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DRAFT MEMORANDUM

TO:	Stacey Woodruff	REF. NO.:	046254-07-07
FROM:	Gary Lagos/Elaine Stormer/jdh/5	DATE:	January 15, 2010
RE:	**Woolwich Bio-En Inc. Facility Hydrogeological Assessment, Elmira, Ontario**		

1.0 INTRODUCTION

This memorandum was prepared by Conestoga-Rovers & Associates (CRA) to provide a hydrogeological assessment of the area surrounding the Woolwich Bio-En Inc. Facility (herein referred as the Site). The hydrogeological assessment was completed following the conditions set forth in Section 7 of Table 1 in the O. Reg. 359/09, Renewable Energy Approval (REA). The conditions set forth for hydrogeological assessment in Section 7 of Table 1 in the O. Reg. 359/09, are listed below:

1. *Report to be completed by one of the following persons after the person has conducted hydrogeological assessment in respect of the renewable energy project.*
   - i. *A professional engineer.*
   - ii. *A professional geoscientist.*
   - iii. *A person working under the supervision of a person mentioned in subparagraph i. or ii.*
2. *Set out the following information in respect of the renewable energy project.*
   - i. *Plans, specifications and descriptions of the geological and hydrogeological conditions of the land within 300 metres of any biomass storage areas, source separated organics storage areas, farm material storage areas, storage tanks and digester tanks.*
   - ii. *An assessment of the suitability of the project location for the handling, storage and processing of biomass, taking into account:*
     - A. *the design of the facility, including existing features and features that are proposed to be implemented to control the expected production of leachate.*
     - B. *the ability to identify, through monitoring any negative environmental effects that may result in groundwater from leachate production; and*
     - C. *the feasibility of contingency plans that could be implemented to control leachate produced in a quantity greater than expected or with a quality worse than expected.*

2.0 HYDROGEOLOGICAL ASSESSMENT

The purpose of a hydrogeological assessment is to develop a clear conceptual model of the hydrogeology and the potential for human health and ecological risks at a particular location.

The following sections will provide a detailed review of the Site conditions both in a Regional and a Site-specific context. In addition, a section discussing the project location suitability will be used to assess the location's suitability for the handling, storage and processing of biomass. The memorandum will therefore be structured as follows:

Section 3.0 Regional Setting
- 3.1 Site Location
- 3.2 Physiography
- 3.3 Climatology
- 3.4 Geology
- 3.5 Hydrogeology
- 3.6 Hydrology
- 3.7 Groundwater Use

Section 4.0 Site Setting
- 4.1 Site History
- 4.2 Physiography
- 4.3 Geology
- 4.4 Hydrogeology

Section 5.0 Project Location Suitability

Section 6.0 Conclusions

A professional geoscientist has completed the hydrogeological assessment report.

The geologic and hydrogeologic settings in the vicinity of the Site have been studied in considerable detail. There are numerous published reports on file with the Ontario Ministry of the Environment (MOE), the Region of Waterloo (ROW), and the Ontario Geological Survey (OGS) which provide descriptions of the regional and more local geologic/hydrogeologic setting. These publications have been prepared specifically for the purpose of assessing the hydrogeologic characteristics of the aquifer/aquitard systems in the Regional Municipality of Waterloo, including Elmira. Section 7.0 of this memorandum provides a list of the publications reviewed and evaluated within the context of the hydrogeologic framework within the Site. These publications are the foundation of this hydrogeologic assessment, which presents a very comprehensive evaluation of the hydrogeologic suitability of this location for the handling, storage and processing of biomass.

At this point there is no need to propose a Site-specific groundwater monitoring system be implemented. The hydrogeologic conditions are suitable for the operation of this facility. Also, all of the storage and operation structures have considerable safety mechanisms which would prevent potential impact to the groundwater environment.

3.0 REGIONAL SETTING

This section describes the regional conditions to the physical framework within the Site. The regional setting is presented in order to assist in identifying potential receptors of off-Site groundwater flow.

3.1 SITE LOCATION

The Woolwich Bio-En Facility Inc. (Site) is located in the north-end of Elmira, in the Township of Woolwich, within the Regional Municipality of Waterloo in Southwestern Ontario. The Site is situated east of Arthur St. North and south of Township Road 14 on an undeveloped property at 40 Martin's Lane. The Site Location is presented on Figure 1.

The Site has a total area of approximately 1.55 hectares (ha). The entire Site will be used for the biogas generation, storage, and utilization facilities as well as the supporting infrastructure. The buildings and tanks will have a final building footprint of approximately 0.33 ha and the service area, including stormwater management (SWM) pond and parking, will cover an additional 0.56 ha. Access to the Site will be achieved by extending Martin's Lane.

3.2 PHYSIOGRAPHY

This section defines the general topographic/physiographic conditions in the vicinity of the Site.

The physiography of southern Ontario has been shaped by geological processes including sedimentation, glaciation, uplifting, erosion, and weathering (Singer, 2003). In particular, glaciation has been prominent in the location of the Site. The Town of Elmira includes part of the Waterloo Hills physiographic region which is composed of sand hills, ridges of sandy till, kames, and moraines in the highlands and outwash sand and gravels in the intervening hollows (CH2M Hill, 1991). Surface topography in the vicinity of Elmira is hummocky to steeply rolling. Regionally, the topographic elevations around the Site vary from approximately 365 m AMSL north of the Site to an elevation of approximately 349 m AMSL near the Canagagigue Creek.

Two moraines are prominent in the area surrounding the Site, the Waterloo and the Elmira moraines.

The Waterloo moraine is the main physiographic feature within the area and encompasses portions of the Cities of Kitchener, Waterloo, and the Townships of Wilmot, Wellesley, and Woolwich.

The Waterloo moraine is located on the eastern rim of the Michigan basin. The glacial landforms and depositional features that make up the Waterloo moraine were deposited and re-shaped during the latter part of the last ice age. Numerous advances of ice from the Huron-Georgian Bay lobe and the Erie-Ontario lobe have added to the complexity and thickness of sediments in the geographical area of the Waterloo moraine. The Waterloo moraine is an irregular tract of hummocky to steeply rolling ground with a core of fine sand and/or sand and gravel and is extensively capped by fine tills.

Elmira is located in the interlobate area between the Huron, Georgian Bay, Ontario, and Erie glacial ice lobes and as the glacier receded, sand and gravel were deposited in the valley between the lobes, forming the Elmira moraine. The Elmira moraine is located west of Elmira and is smaller than the Waterloo moraine. In the southern extent it has a low curved till ridge (Tavistock Till) with a sand core and in the northern extent it has a till capped hummocky mass of sand that trends northward and is mostly kame gravel (CH2M Hill, 1991).

The Ontario glacial ice lobe gave rise to 3 eskers between Waterloo and Elmira. These eskers trend west-northwest and are associated with the Port Stanley Till derived from the east. There are also numerous small relict features noted in the area, such as patches of outwash gravel capped by thin Port Stanley Till.

3.3 CLIMATOLOGY

This section presents climatological information, particularly precipitation data.

Climatic data were obtained from the Environment Canada website, under Canadian Climate Normals 1971-2000. During this time period, the nearest weather station was located in Waterloo, Ontario, at the Region of Waterloo International Airport, approximately 25 kilometres (km) south of the Site. The Region of Waterloo International Airport is currently the nearest weather station to the Site.

The annual average monthly normal temperature for Waterloo is 6.7°C. Monthly normal temperatures range from –7.1°C in January to 19.8°C in July. The maximum monthly normal temperatures range from -3.1°C in January to 25.9°C in July. The minimum monthly normal temperatures range from –11°C in January to 13.7°C in July (Environment Canada, 2009).

The monthly normal precipitation in Waterloo ranges from 51.5 mm in February to 91.8 mm in July, with an average total annual precipitation of 907.9 mm (Environment Canada, 2009).

3.4 GEOLOGY

This section defines the regional stratigraphic conditions. These conditions are evaluated in order to verify and correlate with the geologic conditions encountered beneath the Site.

3.4.1 Stratigraphic Units

Overburden

A series of glacial till strata were deposited in succession during subsequent advance-retreat of the Ontario-Erie and Huron-Georgian Bay glacial ice lobes (refer to Section 3.4.2 for further detail).

