Royston and Union Bay Sewage Study:

Effects of Onsite Sewage Systems on Water Quality

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Prepared for

Comox Valley Regional District
Courtenay, BC

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1. Introduction

This 53-page report reviews the effects of onsite sewage systems in Royston and Union Bay. *This report is subject to the attached Statement of General Conditions (Appendix 7).*

1.1 Project Background

Royston and Union Bay are unincorporated suburban communities comprising approximately 1400 properties, located south of Courtenay, in the Comox Valley Regional District. The Study Area comprises the higher density areas of Royston and Union Bay (See Figure 1). Each developed property has an onsite sewage system. There are no private communal or municipal sewage systems in the study area.

Prior to this study, some reports had suggested that a number of the onsite sewage systems were failing or functioning poorly. In response, the Regional District is considering building one or more municipal sewage systems to serve all or parts of this area. The main purpose of this study is to evaluate how well existing septic systems are functioning and advise on the benefits of installing a municipal sewer in Royston and Union Bay. This study uses shallow ground water quality as a measure of the effectiveness and performance of septic systems. The basic principle is that a properly functioning septic system will protect the quality of downslope ground water. A poorly functioning, or failing, septic system will pollute ground water, or surface water, downslope from the drainfield. The most common pollutants of concern are pathogenic bacteria and viruses, and nitrate.

1.2 Study Purpose and Objectives

The objectives of this study are as follows.

1) Dig test holes, install monitoring wells, and collect ground water samples to test for sewage pollutants.
2) Use the results to identify areas where onsite sewage systems have failed to protect water quality.
3) Evaluate the rate of failure of sewage systems in the Study Area.

1.3 Study Limitations

This is a regional study; it does not evaluate soil conditions or conditions of sewage systems on any specific property. The sampling wells were located on public roads. The methodology of this study is considered conservative. The testing will tend to underestimate the number of failures, for two reasons:

1) Since the sampling wells are on public property, they are expected to be at least three metres (10 feet) away from the nearest onsite sewage system, and may not be located directly downslope from the nearest system.
2) Wells were sampled in April of 2009. April is typically a dry month. April of 2009 followed an unusually dry winter of 2008-2009 (See Appendix 3). In general, more sewage systems will fail during the wet winter months, especially December and January.

2. Background Information

2.1 Scope of this Review

During March and April of 2009, PEG (Payne Engineering Geology) reviewed the performance of onsite sewage systems in Royston and Union Bay. This study included the following main activities:

- Consultation with Comox Valley Regional District, Koers and Associates Engineering, Vancouver Island Health Authority, Environment Canada, Fisheries and Oceans Canada, and the Royston and Union Bay Improvement Districts.
- Review of background maps and reports (Appendix 2).
- Dividing the overall study area into 23 sub-areas, with 55 to 70 properties in each sub-area.
- Selecting locations for test holes in the lower elevations of each sub-area.
- Checking for buried utilities (water, gas, telephone, electrical) at the selected test hole sites.
- Selecting a workable site for each test hole.
- Digging test holes to the depth of the water table, or to the deepest depth practicable with hand tools.
- Logging the soil profile.
- Installing shallow 50-mm diameter sampling wells.
- Purging the wells and measuring water characteristics (temperature, pH, electrical conductivity).
- Collecting two sets of water samples for lab analysis.
- Submitting samples to North Island Laboratories for Escherichia Coli analysis.
- Using test strips for approximate analysis of samples for nitrate.
- Analysis and reporting of the results.

Appendix 2 summarizes the procedures and test methods used in this study.

2.2 Geography and Infrastructure

The Study Area (Figure 1) includes about 1400 properties, with a current population of about 3500. Most of the land use is suburban residential, with some commercial and industrial uses. The following is an overview of land uses (from Comox Valley RD):

1) Royston: Mostly suburban or rural residential use. A few properties with industrial use. A few commercial properties, mainly retail.
2) Gartley Point to Hart Creek: Mostly suburban residential. A few light industrial properties. Two tourist commercial properties.
3) Large parcels west of Highway 19A, the old Island Highway: Forestry use, zoned as Rural.
4) Union Bay: Mostly suburban residential. A few commercial and light industrial properties. One property, at 5648 Third Street, has multi-family housing.
5) Garvin Road: Suburban residential use, zoned as *Country Residential*.

In the higher density suburban areas, the lots are very small by onsite sewage system standards, commonly 0.04 to 0.15 hectares (400 to 1500 square metres). In the lower density, sub-rural areas, the lots are commonly 1.0 to 2.0 hectares in size. Within the Study Area there are a few large undeveloped parcels in the range of 10 to 300 hectares.

More information about existing and planned land use in Royston and Union Bay can be found in the Local Area Plans on the following two web sites:

http://www.comoxvalleyrd.ca/section_complan/content.asp?id=218&collection=14

http://www.rdcs.bc.ca/section_complan/content.asp?id=216&collection=14

The Royston and Union Bay Improvement Districts provide water to most properties in the Study Area, with the notable exception of the large undeveloped properties west of Highway 19A (the old Island Highway).

Most properties have onsite sewage systems consisting of a septic tank, gravity distribution box, and conventional septic field. A few properties have a Type 2 or Type 3 sewage treatment system. Several properties have a pump tank with a pressure distribution drainfield or a sand mound.

The Comox Valley Regional District has proposed building a new sewage system for Royston and Union Bay, and is considering a range of options for the layout and design, potentially including one or more community sewage treatment plants, or connecting to the existing Courtenay system, or both. The project engineers, Koers and Associates, are also considering a range of options for discharge or re-use of the treatment plant effluent.

2.3 Geologic Setting

The following table is an overview of the physical setting of Royston and Union Bay, based on regional maps and background reports, and our site reconnaissance.

Table 1
Geologic Setting of Royston and Union Bay

Elevation:	Sea level to approximately 60 metres (upper Union Bay). *From topographic maps.*
Land slope:	Coastal areas, east of Hwy 19A, are strongly sloping and gently rolling, with typical slopes of 3% to 20%. Inland areas are mostly undulating or rolling topography, with common slopes of 1% to 10%. The main exceptions are the Trent River and Hart Creek valleys, with steep slopes ranging from 30% to more than 60% (Jungen, 1985).
Water bodies:	The main "receiving waters" in the Study Area are: (1) Baynes Sound; (2) Trent River; and (3) Hart Creek (See Figures 1 and 2, Appendix 6). Minor mapped water bodies include Roy Creek, Copeman Creek, and Beacon Creek. Readily available water resource mapping does not show any major wetlands within the Study Area. *From BC Water Resources Atlas (2009) and Comox Valley Project Watershed Society (2009).*
Soils mapping:	In this Study Area, the most common soil associations include: (1) Ronald soil group, sub-group 2: Gravelly loam. A flow-restrictive, cemented horizon is present at depth 60 to 100 cm. A shallow water table is common, often observed at a depth of 40 to 80 cm. (2) Ronald soil group, sub-group 1: Gravelly loam. A flow-restrictive, cemented horizon is present at depth 60 to 100 cm. The seasonal high water table is commonly observed at a depth of 40 to 80 cm. Minor, or less common, soil associations are: (3) Bowser soil group: Loamy sand and gravelly sandy loam. Overlies silty or clayey soils. A shallow seasonal high water table is common, at depths of 50 to 70 cm. (4) Chemainus soil group: Present near Gartley Point and Union Point. Loam or silt loam. Moderately well drained deposits on the deltas of Trent River and Hart Creek. There are few mapped deposits of sand and gravel in the Study Area, with the notable exception of the delta of the Trent River, and higher elevation terraces along the Trent River. *From Surficial Geology of Courtenay (Fyles, 1960) and Soils of Southern Vancouver Island (Jungen, 1985), with added notes from PEG project files.*
Rock outcrops:	None seen. *From site reconnaissance, April 2009.*

EBA Engineering (Ma and Bayne, 2008) mapped the suitability for soil-based sewage treatment in the whole of the Comox Valley Regional District, including the Royston and Union Bay areas. That study concluded that most of this Study Area has very poor potential for onsite sewage systems.

2.4 Reported Problems with Sewage Systems in Royston and Union Bay

Most of the homes in Royston and Union Bay were built before the BC Sewage Disposal Regulation of 1985. As a result, the septic systems were built without analysis of the soils, proper designs, sewage permits, or checks by health inspectors. These systems would not meet current standards, as outlined in BC's Sewerage System Standard Practice Manual.

Several reports have referred to failures of old on-site systems within our Study Area (Stanley, 1996; Crane, 1996; BC Environment, 1999; BC Sustainable Resource Management, 2002; Cross, 1996). Several of the people interviewed also referred to failures of old septic systems in the higher-density areas as the main liquid waste problem facing this community (Dave Cherry of Upper Island Health Unit; Brenda Norris of Comox Valley CARE; Bert Kooi of Environment Canada).

Small lots are part of the problem. The design of an onsite system is site-specific, so it is hard to define an exact minimum size of building lot needed. However, as an illustration, a typical Type 1 treatment system (septic tank) and drainfield would be suitable for a property that is larger than 1200 square metres whereas, in this area, many of the older building lots are smaller than 1200 square metres. As a result, some homeowners have constructed relatively expensive Type 2 or Type 3 treatment systems, in order to fit the sewage system to their property. VIHA (Vancouver Island Health Authority) recommends minimum lot sizes of 2000 square metres, even for lots with the most favourable soil conditions.

The following is a summary of an interview with Mr Dave Cherry, Environmental Health Officer with VIHA, in which he describes general soil and sewage system conditions in Royston and Union Bay:

1) Many recently installed onsite sewage systems use a sand mound because of the shallow water table.
2) Many properties have a thin veneer (20 to 40 cm) of moderate-permeability soils overlying a shallow, flow-restrictive horizon, consisting of clay-rich soils or glacial till.
3) Several properties have suspected wintertime hydraulic failures, resulting in surfacing of poorly-treated effluent in drainage ditches.
4) He has noted several failing or malfunctioning sewage systems along Warren, Royston, and Ronald Roads in Royston.
5) Many new land developments, with houses less than 20 years old, have had few known failures to date.
6) Most of the properties are too small to provide for a properly functioning onsite sewage system.
7) Referring to VIHA's sewage system standards (VIHA, 2003), a lot with an onsite sewage system should be at least 0.3 hectares (0.75 acre), based on a water table depth of at least 90 cm. In the case of properties with a water table shallower than 46 cm, VIHA standards recommend a lots size of at least 2.0 hectares (5 acres).

Dave Cherry, 21 September 2001.

2.5 Reports on Water Quality and Shellfish Harvesting

Several areas of the Baynes Sound foreshore are closed to shellfish harvesting as a result of fecal contamination, including the Royston and Union Bay shorelines (Fisheries and Oceans Canada, 2009). Some studies have suggested that treatment failures of septic systems contribute to this contamination.

In 1996, the British Columbia Shellfish Growers Association engaged Mr. Stephen Cross of Aquametrix Research Limited to study water quality in Baynes Sound, focussing on south Baynes Sound (Cross, 1996). Relevant conclusions of the Aquametrix report are quoted below.

Over the past few years Baynes Sound has experienced increased water quality deterioration which has been attributed to non-point source (NPS) pollution. This marine water quality impact has resulted in a direct impact on the production of shellfish in this unique coastal region of the province. Continuing urbanization of the Courtenay-Comox region of Vancouver Island in anticipated to result in a further increase of diffuse sources of contaminant inputs to the Sound, and (without mitigative action) to a continued decline in water quality for the region and a further, measurable impact to the shellfish culture industry which relies on pristine growing water conditions.

Aquametrix studied potential sources of fecal matter entering Baynes Sound near Union Bay, and concluded that the problem 'is likely associated with septic fields (human feces).' The Aquametrix study did not, however, include a similar review of the Royston situation.

During an earlier study in 2001, Mr Bert Kooi, a Program Microbiologist with Environmental Canada's Shellfish Lab in Vancouver, reviewed his knowledge of water quality problems in Baynes Sound. Mr Kooi described problems with old septic systems in Royston, and some very high fecal coliform bacteria counts along the Royston shoreline, even during the dry season, when stormwater is not a contributor. Mr Kooi suggested that failing on-site sewage systems are a major contributor of fecal matter to the Sound, especially during the dry season. He had hoped that fixing cross-connections in Courtenay reduce fecal coliform bacteria counts in Baynes Sound, but recent fecal coliform counts still exceed acceptable levels. Other sources of fecal matter are considered small compared with failing septic systems. There is little agriculture near the shoreline, and few marine mammals, and only a moderate number of birds in the area. By eliminating other fecal matter sources as likely causes of the problem, Mr Kooi concluded that septic systems are the main cause. Results of regular sampling of Roy Creek and Trent River showed higher fecal coliform counts at the mouth than upstream, pointing to septic systems as a source, rather than agricultural runoff. However, Mr Kooi felt there was a lack of good evidence linking the water quality problems to failing on-site systems. He would like to see some dye tests, or other tests and analysis, to link the two problems.

