# MEMORANDUM

KOERS
& ASSOCIATES
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*Consulting Engineers*

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| *To:* | | *From*: | |
|---|---|---|---|
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| **City/Code:** | Burnaby, BC V5G 4M5 | **Date:** | May 11, 2011 |

**Project:** **Arrowsmith Water Service**
**Englishman River Water Intake Study**

**File No.: 0942**

**Subject:** **Site Development – Water Transmission and Distribution**

**CONFIDENTIAL – FOR INTERNAL TEAM REVIEW**

## 1. Background

Three intake/water treatment plant sites, sites No. 1, 3 and 5, have been selected for more detailed investigation.

## 2. Objective

The objective is to identify the water transmission and distribution requirements and strategy from the treated water pump station at the treatment plant to the connection points for each of the service areas for each of the three intake/WTP sites. At this point we need to determine the significant differences in transmission and distribution system requirements between the three site options to be used in the comparative assessment of the overall merits of the sites.

Once the preferred site is chosen, the full transmission/distribution network requirements will be determined for the various design demand conditions.

## 3. Role of Supply Sources and Pressure Zone Strategy

The primary source of water for each of the service areas within AWS is groundwater. The service areas included for future design purposes are the existing AWS service areas of the City of Parksville, the Town of Qualicum Beach, and the Regional District Local Service Areas in Nanoose and French Creek. It is expected that each service area will maintain control of its own groundwater sources, which, in the great majority of cases, feed directly into the various distribution reservoirs. In most cases, the groundwater requires minimal treatment and therefore will likely be the lowest cost water source.

The balance of the total water demand will be met from the new surface water source, which would supply bulk water into the City of Parksville water distribution system, as required to keep the two main reservoirs at Springwood and Top Bridge Park full. Both reservoirs are at TWL 74 m, so this level will control the discharge pressure from the treated water pump station at the treatment plant.

The Qualicum Beach and French Creek service areas will be supplied from the Springwood Reservoir via a booster pump station, with the Qualicum Beach and French Creek supplemental surface water supply going to the Village Way and Church Road reservoirs. This part of the transmission system is the same for all three intake/WTP sites and has therefore not been considered in this analysis.

The Nanoose service areas will be supplied from the Wallbrook Pump Station on Northwest Bay Road, to be completed by the RDN in 2010. This pump station pumps to the Fairwinds Reservoirs, from which the rest of the Nanoose service areas are served. This part of the transmission system also is the same for all three intake/WTP sites and has therefore not been considered in this analysis.

Redundancy and reliability for the bulk water transmission system is inherent in the fact that a substantial groundwater source is available in case of failure of any surface water supply component. Therefore, only single transmission mains are proposed to connect to the distribution systems.

It is not considered reasonable to have dedicated transmission mains from the supply source to each of the service areas. It is proposed that the transmission mains feed into the City of Parksville distribution grid, with improvements made to provide capacity within the distribution system to supply bulk water to the AWS service areas beyond the City distribution system. Bulk water quantities supplied would be measured from a master meter at the treated water pump station and meters into each of the AWS service areas outside the City, with the City bulk water supply being calculated as the difference.

## 4. Transmission System Modeling

The water systems of the City of Parksville, Town of Qualicum Beach, and RDN systems in Nanoose and French Creek were consolidated into a single WaterCAD model. The model incorporates all groundwater well supplies considered to be suitable as primary water supply sources and connected to the appropriate reservoirs in the distribution systems. All reservoirs, pump stations and pressure reducing stations were incorporated into the model.

Several supply scenarios were modelled for each of the proposed surface water intake sites, as follows:

A. High end of total water demand range for 2050 projections

B. Low end of total water demand range for 2050 projections
C. With participation of Qualicum Beach
D. Without participation of Qualicum Beach

The water demand conditions were determined in Discussion Paper 3-2.

## 5. Transmission/Distribution System for Site # 1

For WTP Site # 1 we have considered two intake site options. Intake Site # 1A below the crossing of Highway 19 and the E&N Railway and intake Site # 1B on the west bank of the river immediately upstream from the Highway 19A bridge (the same intake site as Site # 3). Site # 1A would dictate a new transmission main to Parksville via Martindale Road taking advantage of the same river crossing trench as the raw water main from the west bank intake location to the WTP site. Site # 1B would dictate a new transmission main to Parksville via Highway 19A taking advantage of common trench installation with the raw water main from the intake site to the WTP site and avoiding an expensive river crossing in rock by suspending the new water mains from the Highway 19A bridge.