The area around Elmira is underlain by some of the thickest drift in southwestern Ontario (Karrow, 1993). In the area around buried valleys, the glacial drift can be upwards of 91 metres (m) thick; and away from valleys the drift is generally 61 m thick (Karrow, 1993). Till is a classification of drift deposited directly by the glacial ice which results in the deposited material being neither sorted nor stratified.

Following successive till strata, glaciofluvial sediments were laid down by meltwater flowing from glacial ice. The resulting sediments are stratified and sorted to varying degrees and the casts are more or less rounded as they are transported via water. Most of the glaciofluvial deposits lying between tills are thin and lenticular. In addition to glaciofluvial deposits, glaciolacustrine sediments are also present between till sequences within the area. Glaciolacustrine deposits are fine sediments deposited by glacial meltwater in slow-moving or quiet bodies of water (such as ponds and lakes). Lacustrine deposits are associated with gentle topography of till plains where it spreads widely as a thin veneer on top of the till.

The glacial tills deposited in the Elmira area from oldest to youngest are described in the following paragraphs.

The oldest exposed unit is Catfish Creek Till, overlain by a thick sequence of interbedded lacustrine clay and clayey till, representing a fluctuating ice front in a glacial lake confined to the Nith River Valley. There is evidence that older tills and water-laid sediments exist below the Catfish Creek Till, however due to sporadic and very limited exposure of these older deposits, their correlation and interpretation has been difficult (Karrow, 1993). The only pre-Catfish Creek Till in the region that has been named and traced through several exposures is the Canning Till of the Lower Nith River valley. Canning Till is generally assumed to be of Early Wisconsinan age and is identified as a clayey to silty till.

The Catfish Creek Till is generally the lowest unit exposed along the stream valleys and it forms the general base of the exposed till sequence. The thickness of Catfish Creek Till varies between 3 and 6 m. It is stony and contains little clay, however it is abundant in sand and silt. It is commonly hard and difficult to drill through and is often referred to as "hardpan." It is yellow to buff or olive in colour when oxidized and grey when unoxidized. The Catfish Creek Till is usually oxidized as a result of seeping groundwater because it is coarse and more permeable than the overlying finer tills (Karrow, 1993). Although similar tills are found below the Catfish Creek Till, most of the younger till are distinctly finer and usually provide a marked contrast (e.g., Maryhill Till is very clay rich). The Catfish Creek Till was deposited during the maximum extent of the Late Wisconsinan ice, during the Nissouri Stade (between 16,000 and 24,000 years ago). Catfish Creek Till is considered correlative with the Navarre and Kent Tills of Ohio and is believed to be the oldest till appearing on the surface in Southern Ontario (Karrow, 1993).

Maryhill Till overlies the stony-sandy Catfish Creek Till. It is commonly less than 3 m thick, although together with interbedded lacustrine clay it may exceed 15 m. It is characterized as clay till with a fine texture and generally stone-free nature. Typical exposures are evident along the Grand River valley, where Maryhill Till is often interbedded with laminated or varved clay and silt. Maryhill Till is also evident capping much of the Waterloo moraine. The Maryhill Till was deposited between 14,000 and 15,000 years ago during the early Port Bruce Stadial. It generally corresponds closely in age with the Stirton Till of the Georgian Bay lobe, and is probably equivalent to the oldest sheets of Port Stanley Till (Karrow, 1993).

Port Stanley Till generally overlies Maryhill Till, however when the underlying Maryhill Till is missing, the Port Stanley Till is sometimes difficult to distinguish from Catfish Creek Till. This till sheet is generally thin and absent near valley exposures. Port Stanley Till is characterized as buff, soft and loose sandy material (possibly ablation till), often stony and interbedded with sand. This till is associated with lacustrine silt and sand deposits and is interpreted as having formed in shallow meltwater ponded between the ice to the east and gently rising ground near the Elmira moraine to the west. The Ontario-Erie ice lobe that deposited the Port Stanley Till, may have been contemporaneous with Tavistock ice (Georgian Bay lobe) around Waterloo since the two tills overlie the same older sand and gravel deposits (Karrow, 1993). The Port Stanley Till was deposited during the Port Bruce Stade and represents an important re-advance of the Ontario-Erie lobe following an interval of ice retreat.

Tavistock Till overlies Catfish Creek Till and Maryhill Till near Elmira. Tavistock Till is generally characterized as having many stones, a gritty, clayey silt texture, and commonly contains small pieces of red shale. Erratics of Precambrian jasper conglomerate have been found on the surface of this till, as this rock comes from the Huronian beds north of Lake Huron (Karrow, 1993). The Tavistock Till was deposited during the early Port Bruce Stade. The Tavistock Till is believed to be close in age to the Port Stanley Till of the Ontario-Erie lobe and was the earliest widespread advance of the Huron-Georgian Bay lobe following the Erie Interstade (Karrow, 1993).

The surficial deposits are principally classified as sand or gravel. The materials for the most part compose the Waterloo and Elmira moraine complexes and consist of poorly to well sorted kame sands and gravels with associated outwash channels containing well-sorted fine to coarse sand and fine to medium gravel. Thicknesses of surficial sands and gravels throughout the area range from 5 to 15 m with deposits of up to 40 m occurring in Woolwich Township (CH2M Hill, 1991).

Bedrock

The bedrock underlying Elmira consists of marine sediments deposited during the Silurian period of the Paleozoic Era, between 417 and 443 million years ago.

The oldest Paleozoic bedrock beneath the Elmira area is the Salina Formation of the upper Silurian age. The Salina Formation consists of 122 to 183 m of thinly bedded grey to green shale interbedded with argillaceous brown dolostone, as well as evaporate beds (anhydrite and gypsum) (Terraqua, 1995). The Salina Formation is generally found at depths of between 295 and 330 metres above mean sea level (m AMSL) in the area of Elmira (Holden, 1993); however it was located approximately 3 m under the Conestogo River, which is the closest bedrock to the surface in the vicinity of the Site (Karrow, 1993).

3.4.2 Glacial History

The glacial history is described in the hydrogeologic assessment to highlight the complexity of the stratigraphic framework regionally and in the vicinity of the Site.

The glacial history of the Elmira area was defined by a series of advance and retreats of the Erie-Ontario and the Huron-Georgian Bay glacial lobes. These patterns of advance-retreat left a series of glacial till strata covering the area, as well as surface features such as moraines, drummlins, eskers, and kames.

A major erosional unconformity separates the Silurian Formation from the Quaternary sediments (Karrow, 1993). The oldest known Quaternary deposits within the area are the occurrence of pre-Catfish Creek tills, which are probably of Early or Middle Wisconsinan age (Karrow, 1993).

The Middle Wisconsinan age ranged from 23,000 to 70,000 years ago. It was a relatively warmer time resulting in glacial retreats and glacial deposition consisting of glaciofluvial and glaciolacustrine silts and sands. The major glacial retreat was known as the Port Talbot Interstadial.

The first Wisconsinan event, which has been widely recognized as the Nissouri Stadial ice advance, laid down the Catfish Creek Till (Karrow, 1993). At that time, approximately 20,000 years ago, thick ice spread over all of southwestern Ontario and covered regions down to Ohio.

Approximately 18,000 years ago, the ice front began receding from Ohio and by about 16,000 years ago, during the Erie Interstade, much of southwestern Ontario was ice-free. Large glacial lakes formed in the Erie and Huron basins, and numerous small lakes and ponds existed on the uneven surface of the drift deposited by the Catfish Creek ice. The lakes deposited fine-grained sediments which were not laterally extensive (Karrow, 1993).

A strong re-advance of the Erie-Ontario and Huron-Georgian Bay glacial lobes during the Port Bruce Stade covered most of southwestern Ontario with ice once again. The Erie-Ontario lobe deposited the Maryhill Till and later the Port Stanley Till in this area, as well as subsequent fluvial sediments. At the same time, the Huron-Georgian Bay lobe advanced from the northwest and laid down the Stirton Till (which was less extensive) followed by the more widespread Tavistock Till. Subsequent local re-advances deposited the Mornington Till. These re-advances were short-lived pulses of the retreating Huron-Georgian Bay lobe, which show little correspondence with those of the Ontario lobe (Karrow, 1993). A stronger re-advance of the Georgian Bay lobe brought the ice back for the last time, approximately 14,500 years ago, to cover the western and northern parts of the Region of Waterloo.