In 2002, the BC Ministry of Sustainable Resource Development reported that:

A significant portion of Baynes Sound waters have been subjected to bacterial contamination from a variety of upland sources such as sewage and agricultural runoff. Harvesting shellfish in Baynes Sound is under a sanitary management Plan overseen by Fisheries and Oceans Canada and the Canadian

Food Inspection Agency.

Sound waters have experienced increasing pollution related to rural and urban development and these have affected the area available for shellfish aquaculture. Of the 8,500 hectares in Baynes Sound, 2091 hectares (25%) are affected by Sanitary Shellfish Closures. Seasonal closures also affect the majority of the Sound. Causes include runoff from agricultural areas, faulty sewage disposal in residential areas and microbial contamination from activities around nearby commercial and recreational wharfs.

3. Sewage System Evaluation Based on Water Quality

3.1 Soil Analysis

Previous Test Holes

There are few, if any, publicly available studies with test holes describing or evaluating the soil profile on private properties in the study area. Regional soils and geology maps provided some information on the typical soil profile for the region.

Soil Profile

This study involved digging 23 test holes. The location of each test hole, and monitoring well, was selected to represent an area of 55 to 70 properties. As a result, test holes are closely spaced in areas of higher housing density. Appendix 4 includes logs of the soil profile in the test holes. Figure 2 shows locations of the test holes. Test hole logs show the following typical conditions:

- Gravelly to very gravelly sand, loamy sand, or loam.
- Consistence (rupture resistance) of loose to friable.
- Root depth typically 25 to 70 cm.
- Seepage observed at depth 10 to 60 cm.
- Typically overlies a firm to very firm silty clay loam.

In our interpretation, the typical seasonal high water table occurs at a depth of 10 to 60 cm.

Monitoring Wells

For water sampling, PEG installed a 50-mm diameter monitoring well in each test hole. Refer to Appendices 2 and 4 for details on well materials and installation methods.

3.2 Sampling and Testing of Ground Water

This study evaluated ground water quality as an indirect way to evaluate how well existing septic systems are treating wastewater. We tested monitoring wells for the most common wastewater pollutants, Escherichia Coli bacteria (a general indicator for pathogenic microorganisms), and nitrate nitrogen. The test results provide a reasonable overview of ground water quality at the time of the study, but will not accurately reflect water quality at other times of the year.

On April 6 and 7, 2009, we purged the wells, measured field parameters, and collected a duplicate set of samples from 19 of the monitoring wells. The other four wells were either dry, or contained insufficient water for sampling. Appendix 2 details our sampling and testing methods, and Appendix 4 contains details of well purging and sampling. Appendix 5 lists field measurements and laboratory analyses.

3.3 Ground Water Quality and Effects of Sewage Systems

This study involved 23 shallow monitoring wells. Two wells (TH-2 and TH-10) contained no water because of a deep water table at the time of sampling, in April 2009. For the failure analysis, these two wells were rated as a "pass" because the deeper water table indicates more favourable conditions for onsite sewage systems.

Two wells (TH-13 and TH-23) contained insufficient water to sample because of very slow seepage into the well. Because of insufficient data, these wells were not used for the failure analysis. One well (TH-15) is located in an undeveloped area upslope from the developed part of Royston, and was used as a background well. It was not used for the failure analysis.

As a result, 20 wells were used for the failure analysis, the 18 that were sampled, plus the two wells with a deep water table. These monitoring wells are down-slope from developed areas with septic systems.

The ground water quality was classified as "fail" if the E.Coli count was greater than 14 MPN / 100 mL, or if the nitrate nitrogen was greater than 10 mg/L. All of the monitoring wells met had nitrate less than 10 mg/L. However, 5 of the 20 monitoring wells failed to meet the E. Coli criterion. The water quality was classed as "pass" if the E.Coli count was less than 14, or if the water table was too deep to sample. By this criterion, 15 of the 20 wells passed (see Appendix 5 and Figure 2).

The project-specific criterion for E. Coli (less than 14) is based on the criterion for ambient water quality in shellfish harvesting waters. The project criterion for nitrate nitrogen (less than 10 mg/L) is based on the drinking water criterion. There is no water quality criterion for nitrate in shellfish harvesting waters. In general, a properly functioning septic system should be able to meet both of these criteria in monitoring wells located down-gradient from the septic field. In a similar study near Cape Lazo, for example, all of the wells sampled met these criteria.

The overall failure rate for the Royston and Union Bay area was 25%, based on ground water sampling in April of 2009.

The monitoring wells were sampled during a dry month, April 2009, following a dry winter (See Appendix 3 for weather records). During December or January of a typically wet winter, we would expect to see a higher failure rate, in our estimation, 35% to 50%.

The failure rate did vary between neighbourhoods. In Royston, the measured failure rate was 10%. In the neighbourhoods between Royston and Union Bay, from Briardale Road south to Kilmarnock Drive, the failure rate was 33%. The one well near Spence Road (TH-18) passed. In Union Bay, from Jones Street south to Lytton Street, the failure rate was 50%. In the Garvin Road area, south of Union Bay, well TH-23 had insufficient water to sample.

In this Study Area, the interpreted background concentration of nitrate is 0.1 to 0.5 mg/L. Five of the 20 down-gradient wells showed elevated concentrations of nitrate; test holes TH-5, TH-8, TH-17, TH-19, and TH-20. However, the highest measured concentration was 5 mg/L, so all of the wells met the project criterion of nitrate less than 10 mg/L (see Appendix 5).

4. Summary and Conclusions

4.1 Evaluation of Existing Sewage Systems

This study evaluated the overall failure rate of onsite sewage systems in a Study Area that included the higher density suburban areas of Royston and Union Bay (See Figure 1). Septic system success, or failure, was tested by sampling monitoring wells installed on public property, downslope from populated areas. Wells were sampled in April of 2009, after an unusually dry winter. As a result, the study gives a low or conservative estimate of the septic system failure rate.

From this study, the overall septic system failure rate is 25%. Five of the twenty monitoring wells tested indicated significant contamination with E. Coli bacteria, higher than 14 MPN / 100 mL.

Five of the twenty monitoring wells tested showed nitrate concentrations elevated above background levels, but all wells had nitrate concentrations less than 10 mg/L, the protect criterion for nitrate.

It is reasonable to predict that the failure rate would be higher during December or January of a typically wet winter. In our estimation, the failure rate could reasonably be 35% to 50% during rainy weather, when the water table is shallower.

The highest failure rate, 50%, was recorded in Union Bay. As a result, we recommend that the Regional District focus on Union Bay as the first priority for a new community sewer system.

The problems with failing septic systems can be solved using a new community sewer system, or by upgrading old onsite sewage systems. Upgrading of onsite systems is a workable and economical option for larger lots, particularly larger than 4000 square metres (one acre). However, for lots smaller than about 2000 square metres, it is often expensive to upgrade and maintain onsite sewage systems.

4.2 Problems With Existing Sewage Systems

In this Study Area, failures of onsite sewage systems are relatively common, particularly in Union Bay. This study did not include interviews with homeowners or inspections of individual sewage systems, but did find that, in general, the treatment failures resulted from a combination of:

1) small lots, many less than 2000 square metres
2) a shallow winter water table, shallower than 45 cm (18 inches) in some areas
3) inappropriate designs including, in some cases, drainfield trenches set deeper than the water table
4) undersized septic tanks and drainfields
5) lack of maintenance
6) aging systems in need of repair or upgrade (some systems are about 50 years old)

4.3 Benefits of a Municipal Sewage System in this Area

This study found a septic system failure rate of at least 25% in the Study Area, including Royston and Union Bay. Other studies have reported that sewage system failures in Union Bay contribute to fecal contamination on the shoreline of Baynes Sound (Crane, 1996: Cross, 1996; BC Sustainable Resource Management, 2002). As a result, a new sewage system serving this area should lead to a marked improvement in water quality along the shoreline of Baynes Sound.

For homeowners with small lots and a shallow winter water table, an upgraded onsite sewage system will likely include a treatment plant, pump and pump tank, and a sand mound. These types of onsite sewage systems can be highly effective, but commonly cost $20,000 to $40,000. For these homeowners, a municipal sewage system is an inexpensive alternative.

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Appendix 2: Study Methodology

This appendix reviews the process, rationale, methods, and materials used in this study.

1 Divide the study area into 23 sub-areas

1.1 Rationale: The project budget allowed for installing and sampling 20 to 25 wells. The study area includes about 1410 properties, so this is equivalent to one well for every 56 to 70 properties. The study design was intended to provide one well that may be considered representative for each sub-area.

1.2 Methods: Desk-top exercise.

1.3 Materials: Property maps obtained from the Comox Valley RD web site.

2 Select sites for test holes

2.1 Rationale: Test hole locations were selected at the lower elevation or "bottom end" of each sub area. The intent is to locate the wells so they sample treated wastewater from up-slope septic fields.

2.2 Methods: Desktop exercise.

2.3 Materials: Topographic maps and aerial photographs obtained from the Comox Valley RD web site.

3 Check for buried utilities at each test hole site

3.1 Rationale: The plan was to dig test holes by hand, so it might not be necessary to check for buried utilities at test hole sites. However, as a precaution, we checked for buried utilities at the locations that we selected from the desktop exercise above.

3.2 Methods: We faxed a list of test holes sites to BC One Call. In response, we received email memos and maps from BC Hydro, Terasen Gas, and BC Tel. To check for buried water lines, we contacted the Royston and Union Bay Improvement Districts directly and viewed their as-built drawings of water line locations. We noted the locations of buried utilities on our field maps and, where practicable, we located our test holes on the opposite side of the street from the buried utilities.

3.3 Materials: Project base maps.

4 Select a site for each test hole

4.1 Rationale: After selecting test holes sites on maps, we needed a reconnaissance to select workable sites for each test hole. The sites needed to be accessible, have a reasonable prospect of reaching the water table by hand digging, no obstruct public use of the road or right-of-way, and not cause unsightly damage. At many locations, the test hole site is in the sloping side wall of a drainage ditch, between the bottom of the ditch and the adjacent private property. In these cases, the water level in the well is at a higher elevation than the water level in the ditch, so that the well intercepts seepage, and cannot intercept ditch water.

4.2 Methods: This is basically an exercise in judgement; at some sites, we observed the vegetation and soil moisture for clues to locations with a shallow water table.

4.3 Materials: Base maps.

5 Dig test holes

5.1 Rationale: The purpose of the test holes were to log the soil profile and to install monitoring wells.

5.2 Methods: Holes were dug by hand to avoid or limit damage to buried utilities.

5.3 Equipment and materials: Shovel, digging bar, 15 cm diameter hand auger, 7 cm diameter hand auger. UTM coordinates from Lowrance iFinder GPS.

6 Log the soil profile

6.1 Rationale: The purpose was to record the typical soil profile in the lower elevations of each of the 23 sub-areas. However, it should be noted that several of the test holes were located in side walls of drainage ditches and, as a result, do not record the upper horizons of the soil profile.
6.2 Methods: Soil description according to ***Field Book for Describing and Sampling Soils, Ver 2.0*** (Schoeneberger, 2002).
6.3 Materials: None.

7 Install sampling wells

7.1 Rationale: Where feasible, holes were dug to a depth of about 30 cm below the water table, to allow for repeated sampling of slow recharging wells. Wells were installed in a manner suitable for single samples, rather than for long-term monitoring wells, and using a simple design that meets the needs of the project budget. The wells used short sections of slotted PVC well casing with no sand filter or filter fabric, and not bentonite seal. This design was appropriate for this study because no surface runoff was observed during the sampling program, so surface annular seals were not needed to isolate the shallow ground water from surface water runoff.
7.2 Methods: At each well site, we built a 50-mm diameter PVC well using a bottom slip cap, slotted well screen, 50-mm diameter pipe, and threaded cap. We did not use solvent cement to join the caps. Top caps were tightened with pipe wrenches to prevent tampering. The annular space was back-filled with native soil. Field notes in Appendix 4 indicate the depth of the well screen in each well.
7.3 Materials: The wells used 50-mm diameter Schedule 40 PVC pipe. The well screen was machine cut with 0.25 mm slots. The well screen and well casing had ASTM F480 threaded ends with O-ring seals (RST Instruments, Coquitlam).

8 Purge wells and measure water characteristics

8.1 Rationale: The wells were purged to remove fine sediment from the well (well development) and to purge the well of stagnant well water that would not be representative of the ground water.
8.2 Methods: Rather than purging a set number of well volumes, we used the more reliable purging technique of measuring field parameters and purging the well until those parameters stabilize, or until the well is purged dry. Purging methods conformed with ***Practical Handbook of Ground-Water Monitoring*** (p. 466). We recorded the number of well volumes purged and the water parameters (See Appendix 4). The water quality meter was calibrated the day before the purging, using Hanna pH and EC calibration buffers. Sampling technicians washed their hands before and after each purging and sampling activity. Purged water was disposed to the nearest downslope drainage ditch.
8.3 Materials: Each well was purged and sampled using a new, dedicated, one-litre weighted PVC bailer. Field parameters were measured using a Hanna HI 98129 pH/EC/TDS/temperature meter.