The new transmission and distribution mains required to connect from WTP Site # 1 to existing distribution are shown in red on Figures 7 and 8 for the two intake site options. The pertinent existing infrastructure is shown in blue. New main sizes shown are for the high demand condition and are the same for inclusion or exclusion of the Town of Qualicum Beach. Cost estimates for these scenarios are presented at the end of this memo.

Transmission to Parksville, French Creek and Qualicum Beach

For the Intake Site # 1A option (Figure 7), the transmission main from the treated water pump station will follow the E&N Railway right-of-way along the toe of the railway embankment, under the bridge and across the river in the same trench with the supply main from the intake which will be situated on the west bank of the river. The transmission main then heads over to Martindale Road via the railway ROW and across Lot 13, Plan 20938, DL 128. Apparently an informal bike path used by the public to access the west portion of Top Bridge Park crosses this lot, and it may be possible to combine a pipeline right-of-way with the path. From Martindale, a new distribution main will follow Stanford Avenue to Shelly Road, and connect to the 200 mm dia. main on Shelley and the 300 mm diameter main along Highway 19A. The Stanford Avenue right-of-way is not continuous between Martindale and Shelly and needs to be secured for this alignment. The new distribution main will continue along Stanford Avenue to connect to the 250 mm dia. main on McVickers Street and to the 250 mm dia. Main on McCarter Street.

For the Intake Site # 1B option (Figure 8), the transmission main from the WTP site will require a right-of-way along the northwest property line of the City Public Works Yard, then follow Herring Gull Way to Industrial Way, and Industrial Way and Highway 19A across the bridge to Martindale Road. The main will then continue south on Martindale Road until Stanford Avenue, from where the alignment will be the same as for Intake Site option 1A above.

At Springwood, there will be a booster pump station for further transmission beyond the City of Parksville to French Creek and Qualicum Beach. The transmission alignment and sizing beyond the Springwood Reservoir is the same for all three intake/WTP site options, and transmission or distribution upgrading required past this point has therefore not been considered in this assessment. This will be considered for the final preferred option.

Transmission to Nanoose

For the Intake Site # 1A option (Figure 7), the new main from the treated water pump station to Herring Gull will require a right-of-way along the northwest property line of the City Public Works Yard. Transmission to the RDN service areas in Nanoose requires a new main following public right-of-way along Herring Gull Way and Franklyn Gull Way to Industrial Way, where it would interconnect with the existing 350 mm dia. main at the end of Industrial Way, which connects to the Top Bridge reservoir.

For the Intake Site # 1B option (Figure 8), transmission to Nanoose will branch off from the new main into Parksville along Highway 19A by interconnecting to the existing 300 mm dia. main on the other side of the highway, and by completing the 300 mm dia. main via a new right-of-way across the Trailer Park (Lot 3, Plan 6885, DL125) and adjoining Lot 1, Plan 28271, DL125.

From the Wallbrook pump station into Nanoose the transmission alignment and sizing is the same for all three intake/WTP site options, and transmission or distribution upgrading required past this point has therefore not been considered in this assessment. This will be considered for the final preferred option.

## 6. Transmission/Distribution System for Site # 3

The new transmission and distribution mains required to connect to existing distribution are shown in red on Figure 9. The pertinent existing infrastructure is shown in blue. New main sizes shown are for the high demand condition and are the same for inclusion or exclusion of the Town of Qualicum Beach. Cost estimates are presented at the end of this memo.

Transmission to Parksville, French Creek and Qualicum Beach

From Martindale, a new distribution main will follow Stanford Avenue to Shelly Road, and connect to the 200 mm dia. main on Shelley and the 300 mm diameter main along Highway 19A.

The Stanford Avenue right-of-way is not continuous between Martindale and Shelly and needs to be secured for this alignment. The new distribution main will continue along Stanford Avenue to connect to the 250 mm dia. main on McVickers Street and to the 250 mm dia. Main on McCarter Street.

At Springwood, there will be a booster pump station for further transmission beyond the City of Parksville to French Creek and Qualicum Beach. The transmission alignment and sizing beyond the Springwood Reservoir is the same for all three intake/WTP site options, and transmission or distribution upgrading required past this point has therefore not been considered in this assessment. This will be considered for the final preferred option.