The ice that deposited the Maryhill Till most likely disintegrated rapidly over the Elmira moraine, leaving numerous ice blocks to form kettles and produce abundant meltwater that deeply dissected the moraine locally. The Elmira moraine sands appear to occur between Tavistock and Maryhill Tills and represent glaciofluvial deposition of about the same age as the Waterloo moraine (Terraqua, 1995).

During ice retreat, ablation deposits of sand and gravel in the form of kames, eskers, and outwash plains were laid down. About 13,500 years ago, ice re-advanced to the Paris moraine (east of Cambridge) and diverted the Grand River valley drainage southward (Singer, 2001). Numerous lakes on the uneven till plains received silty sediment during ice retreat. Sedimentation was rapid and the lakes soon drained. Meltwater channels and spillways are valleys that were cut during the retreat of the ice front. Many of these valleys (Conestogo River valley) formerly carried large meltwater streams which began to form during the retreat of the Huron and Georgian Bay lobes (Terraqua, 1995).

As a result of Elmira's relatively high altitude, the area was not flooded by the large glacial lakes that occupied the Great Lakes basins during the recession of the last glacier; although much of the area was inundated during the glacial retreat and pond deposits are widespread (Karrow, 1993). These temporary water bodes were generally shallow and did not develop recognizable shore features. The interlobate position of the area meant it was amongst the first land to be deglaciated in Ontario (Karrow, 1993).

3.5 HYDROGEOLOGY

This section presents the regional hydrogeologic framework. An understanding of the regional hydrogeology is useful to aid in defining groundwater flow paths and identify potential off-Site receptors.

Regionally, the area is composed of a series of aquitards and aquifers (Terraqua, 1995, Waterloo Hydrogeologic, 2000). The nature of tills has a considerable effect on the ability of the unit to either transmit water or effectively prevent the movement of water (Karrow, 1993). Glaciofluvial sand and gravel deposits located between the major till units form the major aquifers in the system.

The abundant and high-quality water resources provided by the Waterloo moraine have been used for municipal supply since the late 1800s (Waterloo Hydrogeologic, 2000) for the Cities of Kitchener, Waterloo and several surrounding rural communities, including Woolwich.

Extensive sands and gravels in the core of the Waterloo moraine are associated with the period of deposition of the Maryhill drift. The Maryhill Till, described as a laterally extensive clay till, acts as a major aquitard throughout the area. The Maryhill Till acts as a significant barrier to vertical water movement where present in thickness greater than 5 m. The Maryhill Till varies in thickness within the Waterloo moraine from 5 to 25 m (Terraqua, 1995).

The high yield areas in the overburden come from highly permeable deposits. Overburden is a significant source of groundwater within the Grand River basin. High water yielding deposits of extensive sands and gravels are found at different depths. Permeable deposits of sequences of sand and gravel up to 25 m thick occur in the vicinity of Elmira. Generally in the Elmira area, most of the domestic wells obtain water from the upper 15 m of the overburden, whereas municipal and some industrial wells penetrate the bedrock to depths of 30 to 188 m below ground surface (CH2M Hill, 1991).

Groundwater flow in Elmira is generally to the southeast, eventually towards Lake Erie, with major flow components diverging to the west and east towards the Nith and Grand Rivers (Singer, 2003). Over three-quarters of the area is drained by tributaries of the Grand River (Karrow, 1993). The Nith and the Conestogo River are main tributaries of the Grand River. The general water table for the Elmira area is similar in pattern to topographic relief. The areas that are considered ice-contact or outwash sands and gravels represent the main recharge areas.

3.6 HYDROLOGY

This section defines the regional surface water hydrology in the vicinity of the Site and its relationship to the regional and Site hydrogeology.

The Grand River basin encompasses an area of 6,770 km^2, with an approximate length of 190 km and an average width of 35 km (Singer, 2001). Elevations in the basin range from a high of 535 m AMSL near Dundalk and a low of 174 m AMSL near Port Maitland at Lake Erie (Sibul, 1980). The main tributaries of the Grand River are the Nith, the Speed, the Eramosa, and the Conestogo Rivers. The basin contains a wide variety of landforms that consequently result in varied drainage patterns. All of the landforms are as a result of the last glaciation of approximately 12,000 years ago, and to post-glacial erosion subsequent to the withdrawal of ice from southwestern Ontario (Sibul, 1980).

Groundwater discharge from the Elmira area along numerous creeks and along the Grand, Nith and Conestogo Rivers. The Conestoga River rises northwest of Arthur, drains an area of about 820 km^2 and has a length of approximately 82 km. The Nith River rises east of the Milverton Moraine, drains an area of about 1,118 km^2 and has a length of approximately 158 km. The Canagagigue Creek is the major body of water in Elmira, which flows southeast from the north end of town to join the Grand River, approximately 4 km to the east. Much of the surface water drainage and upper aquifer discharge occur through the Canagagigue Creek to the Grand River.

Approximately 20-30 percent of precipitation enters the saturated groundwater regime (Waterloo Hydrogeologic, 2000). Baseflow analysis suggests that recharge to the groundwater system is approximately 28 cm/year (CH2M Hill, 1991). Hummocky portions of the Waterloo moraine lead to poor surface drainage and promotes additional recharge. Distribution of groundwater recharge is variable and depends upon surficial geology, the slope of the ground surface, the thickness of the unsaturated zone, and the vegetative or land surface cover. In addition, agricultural tilling of the surficial layer of soils may promote local water storage and increased recharge potential (Waterloo Hydrogeologic, 2000).

3.7 GROUNDWATER USE

This section identifies the type and general location of wells that withdraw groundwater in the vicinity of the Site. This is necessary to identify any potential receptor(s) of groundwater flowing off-Site.

The Region of Waterloo relies on groundwater for approximately 72 percent of its drinking water, with the remaining 28 percent supplemented by water from the Grand River (Waterloo Hydrogeologic, 2000). There are approximately 130 pumping wells grouped into 40 well fields throughout the Region to provide the necessary groundwater supply (Waterloo Hydrogeologic, 2000). There are a total of 17 of the Region's well fields that are located within the Waterloo moraine. Numerous large aquifers in the Waterloo moraine provide the majority of the groundwater to the Region.

Currently, the Region of Waterloo does not operate any production wells in the former Elmira Well field. Some of the previous production wells were either shutdown in 1994 in response to contamination of the Elmira Well Field or are currently used as a containment system. The former production wells in the vicinity of Elmira tapped permeable deposits contained in the complex of interglacial sediments, described in the previous sections at depths of approximately 30 m below ground surface (bgs).

Drinking water in Elmira is piped in from Waterloo. The local aquifer system is not used for water consumption purposes.

There are no domestic wells in Elmira used for water consumption purposes in Elmira (Burnside, 2008). Domestic wells used in rural areas for water consumption purposes are located at significant distances (500 m or more) upgradient of the Site. These wells generally obtain groundwater from the upper 15 m of overburden.

4.0 SITE SETTING

This section defines the physical framework of the Site in order to identify and quantify potential groundwater flow pathways.

4.1 SITE HISTORY

The property on which the Proposed Facility will be located (the Site) is currently owned by Marbro Capital (Marbro) and has historically been used for agricultural crop production. The area of the Site not developed for the Proposed Facility will continue to be used for agricultural crop production until Marbro further develops the parcel of land. Bio-En will lease the Site from Marbro Capital.

4.2 PHYSIOGRAPHY

The Site is located in a relatively topographically flat area, as shown on Figure 2. The topographic elevations range from approximately 365 m AMSL in the north end of the Site to 356 m AMSL in the southern extent of the Site.

The nearest watercourse to the Site is a very small creek/ditch located approximately 240 m northeast of the Site. Canagagigue Creek is located approximately 400 m southwest (downgradient) of the Site, as shown on Figure 2.

4.3 GEOLOGY

The nearest monitoring well to the Site is CH-3, located approximately 200 m to the west, as shown on Figure 3. The stratigraphic and instrumentation log for this monitoring well is provided in Attachment A.