9 Collect two sets of water samples

9.1 Rationale: The purpose of the second set of samples was to confirm the first set of results to provide a statistically meaningful data set. Results in Appendix 5 show that each duplicate sample was within one order-of-magnitude (a factor of ten) of the first sample, which was considered to be accurate for analysis of bacteria in ground water, which is notoriously unstable. For example, if testing of the first sample showed a bacteria count of 49, the acceptable range for a reliable second sample would be 5 to 490. A bacterial count outside this range would suggest unreliable sampling and indicate a need for additional well purging and sampling. In this study, the second set of laboratory results confirmed the reliability of the sampling and testing procedure as an accurate representation of the bacterial quality of the ground water on the date of the sampling. The number of samples was limited to two per well as a result of the project budget and schedule, as set by the Regional District.
9.2 Methods: Samples were collected from purged wells using the PVC bailers and bottom-emptied into sample bottles provided by the laboratory. Water samples were kept in a cooler and were delivered to North Island Laboratories within 24 hours of sampling.
9.3 Materials: PVC bailers. 200 mL HDPE sample bottles, with preservative, provided by North Island Laboratories.

10 Submit samples to a laboratory for Escherichia Coli analysis

10.1 Rationale: Escherichia Coli is commonly used as an indicator of fecal contamination from onsite sewage systems. Some research suggests that E. Coli is preferable to fecal coliform bacteria as a fecal indicator (Health Canada, 1996). The threshold criterion set for this project is median E. Coli less than 14 per 100 mL. This is the Canadian ambient water quality criterion for shellfish harvesting. Considerable research has shown that a properly functioning onsite sewage system can and should meet this criterion immediately downslope from the drainfield. Therefore, a sample bacterial count exceeding this is a positive indicator of fecal contamination from some source not necessarily, but most likely, from the nearest upslope septic system.

10.2 Methods: North Island Laboratories (Courtenay) tested the samples for E. Coli using the Most Probable Number (MPN) standard method. The lab provided the following information on internal laboratory quality assurance and quality control protocols: *Quality procedures are used to monitor method performance for all samples analysed at North Island Labs. Our Quality Control procedures include: (1) a method blank, a blank which undergoes processing identical to that carried out for the samples, (2) a sample duplicate, two sub-sampled portions of the same sample, analyzed by the same method, and (3) a reference sample, accompanied by a certificate.*

10.3 Materials: As selected and used by North Island Laboratories.

11 Use test strips for semi-quantitative analysis for nitrate

11.1 Rationale: The main objective of this study was to measure fecal contamination of shallow ground water. However, onsite sewage systems can sometimes cause elevated or even harmful concentrations of nitrate-nitrogen in ground water. This was a secondary objective because there are few, if any, drinking water wells located downslope from the study area. Since this was a secondary objective of the study, and since the nitrate was used as a general indicator or tracer of septic system contamination, we used a semi-quantitative test method involving test strips.

11.2 Methods: Samples were collected in clean jars, about 200 mL per sample. Nitrate nitrogen was tested using test strips. If the test strip reader found a nitrate concentration greater than 3.0 mg/L, then the water sample was re-tested by a second person to confirm or modify the test result.

11.3 Materials: 500 mL food-grade plastic jars (polyethylene terephthalate). Test strips from Industrial Test Systems, South Carolina, USA.

Appendix 3: Weather Records

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Consulting Engineers

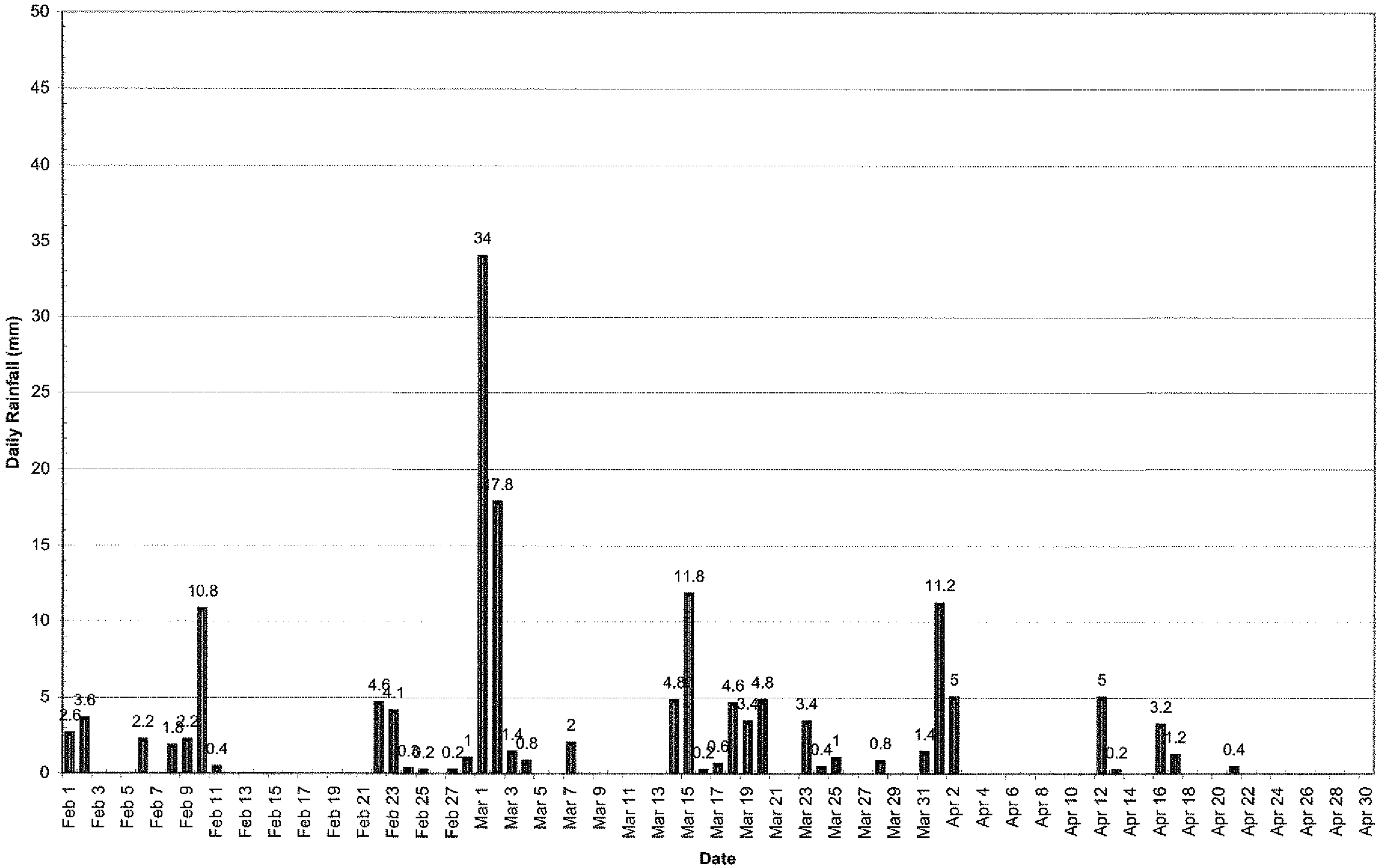
Monthly Rainfall, Comox Airport (mm)

Month	Year															Max (mm)	Min (mm)	Average (mm)
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009			
Jan	245	144	152	257	232	123	92	165	222	208	140	295	134	153	55	295	55	174
Feb	100	129	48	152	322	90	59	105	17	93	33	112	116	46	34	322	17	97
Mar	179	135	200	75	123	85	73	85	175	56	110	150	82	57	93	200	56	112
Apr	60	97	80	22	24	22	47	54	145	19	111	43	86	30	26	145	19	58
May	34	46	76	38	54	27	29	23	28	23	79	30	22	29		79	22	38
Jun	42	15	93	35	41	37	21	35	20	13	40	21	69	29		93	13	36
Jul	35	27	26	27	28	33	13	19	6	10	36	11	31	26		36	6	23
Aug	60	14	60	7	27	7	34	24	2	44	35	6	25	47		60	2	28
Sep	22	79	137	3	18	20	35	27	19	103	26	61	72	17		137	3	46
Oct	111	160	222	103	79	155	96	27	197	155	185	35	125	123		222	27	127
Nov	307	122	141	359	251	91	261	179	83	155	108	354	181	132		359	83	195
Dec	241	216	143	226	126	122	221	229	255	179	218	240	208	138		255	122	197
Total	1,437	1,183	1,378	1,303	1,326	813	982	972	1,168	1,059	1,120	1,357	1,150	827	209	1,437	813	1,148
May - Sept	193	180	391	109	169	124	131	127	75	193	215	129	218	148		391	75	172
May - Aug	172	102	254	106	151	104	97	100	56	91	189	68	146	131		254	56	126
Sept - Jan	825	729	900	924	597	481	778	685	763	732	831	825	739	466		924	466	734
Sept - Feb	954	777	1,052	1,246	687	540	883	701	855	765	943	941	785	500		1,246	500	831
Sept - Mar	1,089	977	1,127	1,369	772	613	968	876	911	876	1,093	1,023	842	593		1,369	593	938
Sept - Apr	1,186	1,057	1,149	1,393	794	660	1,022	1,021	931	987	1,135	1,109	872	619		1,393	619	995
Jan - Apr	584	504	480	506	701	320	272	409	558	376	395	599	418	286	209	701	209	441

Updated to include rainfall for April 30, 2009

KOERS & ASSOCIATES ENGINEERING LTD.
Consulting Engineers

Comox Airport Daily Rainfall, February, March, April 2009



Updated to include: April 30, 2009

Appendix 4
Test Hole Logs, Well Construction, and Purging Records

General Information

Location:	*Royston and Union Bay, Comox Valley Regional District, BC*
Dates:	*Test holes dug 3 - 4 April and 6 April, 2009. Well purged and sampled on 6 - 7 April, 2009.*
Methods:	*See Appendix 2.*
Logged by:	*Michael Payne, P.Eng., P.Geo., and John Langard, ROWP (i.t.)*
Locations:	*See Figure 2, appended.*
Completion:	*50-mm PVC monitoring well installed in each test hole.*

General Notes

Soil classification is based on ***Field Book for Describing and Sampling Soils, Version 2.0*** (Schoeneberger et al, 1998). Coarse gravel (%) is defined as portion of soil consisting of particles larger than 19 mm (3/4 inch).
Some of these test holes were dug in a ditch side wall, to intercept ground water seepage. Therefore, those logs do not describe the true soil profile; the upper part of the soil profile was removed while digging the ditch.

Abbreviations used on test pit logs

USDA Texture Prefixes
- V. - Very

Structure
- sg - single grain
- m - massive
- gr - granular
- abk - angular blocky
- sbk - subangular blocky
- pl - platy
- pr - prismatic
- cpr - columnar

USDA Consistence
(rupture resistance)

- L - loose
- VFR - very friable
- FR - friable
- FI - firm
- VFI - very firm
- EF - extremely firm
- SR - slightly rigid
- R - rigid
- VR - very rigid
- S - soft
- SH - slightly hard
- MH - moderately hard
- HA - hard
- VH - very hard
- EH - extremely hard
- R - rigid
- VR - very rigid

Roots
- ff - few fine roots
- fm - few medium roots
- fc - few coarse roots
- cf - common fine
- cm - common medium
- cc - common coarse
- mf - many fine
- mm - many medium
- mc - many coarse

Mottles
- fF - few faint mottles
- fD - few distinct mottles
- fP - few prominent mottles
- cF - common faint
- cD - common distinct
- cP - common prominent
- mF - many faint
- mD - many distinct
- mP - many prominent

Moisture
- sat - saturated

TH-1

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Water in drainage ditch, about one metre downslope from test hole.*

Soils Log

TH-1 Location: 3547 South Island Highway (Hwy 19A), Royston, ditch side wall. Slope: 10%

UTM 10 East: 357785 m North: 5502865 m + / - 20 m

Top of the test hole is 50 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	20	Dark brown	Gravelly loam	15	10	gr	2	friable		cm			none	moist - sat
20	30	Olive	Gravelly sandy loam	20	5	abk	2	firm	80	ff			none	saturated
30	40	Olive	Gravelly loam	20	5	m	0	VFI - EF		none	30	40	fD	moist
40		BOTTOM									Seepage at 20 - 40 cm			

Well Construction

From	To	Length	Feature	Details
- 40	- 15	25	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 15	+ 25	40	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 40	0	40	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (μS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	0.64 m	0.3	0.3	1.4	11.0	240	7.17	15:00	muddy	
	- water depth:	0.54 m									
	= water ht:	0.10 m									
	x 2.17 =	0.22 litres									
7 Apr	Sample # 1 for E. Coli and nitrate.								11:20	muddy	
7 Apr	Sample # 2 for E. Coli only								15:30	murky	

EC - Electrical conductivity.