Transmission to Nanoose

The existing 250 mm and 300 mm diameter mains near the existing intake on Turner Road need interconnecting. From Martindale, a new transmission main will run along Highway 19A, across the bridge to Tuan Road and from Resort Drive to Northwest Bay Road, to provide a parallel transmission main to the existing 300 mm main to feed the RDN service areas on the Nanoose Peninsula via the Wallbrook pump station. A right-of-way will be required across the Trailer Park (Lot 3, Plan 6885, DL125) and adjoining Lot 1, Plan 28271, DL125, otherwise a longer alignment following public roads will need to be chosen.

From this point into Nanoose the transmission alignment and sizing is the same for all three intake/WTP site options, and transmission or distribution upgrading required past this point has therefore not been considered in this assessment. This will be considered for the final preferred option.

## 7. Transmission/Distribution System for Site # 5

The new transmission and distribution mains required to connect to existing distribution are shown in red on Figure 10. The pertinent existing infrastructure is shown in blue. New main sizes shown are for the high demand condition and are the same for inclusion or exclusion of the Town of Qualicum Beach. Cost estimates are presented at the end of this memo.

Transmission to Parksville, French Creek and Qualicum Beach

From Highway 19A, a new distribution main will follow Shelly Road to Stanford Avenue, and connect to the 300 mm diameter main along Highway 19A. The Stanford Avenue right-of-way is not continuous between Martindale and Shelly and needs to be secured for this alignment. The new distribution main will continue along Stanford Avenue to connect to the 250 mm dia. main on McVickers Street and to the 250 mm dia. Main on McCarter Street.

At Springwood, there will be a booster pump station for further transmission beyond the City of Parksville to French Creek and Qualicum Beach. The transmission alignment and sizing beyond the Springwood Reservoir is the same for all three intake/WTP site options, and transmission or distribution upgrading required past this point has therefore not been considered in this assessment. This will be considered for the final preferred option.

Transmission to Nanoose

A new transmission main will follow Turner Road and Shelly Road to Highway 19A. From Shelly, a new transmission main will run along Highway 19A, across the bridge to Tuan Road and from Resort Drive to Northwest Bay Road, to provide a parallel transmission main to the existing 300 mm main to feed the Nanoose Peninsula. A right-of-way will be required across the Trailer Park (Lot 3, Plan 6885, DL125) and adjoining Lot 1, Plan 28271, DL125, otherwise a longer alignment following public roads will need to be chosen.

From the Wallbrook pump station into Nanoose the transmission alignment and sizing is the same for all three intake/WTP site options, and transmission or distribution upgrading required past this point has therefore not been considered in this assessment. This will be considered for the final preferred option.

## 8. Comparative Cost Estimates

The transmission/distribution requirements between the WTP and the Springwood Reservoirs for the high demand scenario are the same for each intake/WTP site option, with and without participation of the Town of Qualicum Beach, as the Qualicum Beach groundwater capacity pretty well takes care of the projected high Qualicum Beach maximum day demand for 2050.

For the low demand scenario with participation of Qualicum Beach the system between the WTP sites and the Springwood Reservoirs requires only very minor transmission improvements for Sites # 1A and 1B and some simple interconnections for Sites # 3 and # 5, as the French Creek/Qualicum Beach groundwater supply will be able to supply the 2050 maximum day demands without any surface water supply contribution. Without Qualicum Beach participation, these requirements increase, but are still substantially less than those for the high demand scenario.

To determine the impact of the transmission/distribution system improvements required for each intake/WTP site option, we have used the requirements for the high demand scenario.

Tables 1, 2, 3 and 4 show the comparative cost estimates for the transmission/distribution system improvements required for each the intake/WTP site options, Site # 1A, # 1B, #3, and # 5, respectively. It should be noted that the improvements listed only apply to the system between the WTP site and the Nanoose connection at the Wallbrook pump station and the Qualicum Beach/French Creek connection at the Springwood Reservoir. Improvements required beyond these points are the same for each intake/WTP site and will only be determined for the final preferred option.

The costs shown are to a 2010 base for local construction costs. The pipe installation unit costs allow for pipe and all fittings and appurtenances, such as tie-ins to existing, branch and line valves in chambers, air valve and drain assemblies, 1 metre minimum cover, an average of 25% rock excavation, imported backfill, medium complexity with respect to dealing with existing underground utilities, and full pavement restoration. No allowance has been made for contingencies, engineering costs, or any administration, or financing costs. GST or HST is not included.