The stratigraphic framework in the vicinity of the Site has been interpreted from geologic cross-sections presented in the Elmira/St. Jacobs Water Supply Project prepared by CH2M Hill (1991). Geologic cross-sections in the vicinity of the Site are presented on Figures 3 (cross-section location), 3a (north-south/A-A'), 3b (west-east/E-E'), and 3c (west-east/F-F'). These geologic cross-sections show the vertical and horizontal distributions of the stratigraphic units in the vicinity of the Site. The geologic cross-section shown on Figure 3b is the most representative of the stratigraphic conditions beneath the Site, although the other cross-sections give a good indication of the variable geology in the vicinity of the Site.

The conceptual hydrogeologic model for the Site shows the general geologic and hydrogeologic framework, and was obtained from the Crompton Optimization Study prepared by CRA (2007). This schematic is presented on Figure 4.

Overburden

As described in Section 3.4.1, the overburden is classified as a mixture of glacial, glaciofluvial, and glaciolacustrine sediments deposited during the advance and retreat of the Wisconsinan ice age. The overburden in the vicinity of the Site is approximately 30 to 45 m thick.

The surficial layer in the vicinity of the Site is a combination of native sand and gravel and fill. The surficial layer in CH-3 is approximately 12 m in thickness and corresponds to a shallow aquifer about 5 m in thickness on the geologic cross-sections shown on Figure 3b. This is known as the Upper Aquifer (UA) on the conceptual hydrogeologic model shown on Figure 4.

Beneath the surficial layer there is a layer of fine-grained material (glacial clay till at CH-3) composed primarily of silt and clay, with traces to little sand and gravel components as the secondary fraction. This unit is approximately 10 m in thickness in monitoring well CH-3 and the uppermost aquitard shown on Figure 3b. On the conceptual hydrogeologic model shown on Figure 4, this unit corresponds to the Upper Aquitard.

The Upper and Lower Municipal Aquifers underlie the Upper Aquitard. The lithology of these units is highly variable. At monitoring well CH-3 only a thin (less than 1 m in thickness) sand horizon is representative of coarse-grained conditions typical of these aquifers. Regionally these units are on the order of 10 m in thickness.

Fine grained deposits underlie the Upper and Lower Aquifers and overlie the Bedrock. This unit is composed primarily of silt and clay and is regionally on the on the order of 3 m in thickness. At the Site this fine-grained layer is about 8 m in thickness and separates the Bedrock from the overlying thin sand horizon.

Bedrock

The bedrock in the vicinity of the Site is the Salina Formation of the Upper Silurian age. The Salina Formation is a sequence of thinly bedded grey/blue to green shale interbedded with argillaceous brown dolostone, as well as evaporate beds of gypsum and anhydrite, and is found at approximately 318 m AMSL or about 38 m bgs.

4.4 HYDROGEOLOGY

The Site-specific hydrogeology is characterized by a series of aquifers and aquitards, as discussed in Section 3.5. The hydrogeologic units shown on Figure 4 (conceptual hydrogeologic model) and their hydraulic properties are related to the conditions in the vicinity of the Site.

The Surficial Aquitard (SAT) generally is the uppermost unit in the hydrogeologic sequence in the Elmira Area. The thickness is extremely variable and ranges from less than 1 m to 12 m. The SAT is characterized as primarily silt and clay, with trace to little sand and little gravel. It is usually dry to moist and no estimates of hydraulic conductivity are available. The SAT pinches out laterally and is not present in the vicinity of the Site.

The Upper Aquifer (UA) underlies the SAT. The UA is either exposed at the ground surface or is overlain by the SAT. Regionally, the UA thickness is also extremely variable (0 to 22 m). It is characterized as an unconfined aquifer composed primarily of sand or sand and gravel. At the Site, the UA is made up primarily of about 12 m of coarse-grained fill material with no hydrogeologic significance. It has an average documented hydraulic conductivity between 1.0×10^{-1} to 1.0×10^{-2} cm/sec. Groundwater in the UA flows to the southwest and locally discharges to the Canagagigue Creek, which is about 400 m downgradient of the Site.

The Upper Aquitard (UAT) underlies the UA. It generally variable in thickness (1 to 16 m). The UAT is typically composed of clay and little to some silt and various proportions of sand and gravel. At the Site, the UAT consists of about 10 m of impermeable fine-grained material. It is an effective confining unit and separates the UA from the municipal aquifer system.

The Municipal Aquifer (MA) underlies the UAT. The MA is the primary water-bearing unit in the vicinity of Elmira. It is a confined sand and gravel aquifer and is generally divided into upper (MU) and lower (ML) aquifers with an intervening aquitard (MAT). The combined thickness of the MA ranges between 1 and 20 m. At the Site there is only a very thin (less than 1 m) permeable sand horizon underlying the UAT which would be representative of the MA. The MA is a confined aquifer composed of sands and gravels. Groundwater generally flows south under the influence of a regional gradient. As noted in previous sections, the MA is not currently used for drinking water purposes in Elmira.

The Lower Aquitard (LAT) underlies the ML. The LAT thickness varies from 1 to 14 m. The LAT is composed primarily of clay. At the Site the LAT is about 8 m in thickness and offers significant protection and separation to the Bedrock Aquifer (BR) from the overburden.

The BR underlies the LAT. The BR consists of interbedded shale and dolostone with varying degrees of weathering and fracturing. At the Site the BR consists of blue shale about and is found at about 38 m bgs.

5.0 PROJECT LOCATION SUITABILITY

An assessment of the suitability of the project location for handling, storage and processing of biomass will be detailed in the following sections. A discussion of each of the contributing factors allows for an overall assessment of the Site suitability.

A discussion of the topography is a Site suitability consideration. The topography of the Site is relatively flat. The topographic elevations vary from 365 m AMSL in the north end to 356 m in the southern extent of the Site. No major hills or valleys are present. Therefore, the topography is suitable for the Site.

A discussion of the natural surface water features is a Site suitability consideration. The nearest watercourse to the Site is a creek/ditch approximately 240 m northeast of the Site. Canagagigue Creek is located approximately 400 m southwest (downgradient) of the Site. Considering the relatively flat topography of the Site, any surface water will likely either evaporate, or infiltrate the upper portion of the subsurface, with minor overland flow to the surface water courses. Therefore, the natural surface water features are suitable for the Site.

A discussion of the subsurface conditions is a Site suitability consideration. The extensive till sequence that is present in the subsurface provides an adequate hydraulic barrier should a spill occur. If a spill were to occur at the Site, then approximately 10 m of fine-grained glacial till would restrict the downward migration of the contaminant to the Municipal Aquifer unit. Therefore, the subsurface conditions are suitable for the Site.

A discussion of the present zoning is a Site suitability consideration. The present zoning of the Site is designated as a "General Industrial – Dry" while surrounding land partitions are classified as the same, agricultural, or institutional. Considering that the nearest residence is approximately 170 m to the north-west. This residence likely does not have a domestic well on their property and if present, it is not used for water consumption purposes. The nearest domestic wells to the Site are located at least 500 m upgradient.

Therefore, the present zoning is suitable for the Site.

A discussion of the contents to be processed at the Site is a Site suitability consideration. The organics to be processed at the proposed facility include, but are not limited to:

- Organics from food processing facilities, grocery stores, food distribution companies, and milling facilities (0 to 40,000 tonnes/year)
- Livestock manure (0 to 13,000 tonnes/year)
- Glycerol (0 to 3,000 tonnes/year)
- Kitchen waste (0 to 40,000 tonnes/year)
- Fats, oil, and grease (FOG) (0 to 20,000 tonnes/year)
- Renewable energy crops (i.e., corn silage) (0 to 12,000 tonnes/year)
- Organic solids skimmed from a dissolved air flotation (DAF) tank (0 to 20,000 tonnes/year)

The contents to be processed is a major factor deciding the Site suitability as it must be considered how the contents would behave should a spill occur and such contents were released into the subsurface. Since the contents are all organic waste and organic-derived wastes, they will all fully biodegrade within the subsurface, if given sufficient time. Coupled with the fact that downward migration rates would be extremely slow, as a result of the fine-grained glacial till sequence and flat topography, if sufficient microbes, oxygen, and other natural attenuation parameters (iron, manganese, oxidation-reduction potential, etc.) were present, then in all likelihood the contents would more than likely biodegrade before it reached any permeable aquifers. Therefore, the contents to be processed are suitable for the Site.