TH-2

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *No.*

Soils Log

TH-2 Location: 3650 - 3654 S. Island Hwy, Royston, near Chinook Road allowance, ~ 2 m from prop line Slope: 10%

UTM 10 East: 358350 m North: 5502380 m + / - 10 m

Top of test hole at ground level.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	20	Dark brown	V. gravelly sand	30	20	sg	0	loose		cf			none	moist
20	35	Yellow brown	V. gravelly sand	30	20	sg	0	loose		cm			none	moist
35	75	Black	Gravelly loamy sand	20	10	gr	2	V. friable	75	fm			none	moist
75		BOTTOM									No seepage			

Well Construction

From	To	Length	Feature	Details
- 74	- 16	58	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 16	+ 28	44	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 75	0	75	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume	Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (μS)	pH	Time	Sample appearance	Note
6 Apr	well depth: 1.02 m	No water	No sample							
	- water depth: DRY									
	= water ht: 0.0 m									
	x 2.17 = 0.0 litres									

TH-3

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Located ~ 5 m upslope from large pond.*

Soils Log

TH-3 Location: Northeast of 3700 Hilton Road, near large pond, access by trail. Slope: 20%

UTM 10 East: 358895 m North: 5501850 m + / - 20 m

Top of test hole at ground level.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	30	Dark brown	V. gravelly sand	25	10	sg	0	loose	30	fc			none	moist - sat
30	45	Brown	V. gravelly sand	40	15	sg	0	loose		none			none	saturated
45		BOTTOM									Seepage at depth 10 cm			

Well Construction

From	To	Length	Feature	Details
- 44	- 10	34	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 10	+ 53	63	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 45	0	45	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	0.97 m	0.5	0.5		8.8	130	7.55	15:30	murky	
	- water depth:	0.66 m	0.5	1		7.8	115	7.54			
	= water ht:	0.31 m	1	2		7.2	110	7.54			
	x 2.17 =	0.66 litres	1	3	4.5	6.8	110	7.51			
6 Apr	Sample # 1								15:36		
7 Apr	Sample # 2								11:34		
7 Apr	Sample # 3								15:47		

TH-4

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Running water in ditch, about 1 m downslope from test hole.*

Soils Log

TH-4 Location: 3945 Marine Drive, at Warren Ave, in ditch side wall. Slope: 3%

UTM 10 East: 359515 m North: 5501405 m + / - 10 m

Top of test hole is 20 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	30	Dark brown	Gravelly loamy sand	20	10	sg	0	loose		fm			none	moist - sat
30	65	Brown	V. gravelly sand	30	20	sg	0	loose	50	ff			none	saturated
65		BOTTOM									Seepage at depth 30 - 65 cm			

Well Construction

From	To	Length	Feature	Details
- 64	- 32	32	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 32	+ 36	68	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 65	0	65	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	0.99 m	0.5	0.5		8.5	195	7.55	15:54	Murky	
	- water depth:	0.77 m	0.5	1.0		7.2	180	7.42			
	= water ht:	0.22 m	0.5	1.5		6.9	178	7.40			
	x 2.17 =	0.48 litres	1.0	2.5	5.2	6.5	182	7.34			
6 Apr	Sample # 1								16:00		
7 Apr	Sample # 2								11:43		
7 Apr	Sample # 3								15:58		

TH-5

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Flowing water in ditch, ~ 1 m downslope from test hole.*

Soils Log

\# TH-5 Location: 3849 Livingstone Road, ditch side wall. Slope: 6%

UTM 10 East: 359355 m North: 5500930 m + / - 10 m

Top of test hole is 20 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	20	Dark brown	Silt loam	< 1	< 1	gr	3	V. friable	10	cf			none	moist - sat
20	55	Olive grey	Silty clay loam	< 1	< 1	abk	2	friable - v. firm		none	20	55	cD	wet
55		BOTTOM									Seepage at depth 15 cm			

Well Construction

From	To	Length	Feature	Details
- 47	- 27	20	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 27	+ 55	82	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 55	0	55	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	1.02 m	0.75	0.75	1	9.1	300	7.27	16:11	murky	
	- water depth:	0.66 m								well purged dry	
	= water ht:	0.36 m									
	x 2.17 =	0.78 litres									
7 Apr	Sample # 1								11:51		
7 Apr	Sample # 2								16:05		

TH-6

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Running water in ditch, ~ 2 m from test hole.*

Soils Log

TH-6 Location: Little Bear Way at Livingstone Road, southwest corner, between ditch and property line. Slope: 7 %

UTM 10 East: 358965 m North: 5501235 m + / - 20 m

Top of test hole is at ground surface.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	25	Brown	Gravelly loam	20	5	gr	2	V. friable	25	cm			none	wet - sat
25	40	Brown	V. gravelly loamy sand	30	10	m	0	Extremely firm		none			none	saturated
40		BOTTOM									seepage at depth 10 cm			

Well Construction

From	To	Length	Feature	Details
- 38	- 18	20	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 18	+ 27	45	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 40	0	40	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (μS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	0.65 m	0.75	0.75	1.0	11.7	309	7.45	16:24	muddy	
	- water depth:	0.30 m								well purged dry	
	= water ht:	0.35 m									
	x 2.17 =	0.76 litres									
7 Apr	Sample # 1								11:56		
7 Apr	Sample # 2								16:12		

TH-7

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *No water in nearby ditch.*

Soils Log

TH-7 Location: 3939 Marine Drive at Forde Ave, in ditch side wall. Slope: 4%

UTM 10 East: 359790 m North: 5501150 m + / - 15 m

Top of test hole is 115 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	10	Dark brown	Loam	10	2	gr	3	V. friable		cm			none	wet
10	70	Olive	Silty clay loam	10	1	sbk	2	firm	15	fm	10	70	mD	wet - sat
70	90	Olive	Gravelly sandy loam	5	20	sbk	2	friable		none			none	moist - wet
90		BOTTOM									Seepage at depth 55 cm			

Well Construction

From	To	Length	Feature	Details
- 90	- 60	30	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 60	+ 28	88	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 90	0	90	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	1.17 m	1.0	1.0		10.7	242	7.42	17:07		
	- water depth:	0.75 m	0.2	1.2	1.3					Purged dry	
	= water ht:	0.42 m									
	x 2.17 =	0.91 litres									
7 Apr	Sample # 1								12:24		
7 Apr	Sample # 2								16:35		

TH-8

Date: *6 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Location is on the beach about 1 m above the high tide mark.*

Soils Log

TH-8 Location: Near 3851 Marine Avenue, on the beach. Slope: 6 %

UTM 10 East: 360100 m North: 5500945 m + / - 10 m

Top of test hole is at grade, on sandy beach.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	40	Olive brown	Extremely gravelly sand	60	5	sg	0	loose	40	ff			none	dry - wet
40	65	Olive brown	Very gravelly sand	30	20	sg	0	loose		none			none	saturated
65		BOTTOM									Seepage below 40 cm			

Well Construction

From	To	Length	Feature	Details
- 64	- 33	31	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 33	+ 23	56	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 64	0	64	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	0.87 m	0.5	0.5		11.0	390	8.55	17:20		
	- water depth:	0.63 m	0.5	1.0		9.5	328	8.29			
	= water ht:	0.24 m	1.0	2.0		9.1	312	8.13			
	x 2.17 =	0.52 litres	1.0	3.0	5.8	8.9	311	8.08			
6 Apr	Sample # 1								17:40		
7 Apr	Sample # 2								12:30		
7 Apr	Sample # 3								16:47		

TH-9

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Water in ditch, ~ 2 m downslope from test hole.*

Soils Log

TH-9 Location: 4019 South Island Hwy, on a deep road cut. Slope: 15%

UTM 10 East: 360290 m North: 5500710 m + / - 10 m

Top of test hole is on a road cut, approx. 200 cm below natural ground level.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	80	Yellow brown	Gravelly loamy sand	15	2	sg - sbk	0 - 2	V. friable	55	cc			none	moist - sat
80		BOTTOM									Seepage at depth 60 - 80 cm			

Well Construction

From	To	Length	Feature	Details
- 81	- 37	44	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 37	+ 35	72	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 81	0	81	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	1.16 m	0.3	0.3	1.2	8.8	235	7.29	17:52	Purged dry	
	- water depth:	1.02 m									
	= water ht:	0.14 m									
	x 2.17 =	0.30 litres									
7 Apr	Sample # 1								12:39		
7 Apr	Sample # 2								16:54		

TH-10

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *None.*

Soils Log

TH-10 Location: 257 Bartel Road, end of road allowance, near beach. Slope: 3%

UTM 10 East: 361150 m North: 5500340 m + / - 10 m

Top of test hole is at ground surface.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure Type	Structure grade	Rupture resistance	Roots Depth	Roots Quant Size	Mottles Depth from	Mottles Depth to	Mottles Quant Contrast	Moisture
0	15	Yellow brown - olive	V. gravelly sand	35	5	sg	0	loose		cm			none	moist
15	85	Dk brown - black	V. gravelly sand	30	10	sg	0	loose		ff			none	moist
85		BOTTOM	a few shells at 15 - 85 cm								no seepage			

Well Construction

From	To	Length	Feature	Details
- 86	- 50	36	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 50	+ 33	83	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 86	0	86	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	1.19 m	Dry well, no sample taken.						18:09		
	- water depth:	m									
	= water ht:	m									
	x 2.17 =	litres									

TH-11

Date: *3 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Water flowing in ditch, ~ 1 m downslope from the test hole.*

Soils Log

TH-11 Location: West side of South Island Hwy, across from house # 4238, in ditch side wall. Slope: 7%

UTM 10 East: 361025 m North: 5499750 m + / - 15 m

Top of test hole is 45 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	15	Dark brown	Loamy sand	< 2	< 2	gr	3	V. friable	15	cm			none	wet
15	65	Olive	Loamy sand	10	< 2	sg - abk	0 - 2	friable		none			none	wet - sat
65		BOTTOM									Seepage below depth 20 cm			

Well Construction

From	To	Length	Feature	Details
- 63	- 25	38	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 25	+ 45	70	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 65	0	65	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	1.09 m	1.0	1.0		8.4	175	7.37	18:17		
	- water depth:	0.67 m	1.0	2.0		7.0	146	7.35			
	= water ht:	0.42 m	1.0	3.0	3.3	6.3	141	7.33			
	x 2.17 =	0.91 litres									
6 Apr	Sample # 1								18:30		
7 Apr	Sample # 2								12:43		
7 Apr	Sample # 3								17:02		

TH-12

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Running water in nearby ditch, ~ 1 m downslope from test hole.*

Soils Log

TH-12 Location: 4360 South Island Highway, west side, ~ 70 m north of Herondale Road, in ditch side wall. Slope: 8%

UTM 10 East: 361395 m North: 5499330 m + / - 20 m

Top of test hole is about 30 cm below ground level, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure Type	Structure grade	Rupture resistance	Roots Depth	Roots Quant Size	Mottles Depth from	Mottles Depth to	Mottles Quant Contrast	Moisture
0	10	Dark brown	Loam	5	2	gr	2	friable		cm			none	wet
10	70	Olive	Silty clay loam	10	2	abk	2	firm	20	ff	15	65	ff	saturated
70		BOTTOM									seepage at depth 15 - 65 cm			

Well Construction

From	To	Length	Feature	Details
- 72	- 40	32	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 40	+ 31	71	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 72	0	72	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	1.03 m	1.0	1.0		7.9	217	7.31	18:35		
	- water depth:	0.48 m	1.0	2.0		6.9	213	7.49			
	= water ht:	0.55 m	1.0	3.0	2.5	6.3	213	7.37			
	x 2.17 =	1.19 litres									
7 Apr	Sample # 1								12:48		
7 Apr	Sample # 2								17:07		

TH-13

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Large ditch ~ 2 m downslope from test hole.*

Soils Log

TH-13 Location: Near south property line of 221 Ensign Road, on Amber Way R/W, 23 m from Ensign Rd. Slope: 2%

UTM 10 East: 362120 m North: 5498515 m + / - 10 m

Top of test hole is 50 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	40	Olive brown	Silt loam	5	5	gr	3	firm		mf			none	moist
40	70	Olive	V. gravelly silty clay loam	5	40	sbk	2	firm		ff			none	wet
70		BOTTOM									No seepage observed			

Well Construction

From	To	Length	Feature	Details
- 71	- 48	23	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 48	+ 14	62	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 71	0	71	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (μS)	pH	Time	Sample appearance	Note
6 Apr	well depth:	0.85 m	Dry well, no sample taken.						18:54		
	- water depth:	DRY									
	= water ht:	0.0 m									
	x 2.17 =	0 litres									

TH-14

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Flowing water in ditch, ~ 1 m downslope from test hole.*

Soils Log

TH-14   Location: 4617 Kilmarnock Drive, in ditch side wall   Slope: 3%

UTM 10   East: 362150 m   North: 5498275 m   + / - 15 m

Top of test hole is 45 cm below original ground surface, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	30	Olive grey	Gravelly loam	20	2	sbk	2	friable	20	fm			none	moist - sat
30	50	Olive	Silt loam	2	1	m	0	VFi - SR		none	30	50	fF	moist - sat
50		BOTTOM									Seepage at depth 20 to 40 cm			