**Table 1. Site # 1 – Intake Site # 1A. Transmission/Distribution Costs (Figure 7)**

| Pipe No. | Length (m) | Diameter (mm) | Location | Unit Price | Extension |
|---|---|---|---|---|---|
| 1 | 275 | 450 | WTP – Herring Gull | 500 | $137,500 |
| 2 | 835 | 400 | Herring Gull – Industrial Way | 450 | 375,750 |
| 3 | 2585 | 600 | WTP to Stanford via Martindale | 650 | 1,680,250 |
| 4 | 375 | 500 | Stanford, Martindale to Shelly | 550 | 206,250 |
| 5 | 67 | 300 | Martindale, Stanford to 19A | 350 | 23,450 |
| 6 | 660 | 450 | Stanford, Shelly to McVickers | 500 | 330,000 |
| 7 | 560 | 400 | Stanford, McVickers to McCarter | 450 | 252,000 |
| | | | | **TOTAL** | **$3,005,200** |

**Table 2. Site # 1 – Intake Site # 1B. Transmission/Distribution Costs (Figure 8)**

| Pipe No. | Length (m) | Diameter (mm) | Location | Unit Price | Extension |
|---|---|---|---|---|---|
| 1 * | 275 | 750 | WTP – Herring Gull | 500 | $137,500 |
| 2 * | 480 | 750 | Herring Gull – Industrial Way | 500 | 240,000 |
| 3 * | 1245 | 600 | Industrial W & 19A to Resort W | 400 | 498,000 |
| 4 | 50 | 300 | 19A crossing to Resort Dr. | 2000 | 100,000 |
| 5 * | 990 | 600 | 19A, Resort Dr. to Martindale | 400 | 396,000 |
| 6 | 300 | 300 | Resort Dr. to NW Bay Road | 350 | 105,000 |
| 7 | 70 | 300 | Martindale, 19A to Stanford | 350 | 24,500 |
| 8 | 375 | 500 | Stanford, Martindale to Shelly | 550 | 206,250 |
| 9 | 660 | 450 | Stanford, Shelly to McVickers | 500 | 330,000 |
| 10 | 560 | 400 | Stanford, McVickers to McCarter | 450 | 252,000 |
| | | | | **TOTAL** | **$2,289,250** |

***** Unit prices for these sections reduced by $250/m to account for common trench installation with raw water supply main. The cost of the raw water supply main is not included in the transmission/distribution main cost estimates presented in this memo, but will be included in the intake/supply main cost estimates presented elsewhere.

**Table 3. Site # 3. Transmission/Distribution Costs (Figure 9)**

| Pipe No. | Length (m) | Diameter (mm) | Location | Unit Price | Extension |
|---|---|---|---|---|---|
| 1 | 30 | 450 | Connection 250 & 300 Turner | 500 | $15,000 |

| | | | | | |
|---|---|---|---|---|---|
| 2 | 1450 | 250 | 19A, Martindale to Tuan | 325 | 362,500 |
| 3 | 300 | 250 | Resort Dr to NW Bay Road | 325 | 97,500 |
| 4 | 585 | 500 | WTP – Martindale –Stanford to Shelly | 550 | 321,750 |
| 5 | 660 | 450 | Stanford, Shelly to McVickers | 500 | 330,000 |
| 6 | 560 | 400 | Stanford, McVickers to McCarter | 450 | 252,000 |
| | | | | **TOTAL** | **$1,378,750** |