A discussion of the proposed facility design is a Site suitability consideration. The proposed facility will have secondary containment measures around the outdoor input material storage tanks. The pre-treatment, main digester, secondary digester and repository tanks will all be constructed to 150% of the required design criteria. Therefore, the proposed facility design is suitable for the Site.

A discussion on the constructed surface water features is a Site suitability consideration. The constructed surface water features refer to the pavement of surfaces as well as the Surface Water Management Pond (SWM). The surfaces on which hauling vehicles and processing equipment will operate will be paved to limit potential for dust generation and allow for more effective surface water management. All paved areas will be sloped to facilitate surface water collection. The SWM will be located south of the Digester tanks and will be used for collection of any storm water. Residual biomass is not anticipated outside. The SWM will need to be discharged from time to time. Sufficient precautions have been taken to avoid surface water runoff to the nearby creek, any local residences, or collection ditches. Therefore, the constructed surface water features are suitable for the Site.

A discussion of the monitoring is a Site suitability consideration. The proposed facility will participate in numerous Site Inspection programs (e.g., incoming organics volume monitoring, digestate quality monitoring, noise, litter, and dust monitoring, as well as a Site Contingency Plan) to attempt to mitigate and foresee any potential problems. Therefore, the monitoring programs are suitable for the Site.

6.0 CONCLUSIONS

Based on the aforementioned sections the location of the Site is hydrogeologically suitable for the handling, storage, and processing of biomass. The main reasons for this Site being suitable for the proposed activities is provided below:

- the topography is relatively flat with no major hills or valleys on Site
- the nearest watercourse to the Site is a creek/ditch approximately 240 m northeast of the Site. Cangagigue Creek is located about 400 m southwest (downgradient) of the Site
- the extensive fine-grained glacial till sequence of approximately 10 m is sufficient to prevent downward migration of any contaminants to the main groundwater aquifer for the area (Municipal Aquifer)
- the present zoning of the Site is designated as "General Industrial – Dry"
- the nearest residence is 180 m to the west with no domestic well usage
- the contents to be processed are biodegradeble within the subsurface if given sufficient time
- the proposed facility design will have a secondary containment system (for input materials stored outdoors) and the pre-treatment, main digester, secondary digester and repository tanks will all be constructed to 150% of the required design criteria
- the paved surfaces will be sloped and a SWM will be constructed for the collection of storm water.

7.0 REFERENCES

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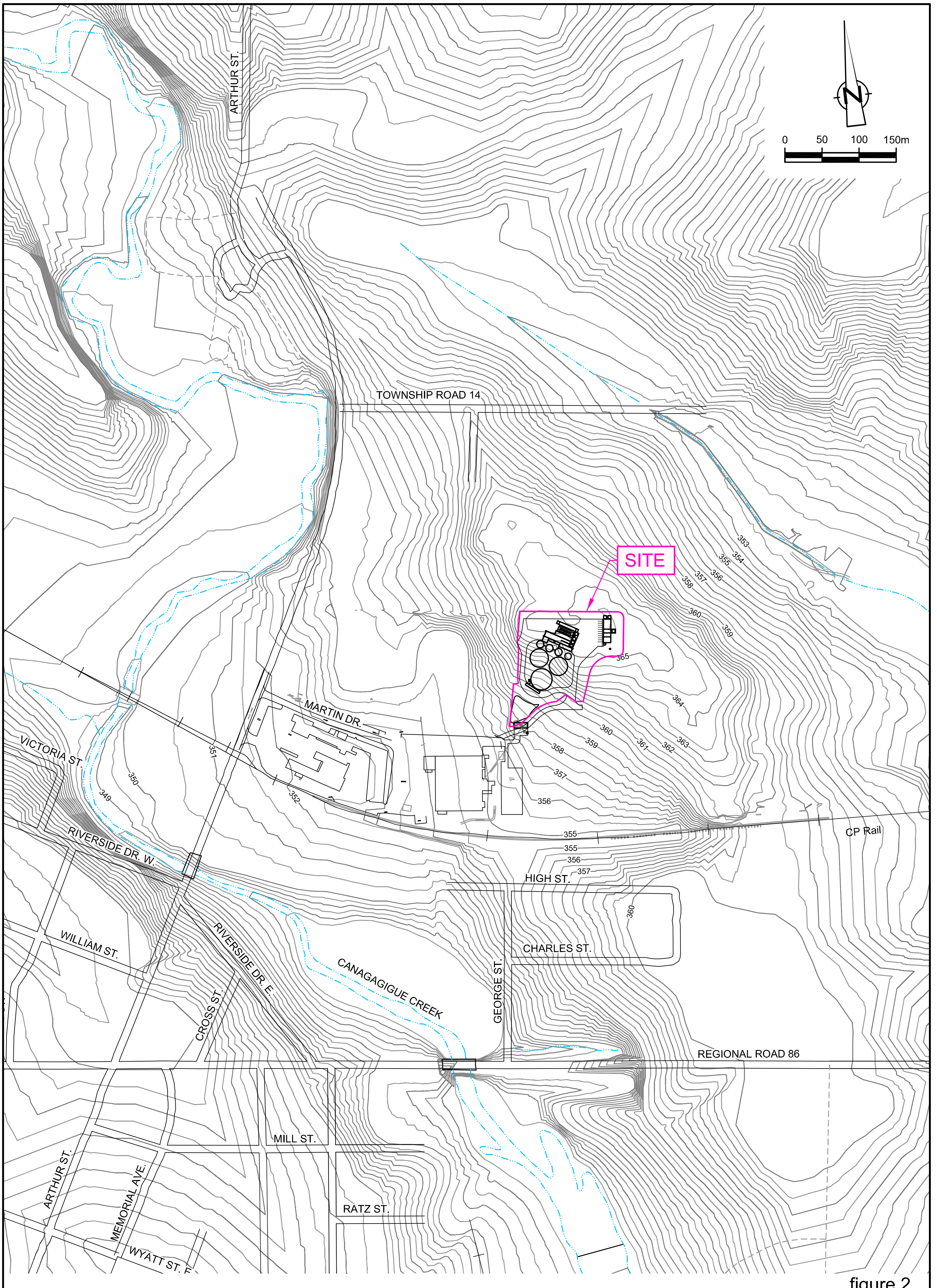
FIGURES