Well Construction

From	To	Length	Feature	Details
- 50	- 28	22	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 28	+ 11	39	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 50	0	50	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.61 m	0.5	0.5		6.7	199	7.28	07:44	murky	
	- water depth:	0.36 m	0.5	1.0		6.4	169	7.30			
	= water ht:	0.25 m	0.5	1.5	2.8	6.2	161	7.25			
	x 2.17 =	0.54 litres									
7 Apr	Sample # 1								07:25		
7 Apr	Sample # 2								12:57		

TH-15

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Flowing water in ditch, ~ 2 m downslope from test hole.*

Soils Log

TH-15 Location: 3611 Cameron Road, in ditch side wall. Slope: 3%

UTM 10 East: 359430 m North: 5500390 m + / - 10 m

Top of test hole is 25 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	30	Olive brown	Gravelly sandy loam	20	1	gr	3	friable	30	fm			none	wet - sat
30	70	Olive brown to yellow brown	Sandy loam	10	1	sbk	2	firm to very firm		none	50	65	fF	wet to saturated
70											Seepage at depth 20 - 40 cm			

Well Construction

From	To	Length	Feature	Details
- 70	- 33	37	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 33	+ 33	66	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 70	0	70	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (μS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	1.05 m	0.4	0.4	1.0	5.2	137	7.36	07:20	muddy	
	- water depth:	0.87 m	Slow recharging well. Purged dry. Insufficient water for nitrate samples.								
	= water ht:	0.18 m									
	x 2.17 =	0.4 litres									
7 Apr	Sample # 1								12:05		
7 Apr	Sample # 2								16:22		

TH-16

Date: *April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Located about two metres from the high tide mark.*

Soils Log

TH-16 Location: Sanborn Road R/W, near 4702 Kilmarnock Drive, about 2 m from high tide mark. Slope: 5%

UTM 10 East: 362320 m North: 5497845 m + / - 10 m

Top of test hole is at ground surface.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	0	Black	Gravelly loamy sand	20	5	gr	2	loose		ff			none	wet
10	10	Dark olive brown	V. gravelly sand	30	30	sg	0	loose	20	ff			none	wet - sat
45		BOTTOM									Seepage below depth 20 cm			

Well Construction

From	To	Length	Feature	Details
- 45	- 23	22	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 23	+ 25	48	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 45	0	45	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.69 m	1.0	1.0		7.5	454	7.75	08:03	murky	
	- water depth:	0.36 m	1.0	2.0		7.0	448	7.89			
	= water ht:	0.33 m	1.0	3.0	4.2	6.9	444	7.96			
	x 2.17 =	0.72 litres									
7 Apr	Sample # 1								08:09		
7 Apr	Sample # 2								13:03		

TH-17

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Water in ditch, about 1 m downslope from test hole.*

Soils Log

TH-17 Location: 250 Argyle Road at Kilmarnock Drive, in ditch side wall. Slope: 6%

UTM 10 East: 362390 m North: 5497420 m + / - 15 m

Top of test hole is about 110 cm below ground surface, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	20	Dark brown	Loam	5	5	gr	3	friable		mf			none	moist - wet
20	65	Olive	Sandy clay loam	10	2	sbk	2	friable	35	ff	30	60	fF	wet - sat
65		BOTTOM									Seepage at depth 20 - 50 cm			

Well Construction

From	To	Length	Feature	Details
- 64	- 33	31	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 33	+ 30	63	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 64	0	64	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.94 m	0.6	0.6	1.0	7.2	291	7.46	08:22	muddy	
	- water depth:	0.67 m								purged dry	
	= water ht:	0.27 m									
	x 2.17 =	0.59 litres									
7 Apr	Sample # 1								13:13		
7 Apr	Sample # 2								17:16		

TH-18

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Test hole is about 6 m from high tide mark.*

Soils Log

TH-18 Location: Road dedication between 5006 and 5014 Spence Road, ~ 6 m from high tide mark. Slope: 9%

UTM 10 East: 363005 m North: 5496470 m + / - 15 m

Top of test hole is at ground level.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	15	Dark brown	Gravelly loam	15	5	gr	3	v. friable		mf			none	moist
15	40	Dark brown	Gravelly loam	20	5	gr	2-3	friable	30	ff			none	moist - sat
40	55	Brown	V. gravelly sand	50	10	sg	0	loose		none			none	saturated
55		BOTTOM									Seepage below depth 30 cm			

Well Construction

From	To	Length	Feature	Details
- 55	- 32	23	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 32	+ 19	51	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 55	0	55	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.74 m	0.45	0.45	1.0	8.1	300	7.63	08:35	muddy	
	- water depth:	0.54 m								purged dry	
	= water ht:	0.20 m									
	x 2.17 =	0.43 litres									
7 Apr	Sample # 1								13:28		
7 Apr	Sample # 2								17:25		

TH-19

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Standing water in ditch, ~ 1 m downslope from test hole.*

Soils Log

TH-19 Location: 350 Russell Rd at South Island Highway, west side of highway, ditch side wall. Slope: 14%

UTM 10 East: 363580 m North: 5494520 m + / - 15 m

Top of test hole is 100 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles				Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast		
0	10	Black	Loam	5	5	gr	3	v. friable		cc			none		moist
10	75	Black	Gravelly sandy loam	20	5	sbk	2	v. friable	45	cc			none		wet - sat
75		BOTTOM	A few shells from 0 - 10 cm. Many shells below 10 cm.								Seepage at depth 50 - 75 cm				

Well Construction

From	To	Length	Feature	Details
- 76	- 42	34	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 42	+ 10	52	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 76	0	76	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.89 m	1.0	1.0		8.2	500	8.21	08:52	muddy	
	- water depth:	0.59 m	1.0	2.0		7.8	497	8.24			
	= water ht:	0.30 m	1.0	3.0	4.6	7.6	491	8.24	08:59		
	x 2.17 =	0.65 litres									
7 Apr	Sample # 1								09:01		
7 Apr	Sample # 2								13:38		

TH-20

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Seepage in ditch, ~ 1 m downslope from test hole.*

Soils Log

TH-20 Location: 5615 First Street, at Douglas St, side wall of shallow ditch or swale. Slope: 8%

UTM 10 East: 363765 m North: 5493590 m + / - 10 m

Top of test hole is 30 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	25	Brown	Loam	5	1	gr	3	v. friable		cf			none	wet
25	70	Brown	Gravelly loam	20	1	sbk	2	v. friable	30	ff			none	wet - sat
70		BOTTOM									Seepage at depth 30 - 70 cm			

Well Construction

From	To	Length	Feature	Details
- 66	- 32	34	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 32	+ 24	56	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 66	0	66	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.90 m	1.3	1.3	1.5	9.2	225	7.68	09:10	muddy	
	- water depth:	0.51 m								well purged dry	
	= water ht:	0.39 m									
	x 2.17 =	0.85 litres									
7 Apr	Sample # 1								14:06		
7 Apr	Sample # 2								17:38		

TH-21

Date: *4 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Flowing water in ditch, ~ 1.5 m downslope from test hole.*

Soils Log

TH-21 Location: 337 McLeod Road at railway, in ditch side wall — Slope: 10 %

UTM 10 East: 363585 m North: 5493745 m + / - 15 m

Top of test hole is 50 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	30	Dark brown	Silt loam	5	1	gr	2	v. friable	30	fm			none	wet
30	55	Olive	Sandy clay loam	10	1	abk	3	firm		none	35	55	cP	wet - sat
55		BOTTOM									Seepage at depth 30 - 55 cm			

Well Construction

From	To	Length	Feature	Details
- 55	- 28	27	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 28	+ 29	57	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 55	0	55	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.84 m	0.5	0.5		7.8	165	7.58	09:22	murky	
	- water depth:	0.61 m	0.5	1.0		7.2	149	7.53			
	= water ht:	0.23 m	0.5	1.5		6.9	144	7.44			
	x 2.17 =	0.50 litres	0.5	2.0	4.0	7.0	143	7.41			
7 Apr	Sample # 1								09:31		
7 Apr	Sample # 2								14:14		

TH-22

Date: *6 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Flowing water in ditch, 1 m downslope from test hole.*

Soils Log

TH-22 Location: 5667 South Island Highway at Richards St, in ditch side wall. Slope: 12%

UTM 10 East: 363895 m North: 5493310 m + / - 15 m

Top of test hole is 50 cm below grade, in ditch side wall.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	25	Dark brown	V. gravelly loam	30	5	gr	2	v. friable	25	mf	20	25	fF	wet - sat
25	60	Olive	Gravelly silt loam	30	1	gr	3	friable - firm		none	25	40	cP	moist
60		BOTTOM							minor seepage at 25 cm					

Well Construction

From	To	Length	Feature	Details
- 52	- 34	18	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 34	+ 32	66	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 52	0	52	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.84 m	0.8	0.8	2.0	9.2	140	7.60	09:42	murky	
	- water depth:	0.67 m								well purged dry	
	= water ht:	0.17 m									
	x 2.17 =	0.37 litres									
7 Apr	Sample # 1								14:22		
7 Apr	Sample # 2								17:47		

TH-23

Date: *6 April 2009*	Excavation type: *Hand shovel and hand auger*
Weather: *Sunny*	Surface water: *Standing water in ditch, ~ 1 m downslope from test hole.*

Soils Log

TH-23 Location: East of Garvin Rd, west side of highway, ~ 150 m south of oyster farm retaining wall, in road cut.

Slope of road cut: 70%

UTM 10 East: 364335 m North: 5492140 m + / - 10 m

Top of test hole is about two metres below natural ground surface, in a road cut.

From	To	Colour	USDA texture	fine gravel (%)	coarse gravel (%)	Structure		Rupture resistance	Roots		Mottles			Moisture
						Type	grade		Depth	Quant Size	Depth from	Depth to	Quant Contrast	
0	25	Brown	V. gravelly loam	20	20	gr	3	V. friable	25	cf			none	moist - wet
25	40	Olive	V. gravelly loam	25	10	m	0	V. firm		none			none	moist
40		BOTTOM	(weakly cemented)								Seepage at depth 20 cm			

Well Construction

From	To	Length	Feature	Details
- 34	- 16	18	Well Screen	Material: *PVC* Diameter: *50 mm* Slot size: *No. 10, 0.25 mm*
- 16	+ 30	46	Well Casing	Material: *PVC* Diameter: *50 mm* Joints: *ASTM F480 threaded, 0-ring seals*
- 40	0	40	Backfill	Material: *Native soil*

Purging and Sampling Record

Date	Calculate water height and well volume		Purge volume (litres)	Cumult. purge volume	Well volumes purged	temp (°C)	EC (µS)	pH	Time	Sample appearance	Note
7 Apr	well depth:	0.64 m	0.1	0.1	0.7	9.8	144	8.08	09:55	muddy	
	- water depth:	0.57 m									
	= water ht:	0.07 m									
	x 2.17 =	0.15 litres									
	Not enough water to sample.										

Appendix 5
Ground Water Quality

Analytical laboratory testing by North Island Laboratories, Courtenay. Full laboratory reports and quality assurance tests are available on request.