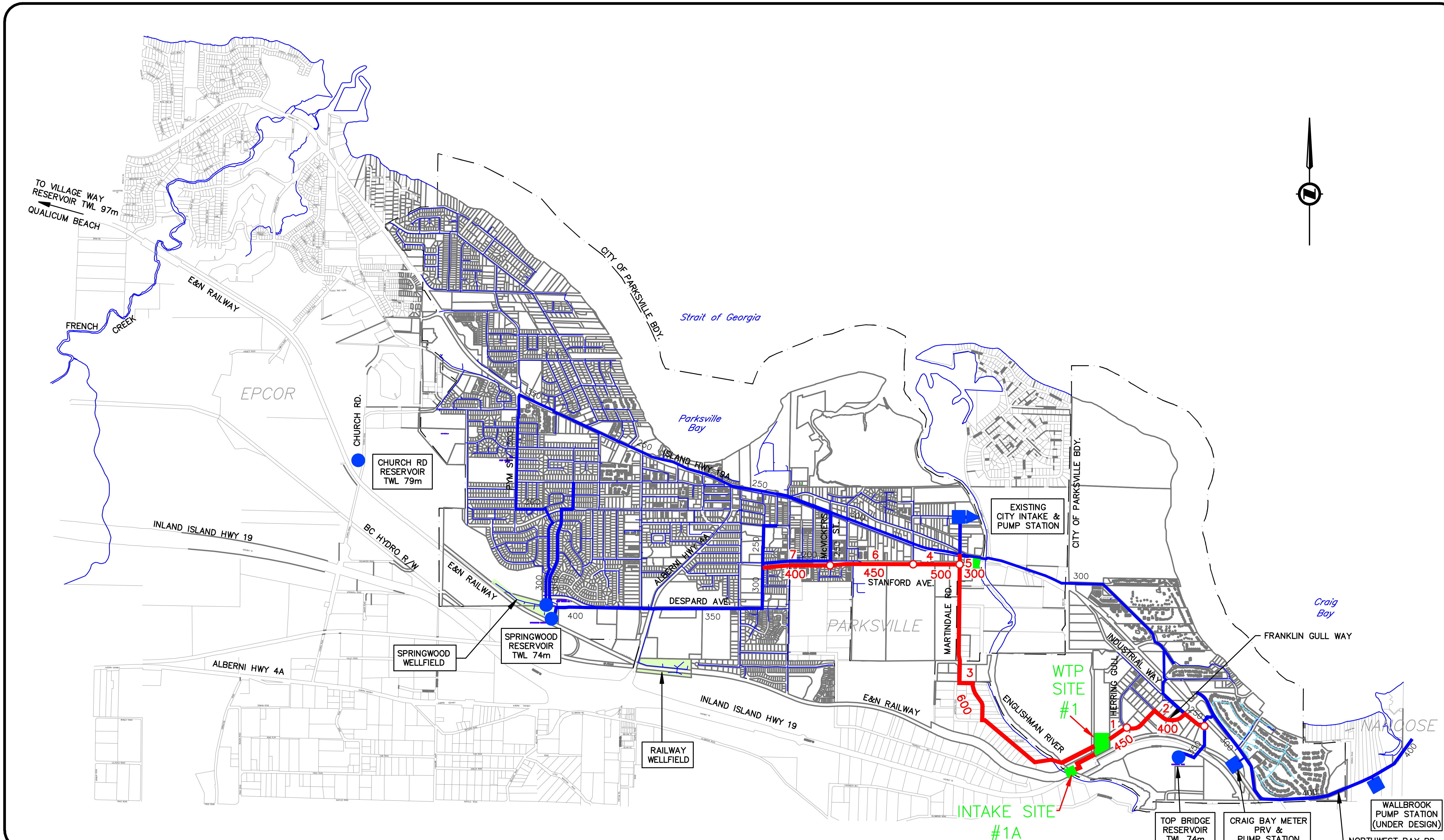
**Table 4. Site # 5. Transmission/Distribution Costs (Figure 10)**

| **Pipe No.** | **Length (m)** | **Diameter (mm)** | **Location** | **Unit Price** | **Extension** |
|---|---|---|---|---|---|
| 1 | 580 | 600 | Shelly R, Turner to 19A | 650 | $377,000 |
| 2 | 1630 | 250 | 19A, Martindale to Tuan | 325 | 529,750 |
| 3 | 300 | 250 | Resort Dr to NW Bay Road | 325 | 97,500 |
| 4 | 785 | 400 | Shelly/Stanford, 19A to McVickers | 450 | 353,250 |
| 5 | 560 | 400 | Stanford, McVickers to McCarter | 450 | 252,000 |
| | | | | **TOTAL** | **$1,609,500** |

By comparison, the estimated costs for transmission/distribution upgrades required to satisfy the low 2050 demand scenario between the Intake/WTP site and the connections to Nanoose at Wallbrook pump station and to French Creek/Qualicum Beach at the Springwood reservoir are the following:

| | Without Qualicum Beach | With Qualicum Beach |
|---|---|---|
| Site # 1A | $1,031,700 | $291,850 |
| Site # 1B | $1,000,000 | $291,850 |
| Site # 3 | 204,925 | 25,000 |
| Site # 5 | 115,000 | 20,000 |

The full transmission/distribution system requirements for the 2050 high and low demand scenarios will be determined for the preferred Intake/WTP site once that is determined.