SOURCE: GRCA AERIAL PHOTOS: GRCA 534_4826, GRCA 534_4828, GRCA 536_4826, GRCA 536_4828

figure 1

SITE LOCATION
HYDROGEOLOGIC ASSESSMENT
WOOLWICH BIO-EN FACILITY
Elmira, Ontario

46254-07(MEMO005)GN-WA004 JAN 14/2010



SOURCE: WALTERFEDY PARTNERSHIP ENGINEERS, PLAN C1-1
ONTARIO BASE MAP 10-17-5350-48250

figure 2

TOPOGRAPHIC ELEVATIONS
HYDROGEOLOGIC ASSESSMENT
WOOLWICH BIO-EN FACILITY
Elmira, Ontario

46254-07(MEMO005)GN-WA003 JAN 14/2010

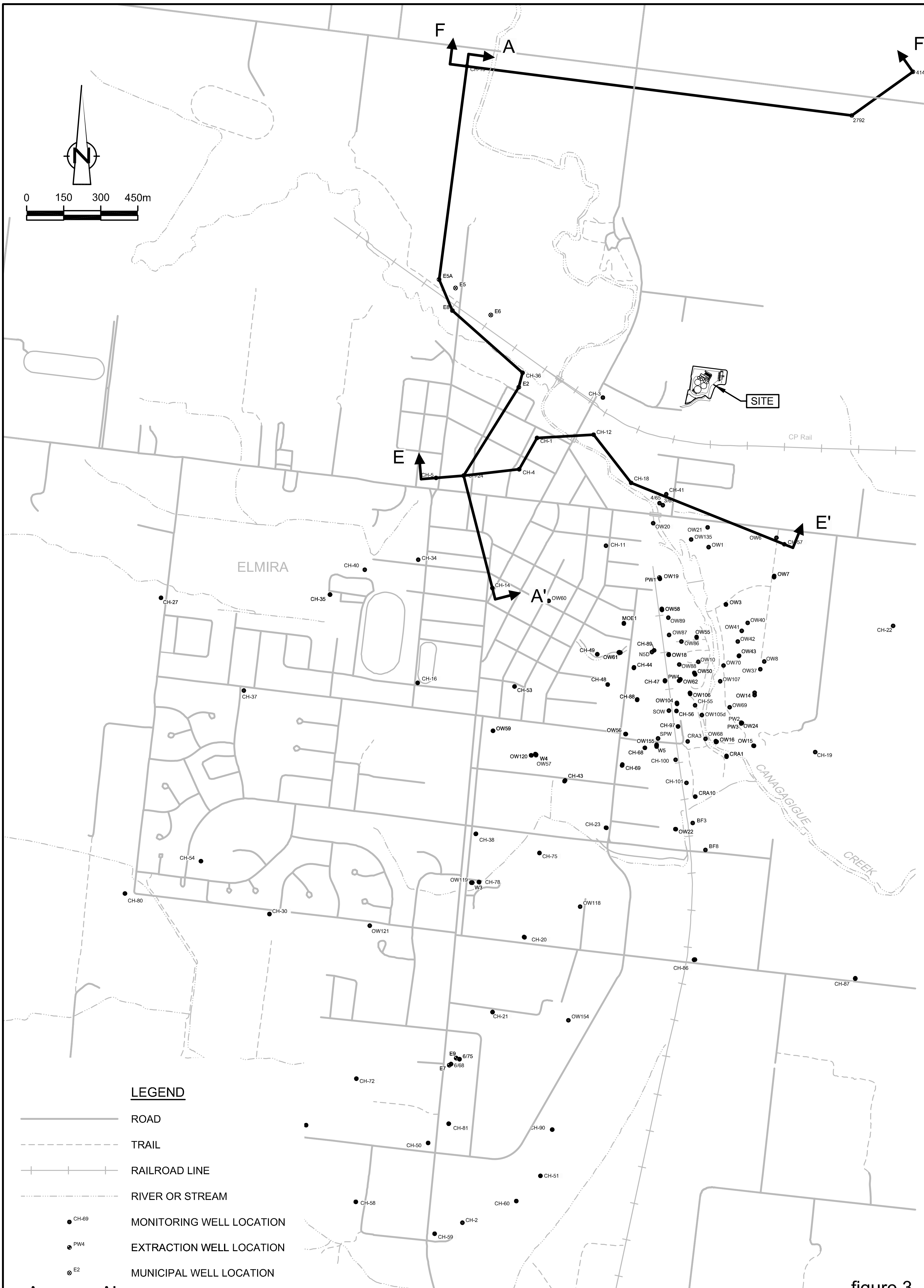
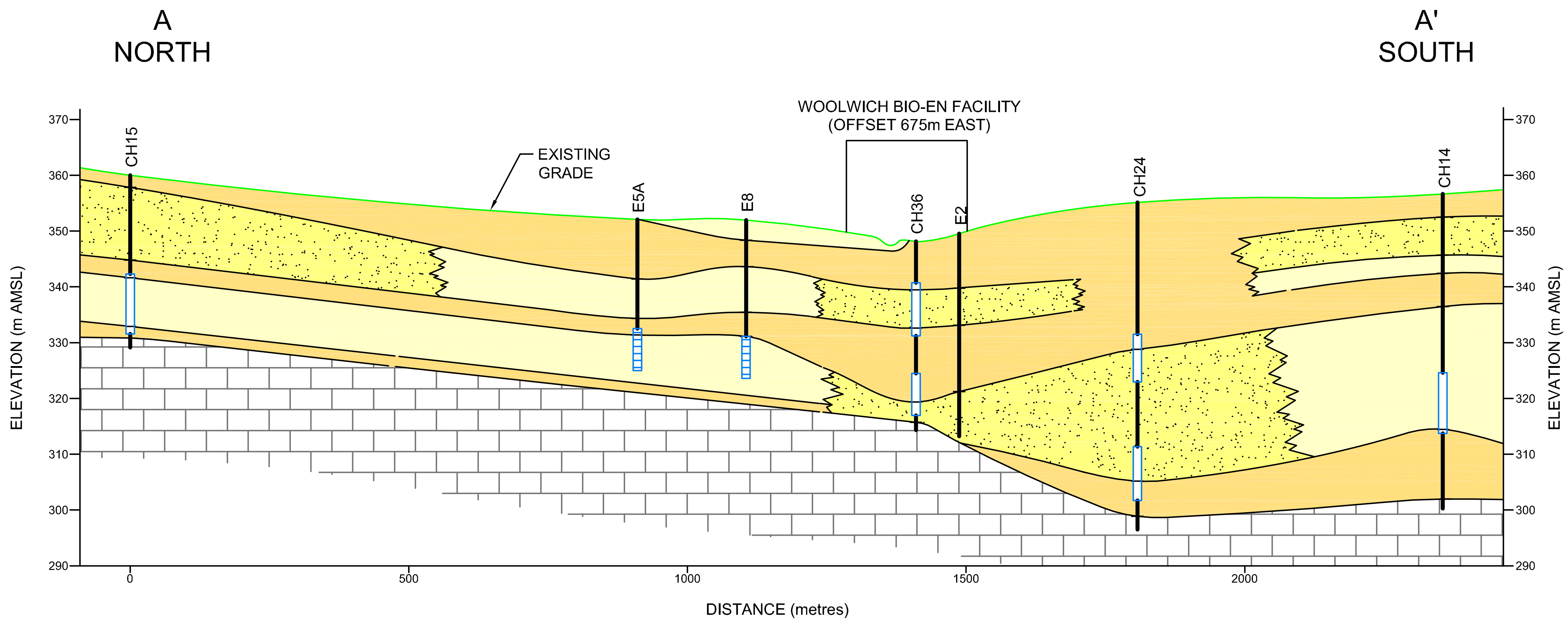