Water Quality in Monitoring Wells

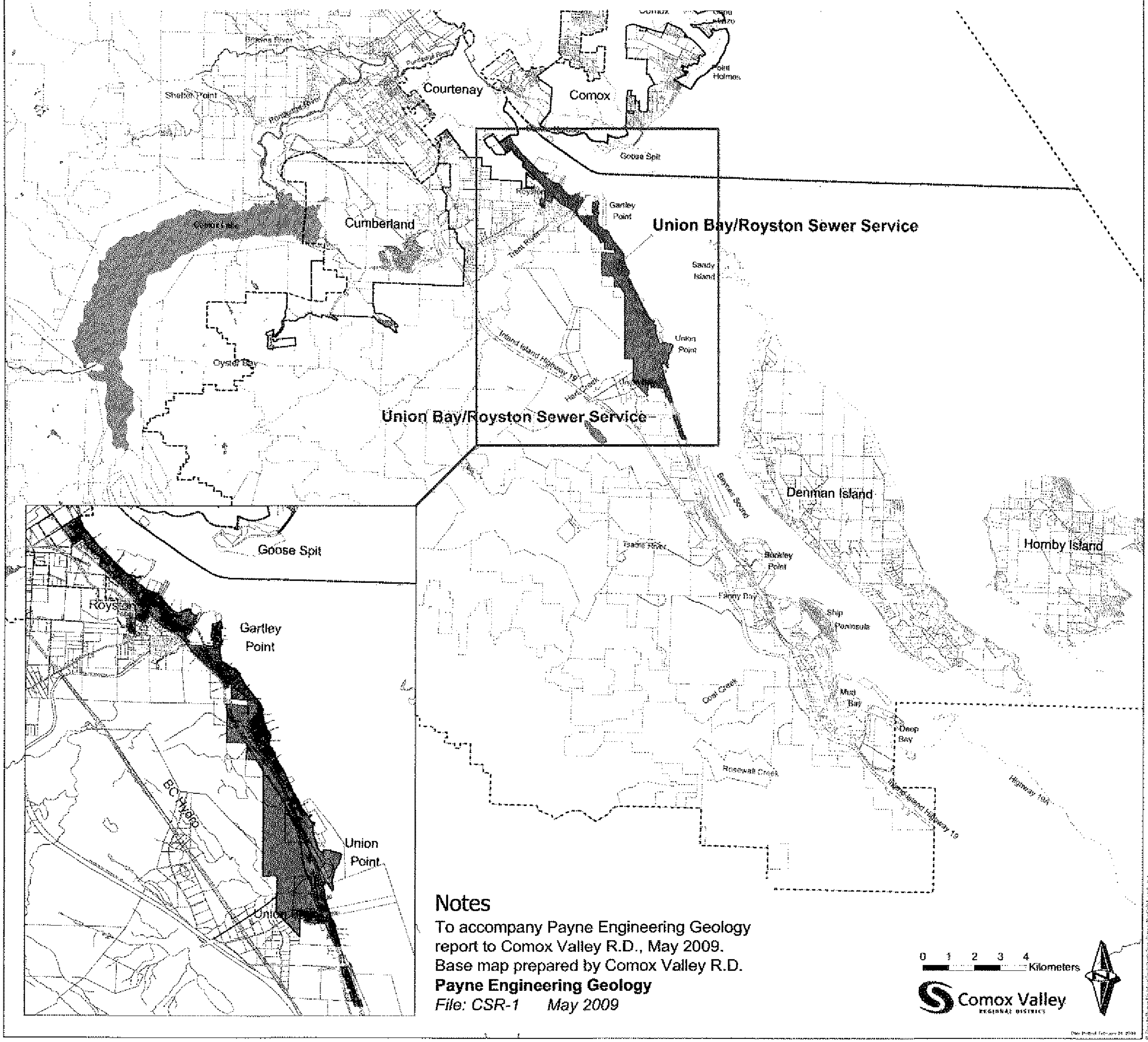
Well	Escherichia coli # 1	# 2	median	Pass or Fail	Nitrate - nitrogen # 1	# 2	# 3	median	Field measurements Temp	EC	pH	Note
	MPN per 100 mL				*mg/L*				*Celsius*	*µS/cm*		
1	0	0	0	Pass	0.5			0.5	11.0	240	7.2	
2				Pass								Water table deeper than 75 cm.
3	0	2	1	Pass	0.2	0.5	0.5	0.5	6.8	110	7.5	
4	0	0	0	Pass	0.5	0.5	0.2	0.5	6.5	180	7.3	
5	8	2	5	Pass	5	5		5	9.1	300	7.3	
6	49	49	49	Fail	0.5	0.2		0.35	11.7	310	7.5	
7	0	0	0	Pass	0.1	0.2		0.15	10.7	240	7.4	
8	0	0	0	Pass	3	4	5	4	8.9	310	8.1	
9	0	0	0	Pass	0.1	0.1		0.1	8.8	240	7.3	
10				Pass								Water table deeper than 85 cm.
11	23	13	18	Fail	0.1	0.2	0.5	0.2	6.3	140	7.3	
12	0	0	0	Pass	0.2	0.5		0.35	6.3	210	7.4	
13				NA								Too little water to sample.
14	0	0	0	Pass	0.5	0.5		0.5	6.2	160	7.3	
15	0	0	0	NA					5.2	140	7.4	Background (upslope) well
16	33	49	41	Fail	0.2	0.5		0.35	6.9	440	8.0	
17	0	0	0	Pass	0.5	1		0.75	7.2	290	7.5	
18	0	0	0	Pass	0.2	0.2		0.2	8.1	300	7.6	
19	0	0	0	Pass	4	1		2.5	7.6	490	8.2	
20	2000	2000	2000	Fail	2	2		2	9.2	230	7.7	
21	170	33	102	Fail	0.2	0.2		0.2	7.0	140	7.4	
22	0	0	0	Pass	0.2	0.1		0.15	9.2	140	7.6	
23				NA					9.8	140	8.1	Too little water to sample.

Footnotes on water quality data

1. All samples collected on April 6 - 7, 2009.
2. Project-specific criterion is median E. Coli < 14 (Canada and BC guideline for shellfish harvesting).
3. Where the E. Coli count is noted as zero, the lab report states "< 2" because the minimum lab detection limit is 2.
4. Where the E. Coli count is 2000, the lab report states "> 1600" because the maximum lab detection limit is 1600.
5. Temperature, electrical conductivity, and pH, measured in the field using Hanna HI 98129.

Appendix 6
Figures

Figure 1: Map of the Study Area for the Royston and Union Bay Sewer

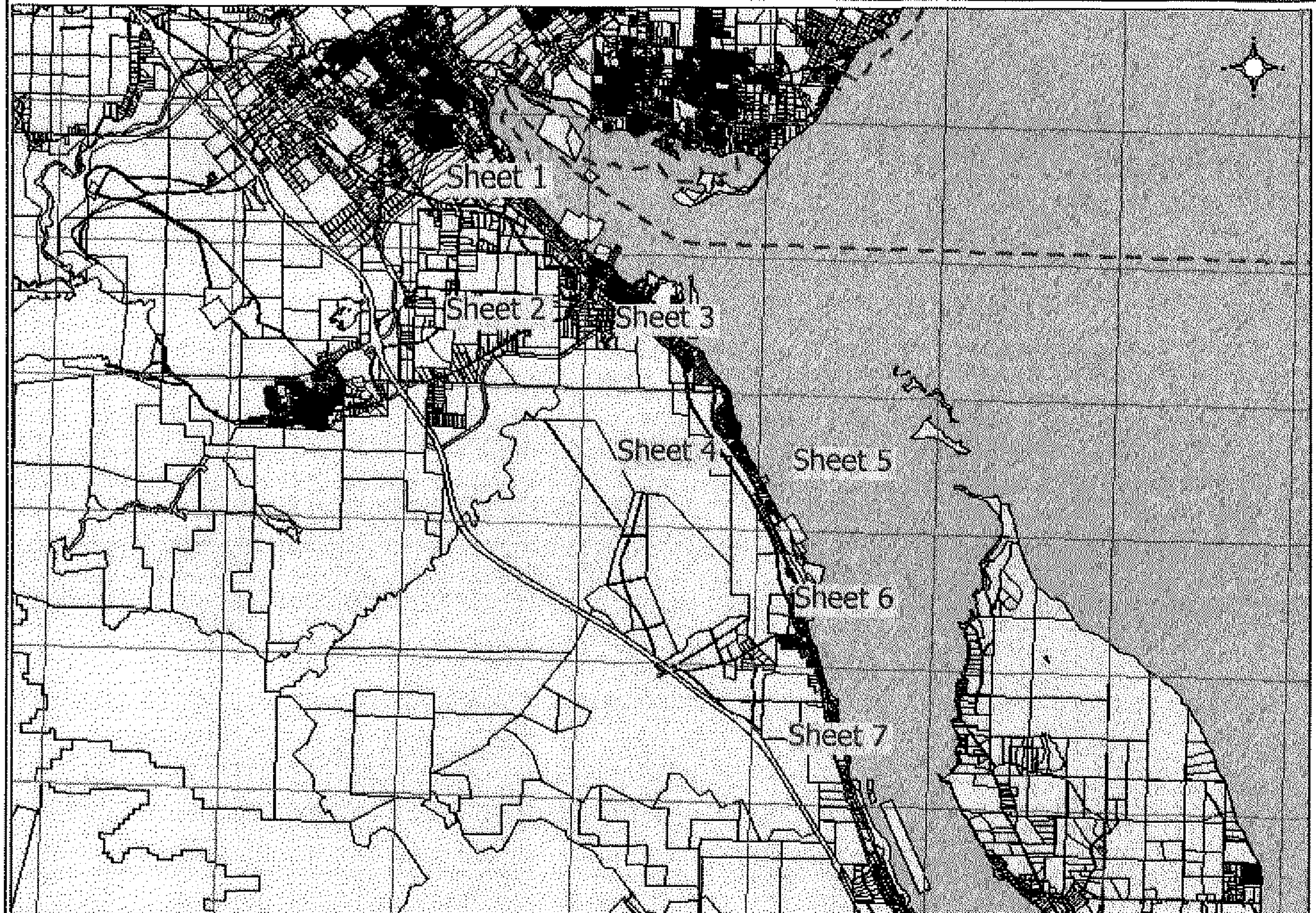


Notes

To accompany Payne Engineering Geology report to Comox Valley R.D., May 2009.
Base map prepared by Comox Valley R.D.
Payne Engineering Geology
File: CSR-1 May 2009

Index Map for Figure 2, Sheets 1 to 7

Payne Engineering Geology *File: CSR-1 May 2009*



Scale 0 ▭ 600 metres

Disclaimer: This map is intended for display purposes only.

Comox Valley

Contact
Name **CVRD GIS Dept.**
Phone **250 334 6000**
Email **imap@comoxvalleyrd.ca**

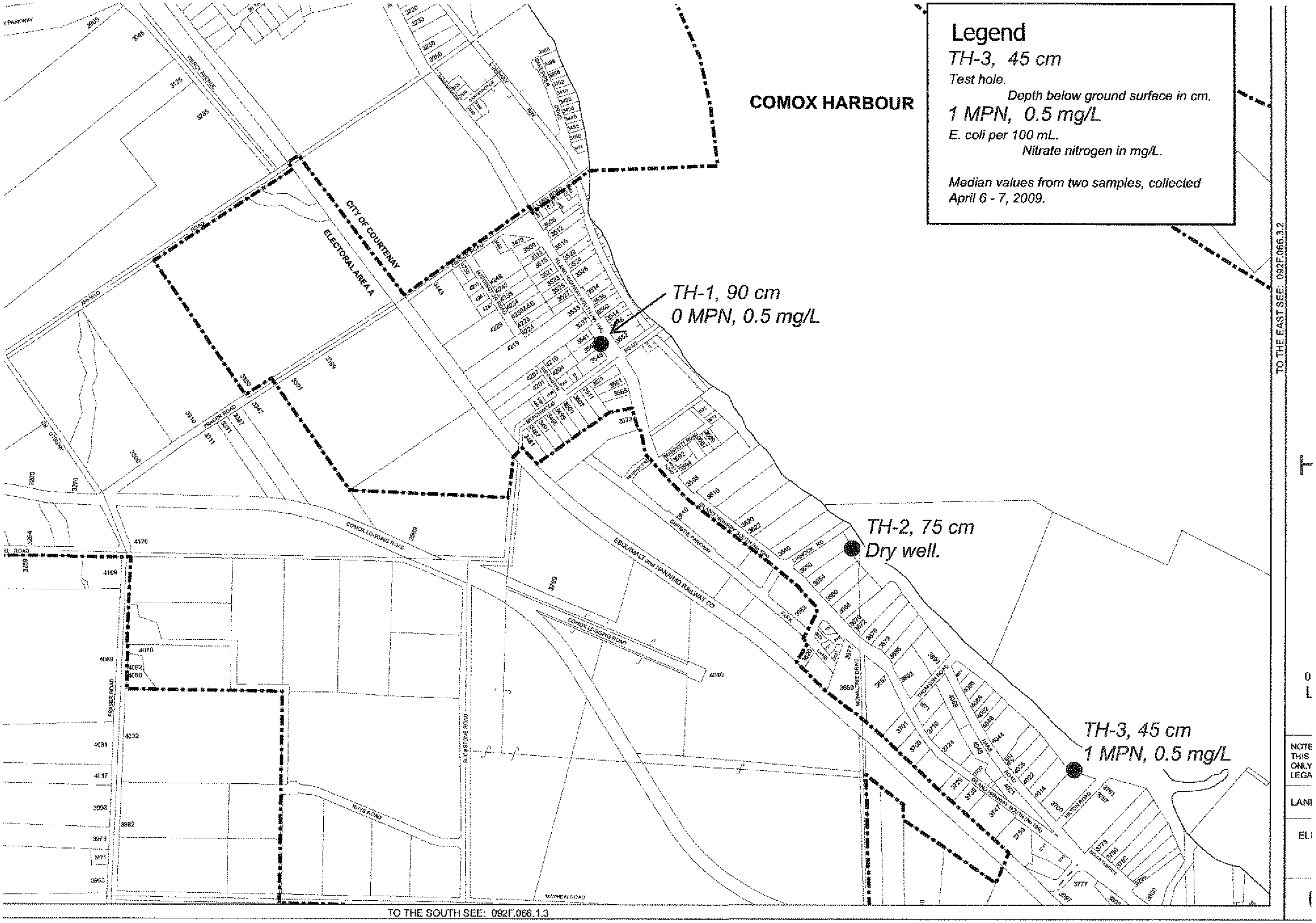


Figure 2: Ground Water Quality (sheet 1 of 7) Not to scale. **Payne Engineering Geology** *File: CSR-1 May 2009*

