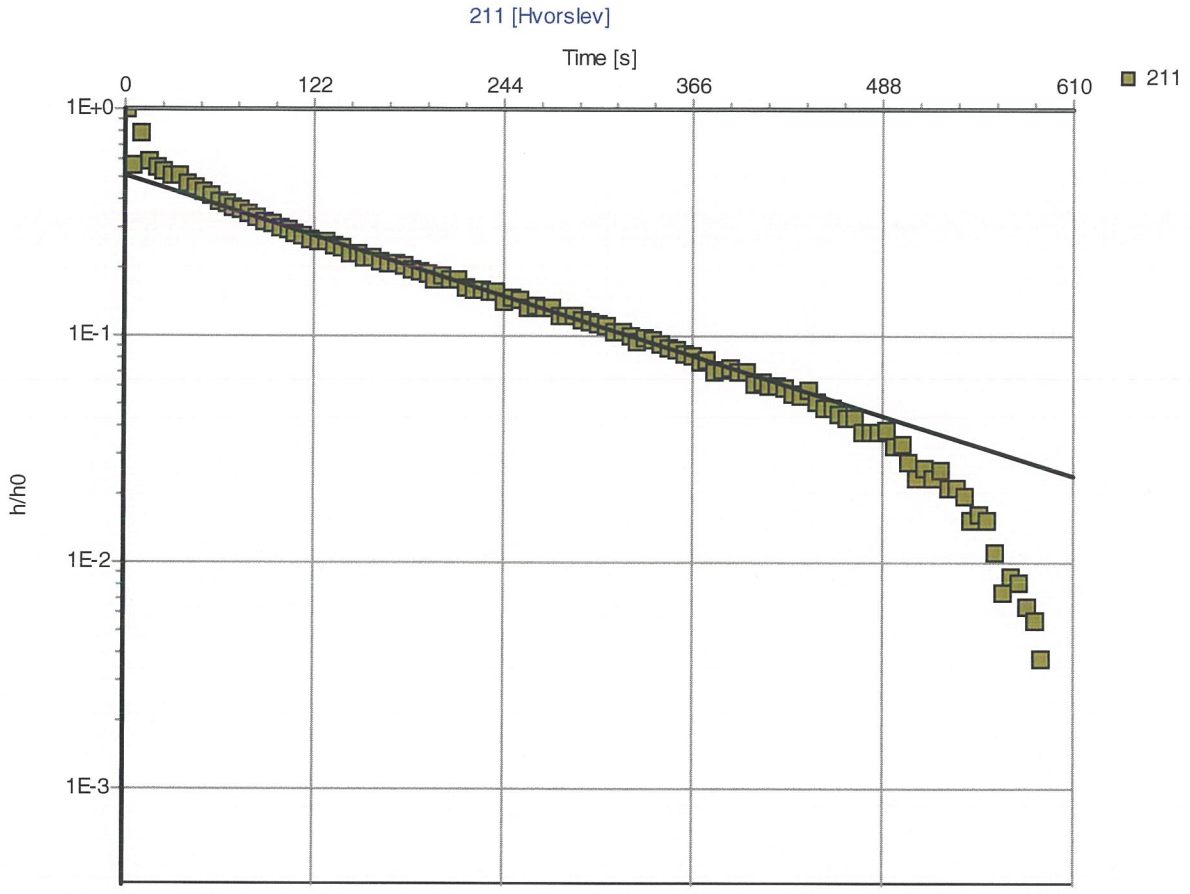
Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

Number: S1607.7

Client: Urban Elements Developments Corp



Slug Test: **211**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.58E-6 [m/s]

Test parameters:

Test Well:	211	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	4.65 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by:

Evaluation Date: 16/07/2012

Clifton Associates Ltd.
4-1925 1st Avenue North
Saskatoon, SK
1 (306) 975-0401

Slug Test Analysis Report

Project: Grasswoods Estates

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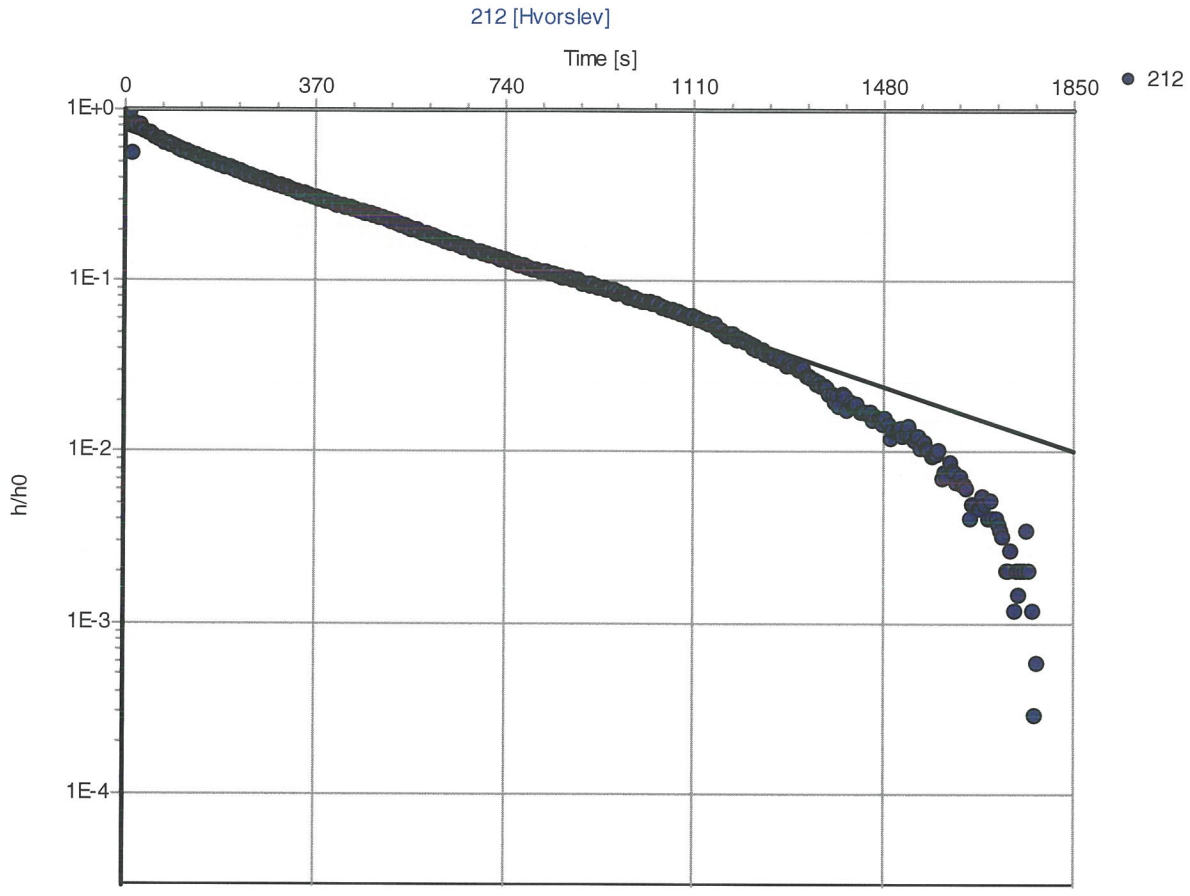
Client: Urban Elements Developments Corp



Slug Test: **212**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 1.19E-6 [m/s]

Test parameters:

Test Well:	212	Aquifer Thickness:
Casing radius:	0.0254 [m]	
Screen length:	2.5 [m]	
Boring radius:	0.0508 [m]	

Comments:

Evaluated by: MN

Evaluation Date: 16/07/2012