figure 3

CROSS-SECTION LOCATIONS
HYDROGEOLOGIC INVESTIGATION
WOOLWICH BIO-EN FACILITY
Elmira, Ontario

46254-07(MEMO005)GN-WA002 JAN 14/2010



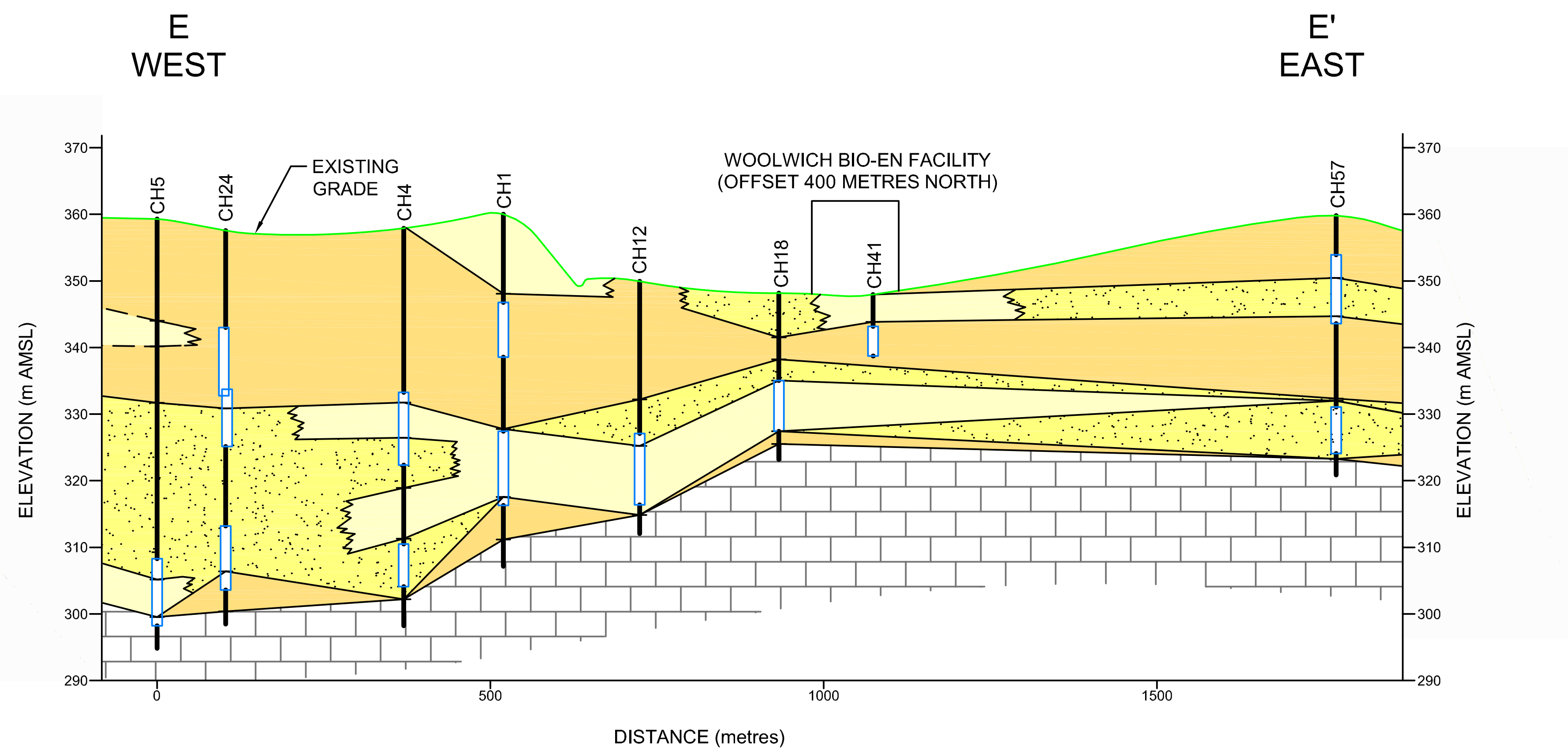
LEGEND

- AQUITARD
- AQUIFER (FINE GRAINED)
- AQUIFER (COARSE GRAINED)
- BEDROCK
- EXTRAPOLATED BOUNDARY
- FILTER PACK INTERVAL
- SCREENED INTERVAL

SOURCE: CH2M HILL DWG. 4 CROSS SECTION A-A'

figure 3a

CROSS SECTION A-A'
HYDROGEOLOGIC INVESTIGATION
WOOLWICH BIO-EN FACILITY
Elmira, Ontario



LEGEND

AQUITARD

AQUIFER (FINE GRAINED)

AQUIFER (COARSE GRAINED)

BEDROCK

EXTRAPOLATED BOUNDARY

FILTER PACK INTERVAL

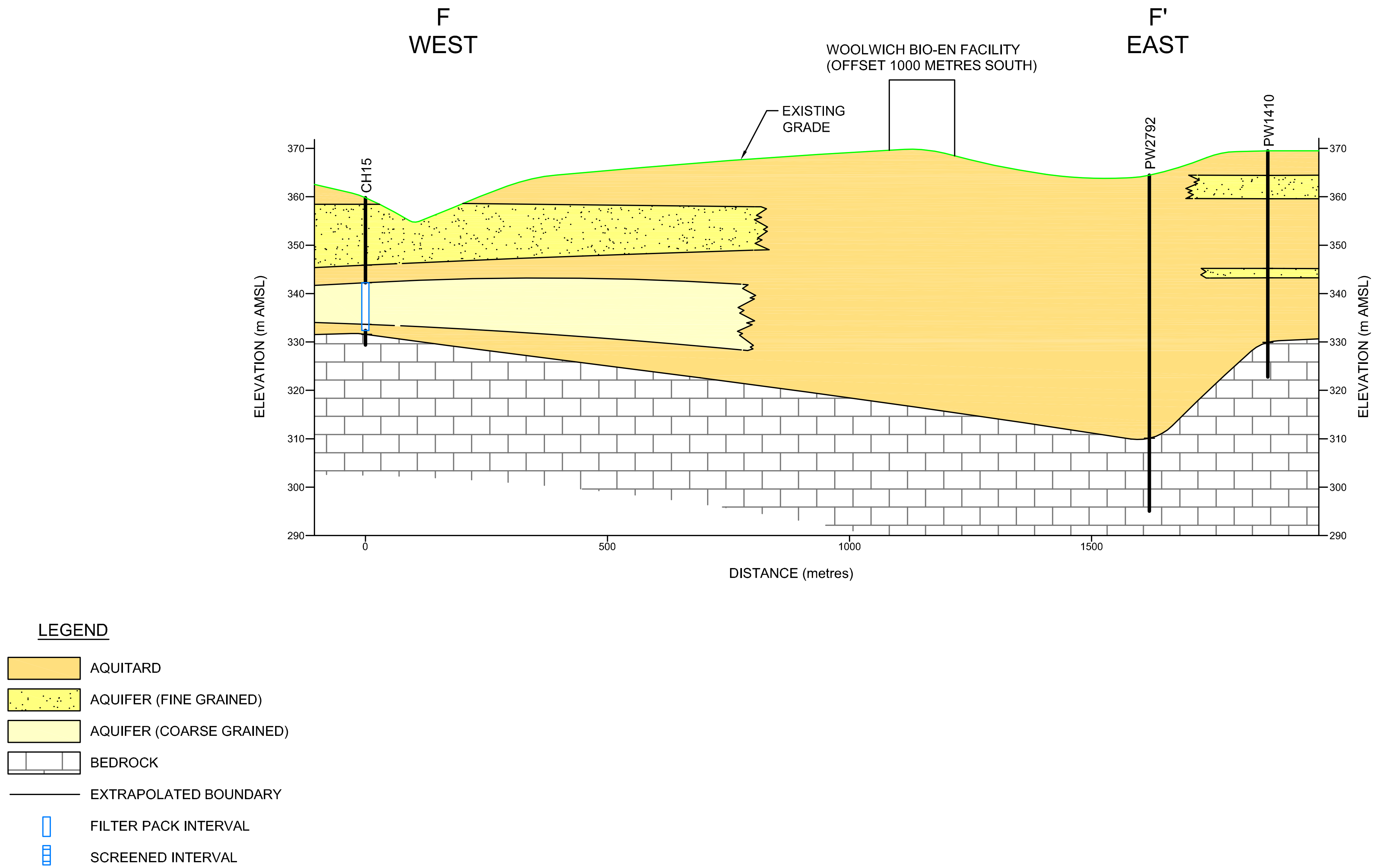
SCREENED INTERVAL

SOURCE: CH2M HILL DWG. 8 CROSS SECTION E-E'