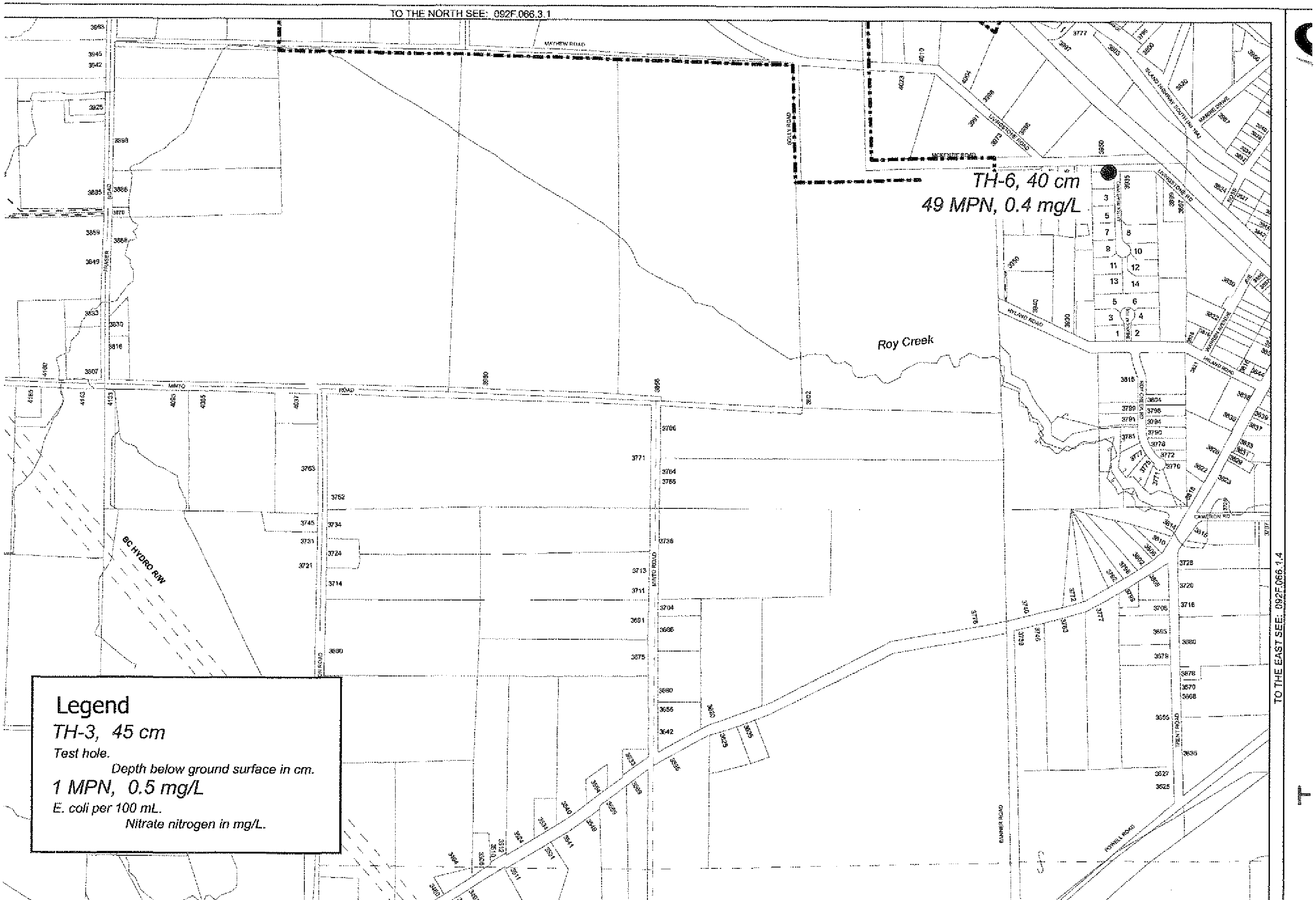


Figure 2: Ground Water Quality (sheet 2 of 7) Not to scale. **Payne Engineering Geology** *File: CSR-1 May 2009*

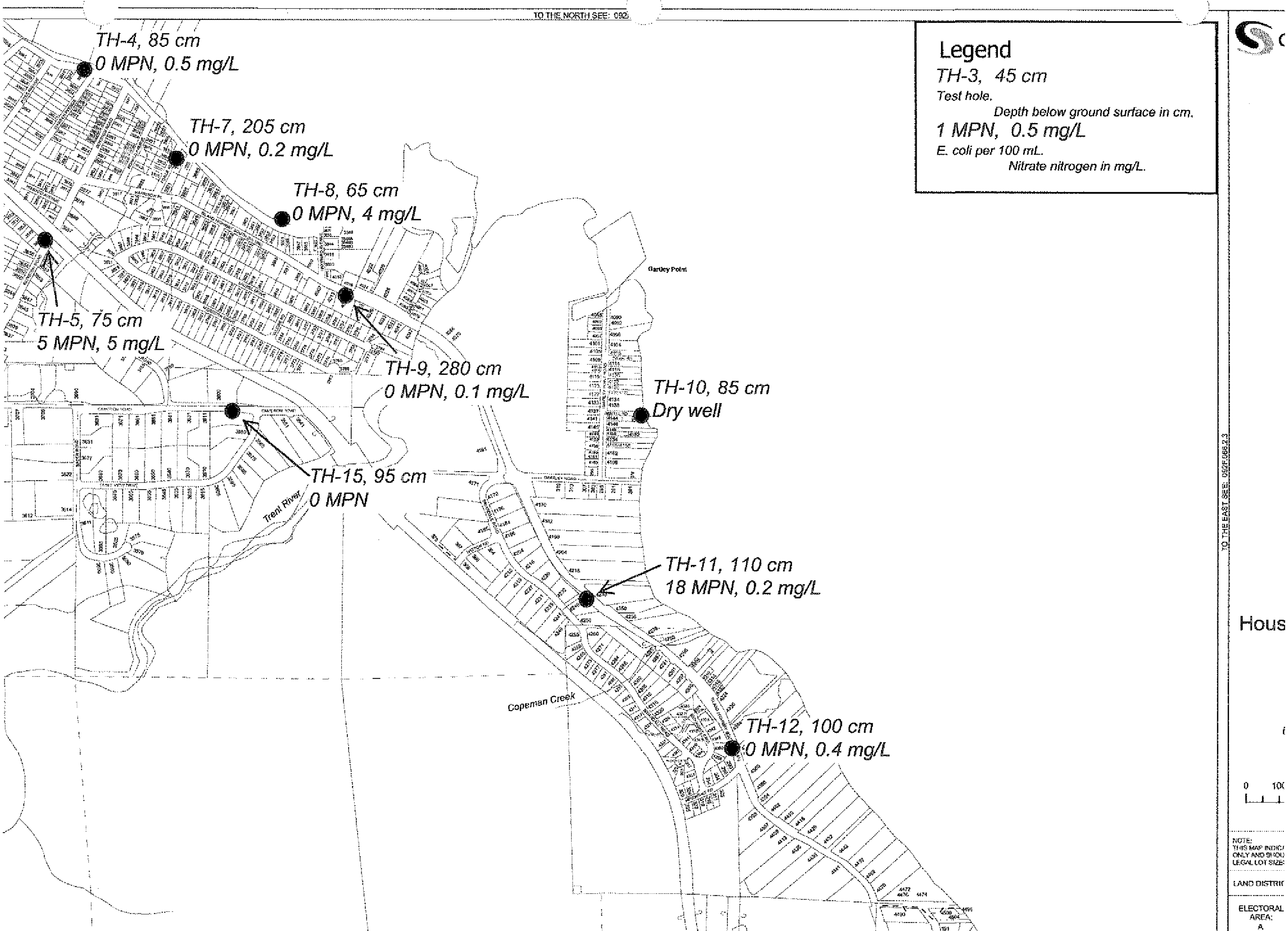


Figure 2: Ground Water Quality (sheet 3 of 7) Not to scale.

Payne Engineering Geology *File: CSR-1 May 2009*

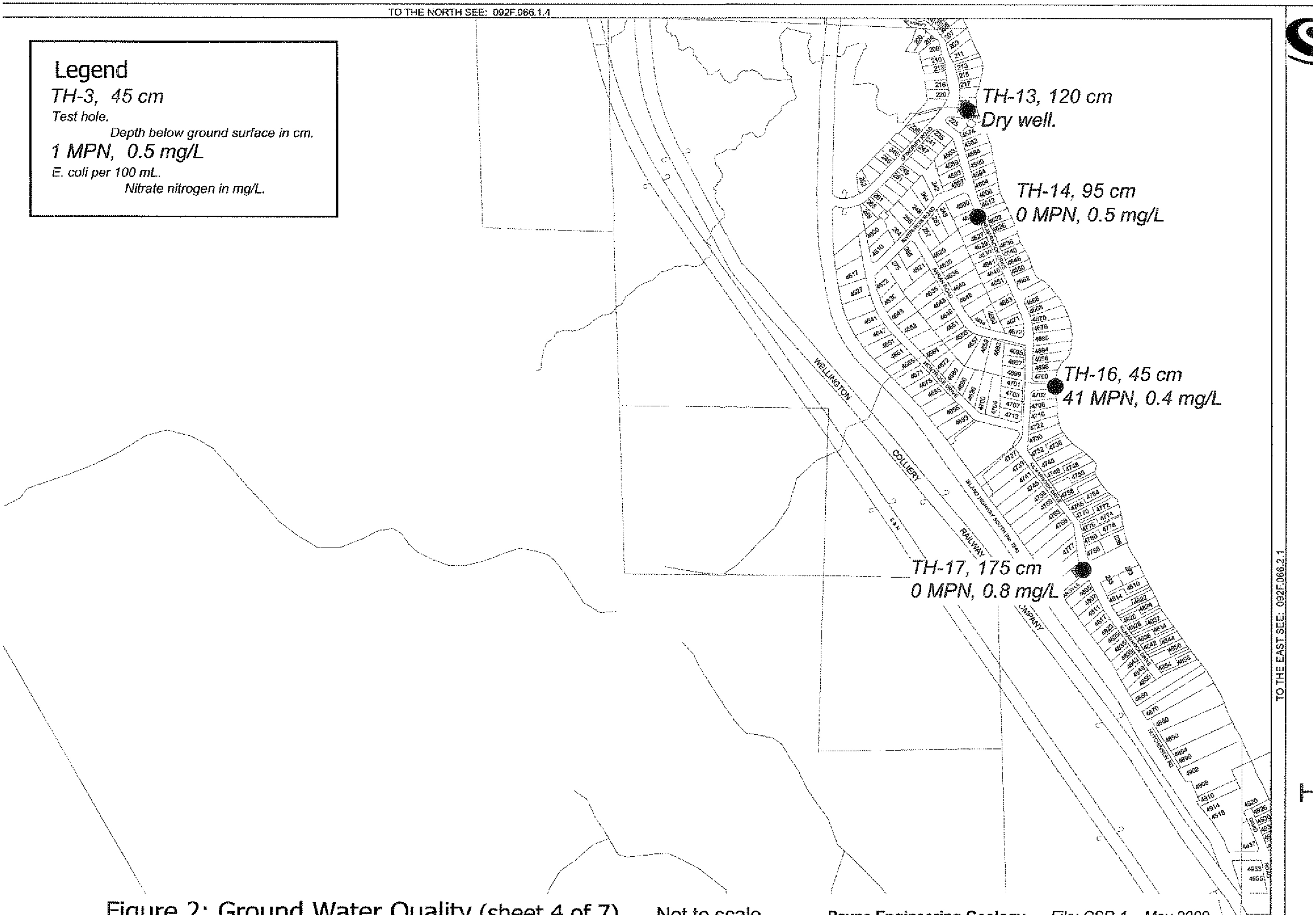


Figure 2: Ground Water Quality (sheet 4 of 7) Not to scale. **Payne Engineering Geology** *File: CSR-1 May 2009*