figure 3b

CROSS SECTION E-E'
HYDROGEOLOGIC ASSESSMENT
WOOLWICH BIO-EN FACILITY
Elmira, Ontario

46254-07(MEMO005)GN-WA001 DEC 08/2009

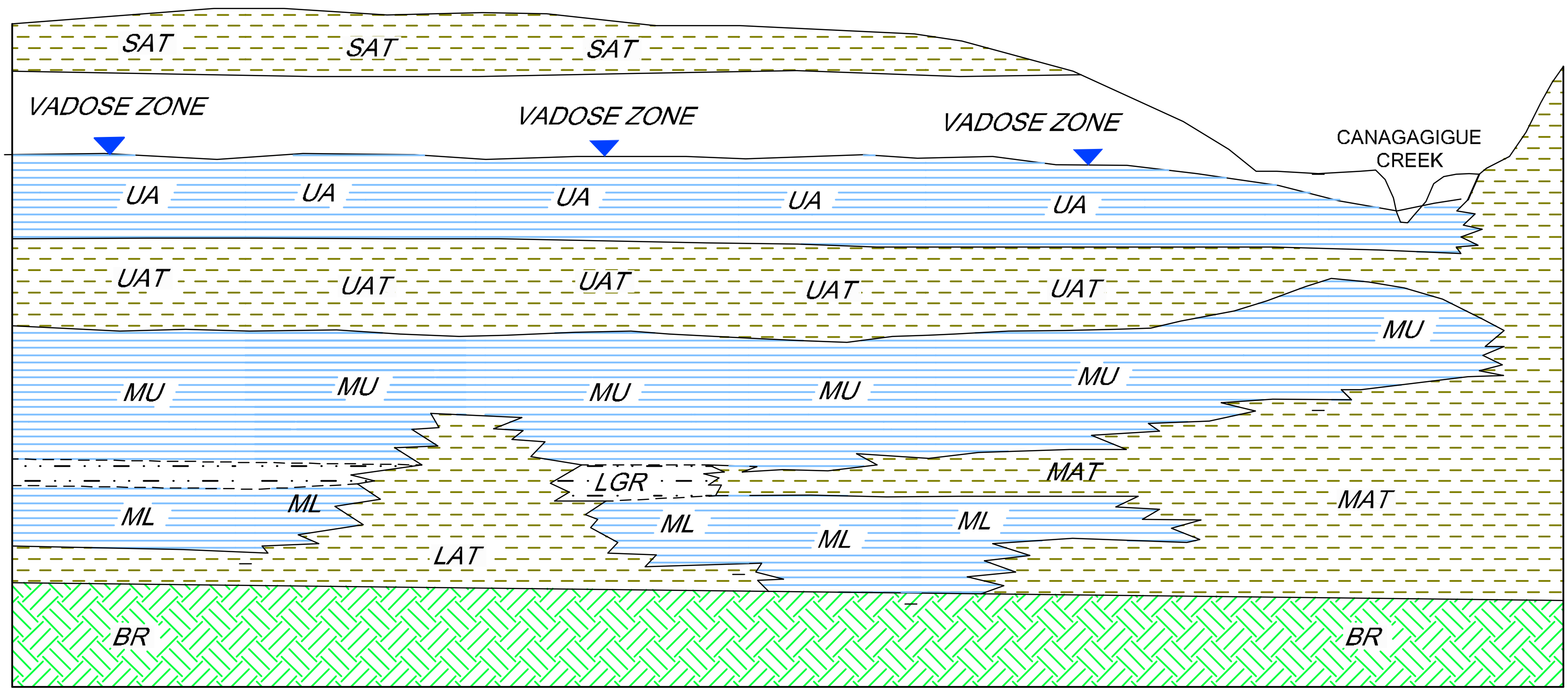


SOURCE: CH2M HILL DWG. 9 CROSS SECTION F-F'

figure 3c

CROSS SECTION F-F'
HYDROGEOLOGIC INVESTIGATION
WOOLWICH BIO-EN FACILITY
Elmira, Ontario

46254-07(MEMO005)GN-WA001 DEC 08/2009



HYDROGEOLOGICAL UNIT

SAT SURFICIAL AQUITARD
UA UPPER AQUIFER
UAT UPPER AQUITARD
MU MUNICIPAL AQUIFER
MAT MUNICIPAL AQUITARD
LGR LOW GAMMA-RESISTIVITY ZONE
ML LOWER MUNICIPAL AQUIFER
LAT LOWER AQUITARD
BR BEDROCK AQUIFER

figure 4

SCHEMATIC CONCEPTUAL HYDROGEOLOGIC MODEL
HYDROGEOLOGIC ASSESSMENT
WOOLICH BIO-EN FACILITY
Elmira, Ontario

CRA

SOURCE: CRA, CROMPTON OPTIMIZATION STUDY
REPORT FIGURE 3.1

46254-07(MEMO005)GN-WA005 DEC 04/2009

ATTACHMENT A

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER KIT 29307.DO	WELL NUMBER CH 3	PAGE 1 OF 2

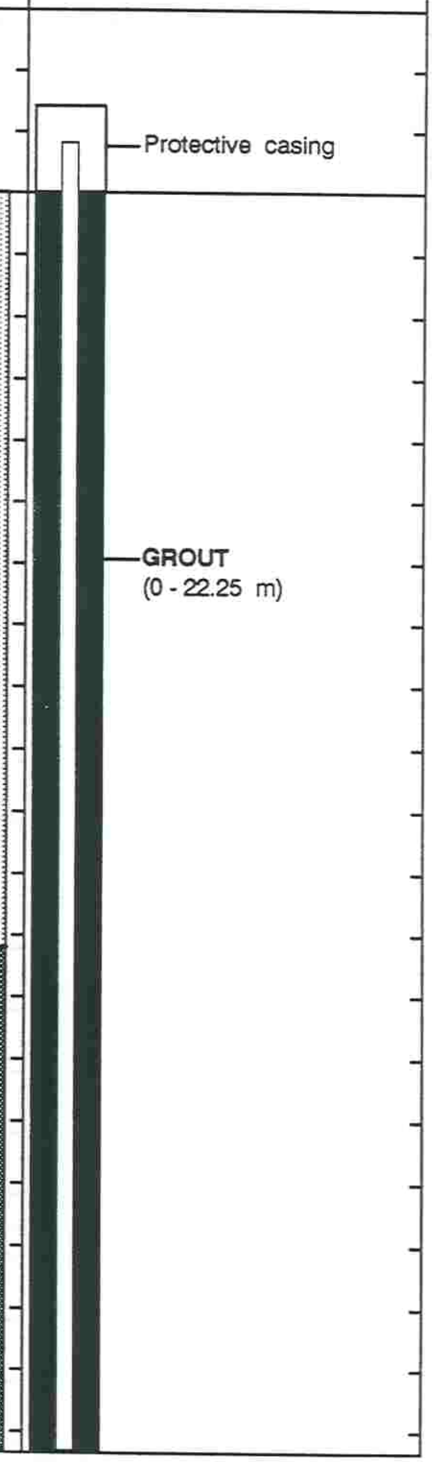
MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: Martin Feed Mill Property
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.

DATE: 12/01/90
LOGGER: Ken Baxter
ELEVATION: -GROUND SURFACE: 351.75 m
-TOP OF RISER PIPE: 352.56 m

DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DEPTH BELOW SURFACE (METRES)		SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL& GRADATION, GROUT INTERVAL, ETC.
2 4 6 8 10 12		**SAND & GRAVEL & LAND FILL** (0 - 12.19 m) Railroad bed cinders at 6.10 m poor sample recovery	GROUT (0 - 22.25 m)
14 16 18 20		**GLACIAL CLAY TILL** (12.19 - 28.96 m) clay rich - 60% with fragment of limestone, sand & rounded pebbles	



CH2M HILL ENGINEERING LTD.	PROJECT NUMBER KIT 29307.DO	WELL NUMBER CH 3	PAGE 2 OF 2
	MONITORING WELL DRILLING & CONSTRUCTION LOG		

PROJECT: Elmira / St Jacobs
CLIENT: Region of Waterloo.
LOCATION: Martin Feed Mill Property
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
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ELEVATION: -GROUND SURFACE: 351.75 m
-TOP OF RISER PIPE: 352.56 m
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DEPTH BELOW SURFACE (METRES): 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42

SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS

GLACIAL TILL

(continued from previous page)
increased clay content

SAND HORIZON (23.97 - 24.69 m)

GLACIAL CLAY TILL
(12.19 - 28.96 m)

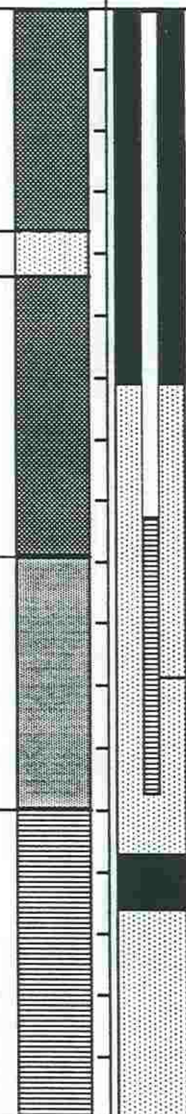
(same unit as above)
50 - 60% clay in coarse fraction

COBBLE CLAY TILL
(28.96 - 32.92 m)

reduced amounts of clay

BEDROCK
(32.92 - 38.1 m)

blue shale



WELL CONSTRUCTION

CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL& GRADATION, GROUT INTERVAL, ETC.

BENTONITE SEAL
(22.25 - 26.06 m)

FILTER PACK
(26.06 - 33.68 m)

SCREEN
(28.19 - 32.77 m)

BENTONITE SEAL
(33.68 - 34.59 m)

SAND PACK
(34.59 - 38.1 m)