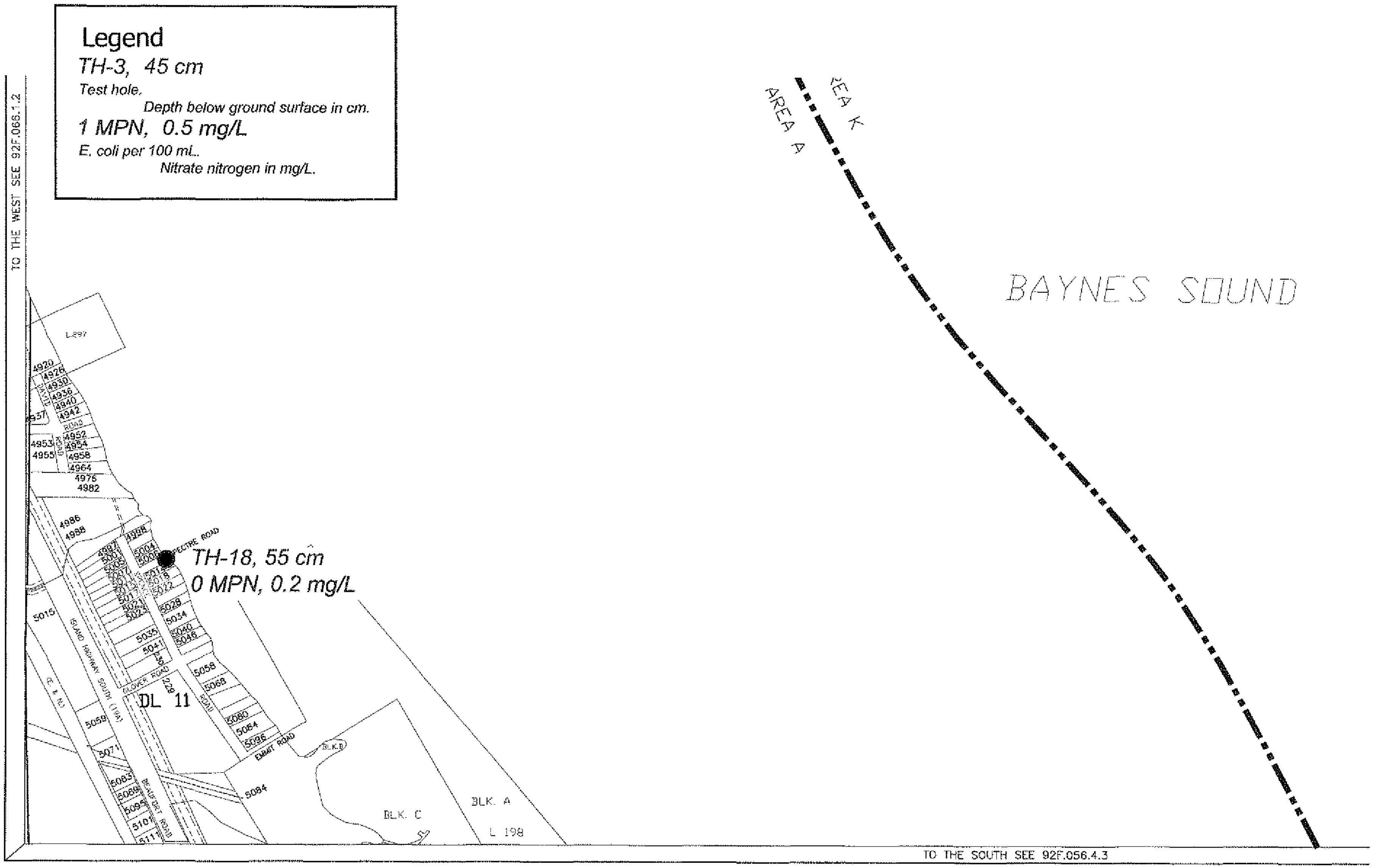


Figure 2: Ground Water Quality (sheet 5 of 7) Not to scale. **Payne Engineering Geology** *File: CSR-1 May 2009*

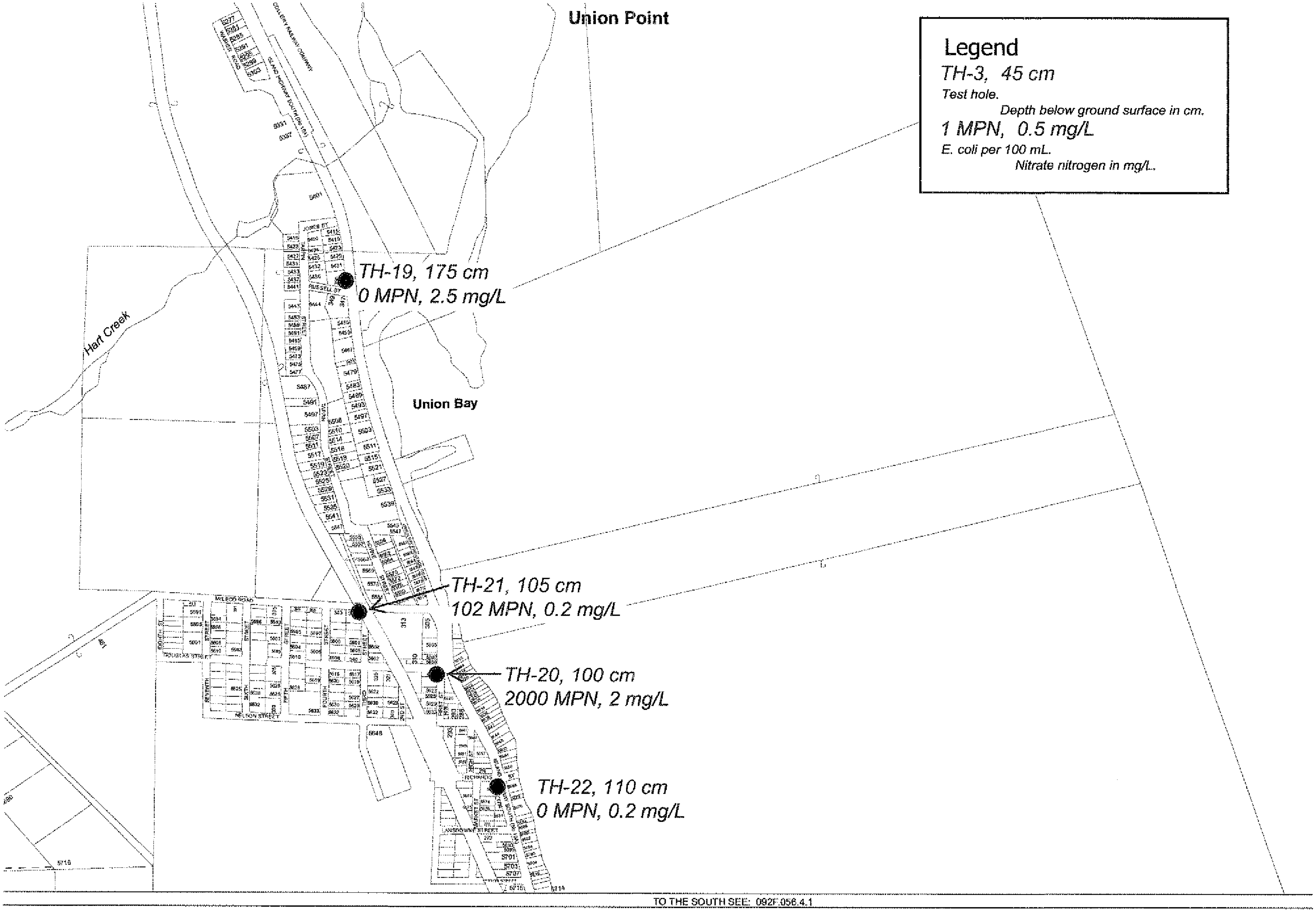


Figure 2: Ground Water Quality (sheet 6 of 7) Not to scale. **Payne Engineering Geology** *File: CSR-1 May 2009*

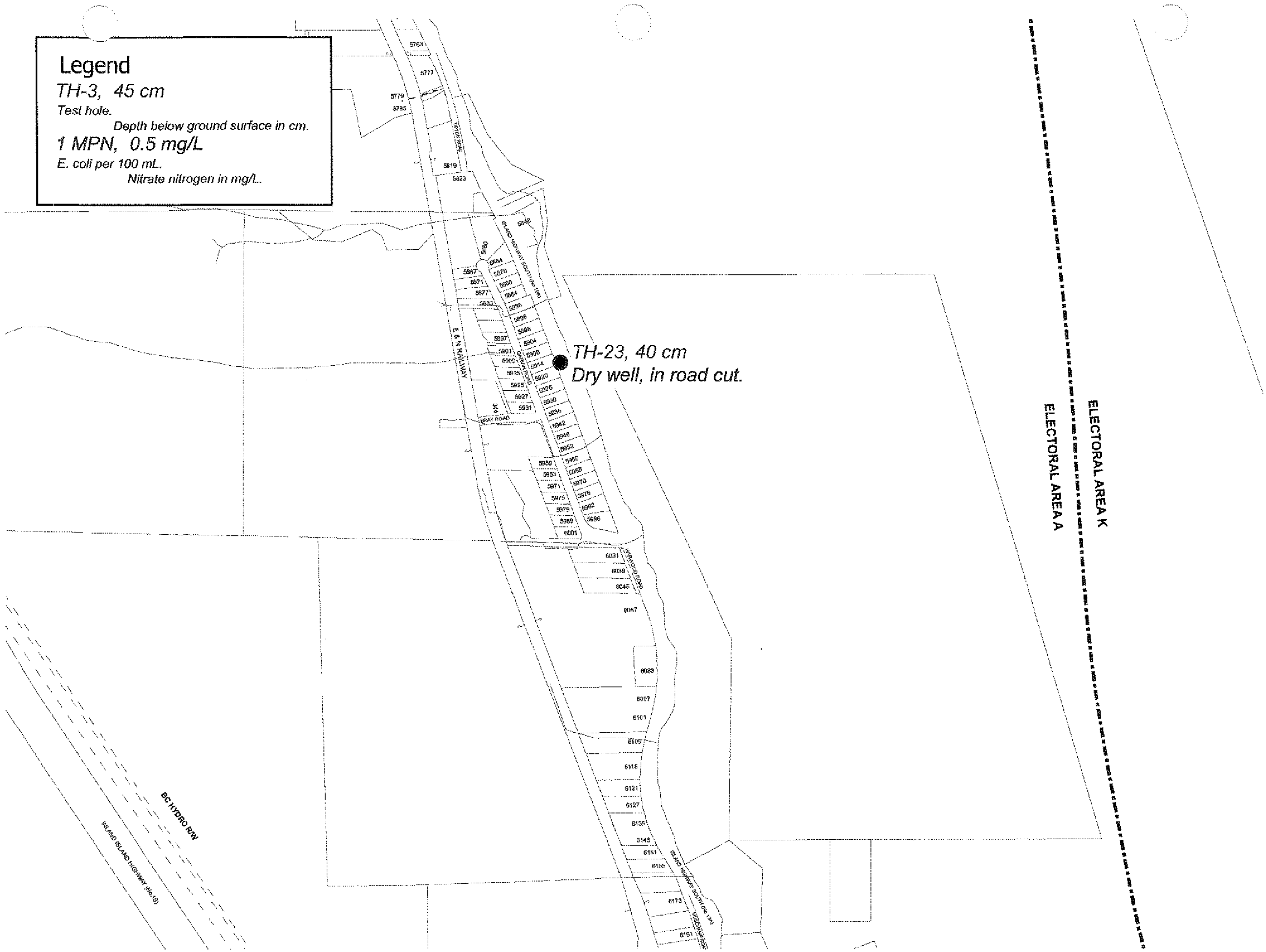


Figure 2: Ground Water Quality (sheet 7 of 7) Not to scale. **Payne Engineering Geology** *File: CSR-1 May 2009*

Appendix 7
Statement of General Conditions

Scope of this Report
This review report satisfies only those objectives stated in the introduction. Payne Engineering Geology (PEG) has not conducted a *Site Investigation*, *Hydrogeology Study* or *Environmental Impact Assessment*.

Use of this Report
This report pertains only to a specific project. If the project is modified, then our client will allow us to confirm that the report is still valid. We prepared this report only for the benefit of our Client and those agencies authorized by law to regulate our Client's activities. No others may use any part of this report without our written consent. To understand the content of this report, the reader must refer to the entire, signed report. We cannot be responsible for the consequences of anyone using only a part of the report, or referring only to a draft report. This report reflects our best judgement based on information available at the time. Any use of this report, or reliance on this report, by a third party is the responsibility of that third party. We accept no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken based on this report.

Reliance on Provided Information
PEG has relied on the accuracy and completeness of information provided by its client and by other professionals. We are not responsible for any deficiency in this document that results from a deficiency in this information.

Logs of Test Holes or Wells and Subsurface Interpretations
Ground and ground water conditions always vary across a site and vary with time. Test hole and well logs show subsurface conditions only at the locations of the test hole or well. The precision with which geological and geotechnical reports show subsurface conditions depends on the method of excavation or drilling, the frequency and methods of sampling and testing, and the uniformity of subsurface conditions.

Descriptions of Geological Materials and Water Wells
This report includes descriptions of natural geological materials, including soil, rock, and ground water. PEG based these descriptions on observations at the time of the study. Unless otherwise noted, we based the report's conclusions and recommendations on these observed conditions.

Changed Conditions
Conditions encountered by others at this site may differ significantly from what we encountered, either due to natural variability of subsurface conditions or construction activities. Our client will inform us about any such changes, and will give us an opportunity to review our recommendations. Recognizing changed soil and rock conditions, or changed well conditions, requires experience. Therefore, during construction or remediation, a qualified professional should be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Standard of Care
PEG exercises a standard of care consistent with that level of skill and care ordinarily exercised by members of the profession currently practising under similar conditions.