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| CLIENT | ASSOCIATED ENGINEERING (BC) LTD. |
| PROJECT | ENGLISHMAN RIVER INTAKE STUDY |

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|---|---|---|---|
| TITLE | TRANSMISSION MAIN IMPACTS INTAKE / W.T.P. SITE #1A | | |
| APPROVED | | SCALE | 1:30000 |
| DATE | APR. 2010 | DWG No. | Figure 5-3 |
| JOB No. | 0942-07 | | |

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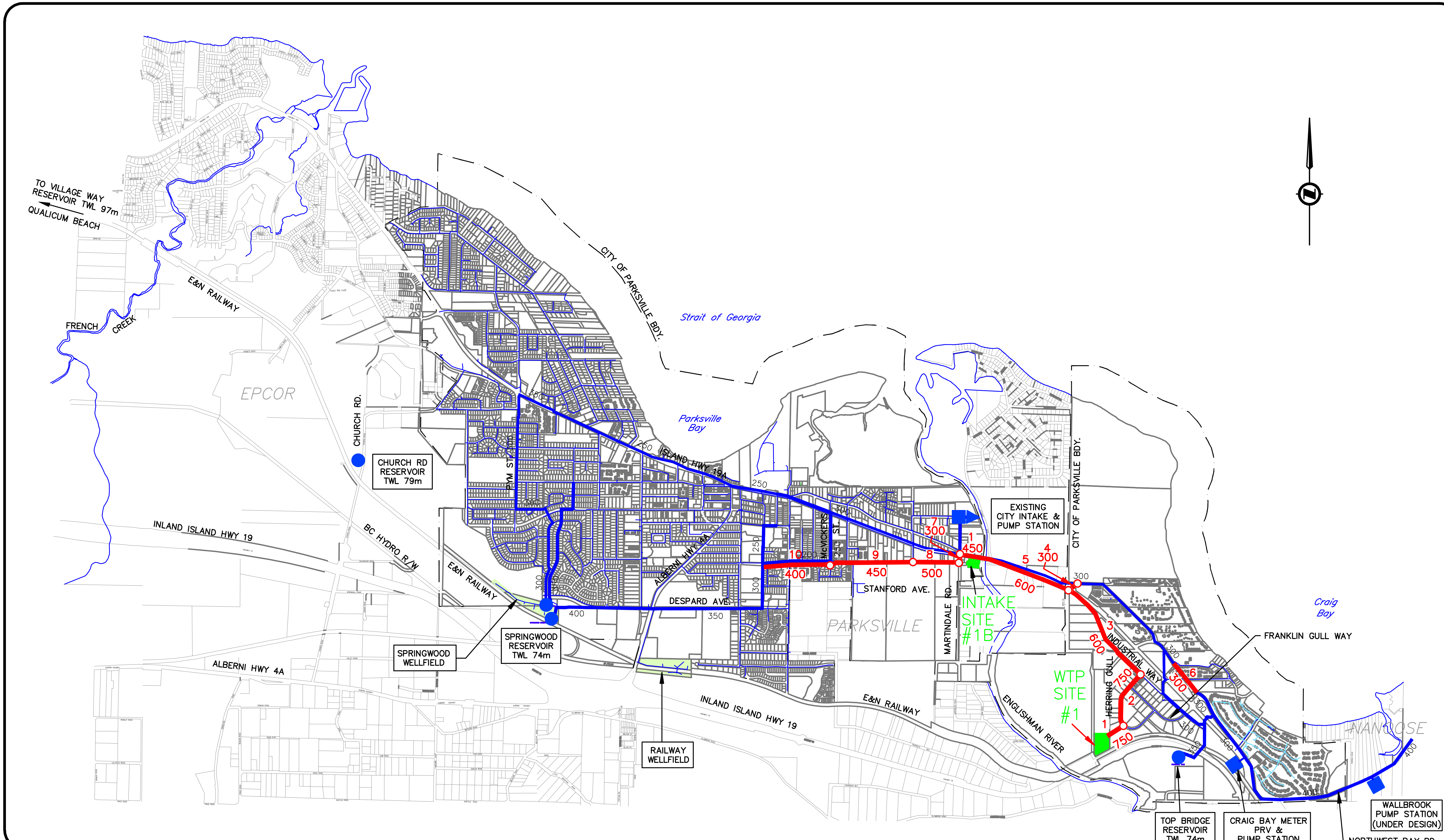


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*Consulting Engineers*

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| CLIENT | ASSOCIATED ENGINEERING (BC) LTD. |
| PROJECT | ENGLISHMAN RIVER INTAKE STUDY |

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|---|---|---|---|
| TITLE | TRANSMISSION MAIN IMPACTS INTAKE / W.T.P. SITE #1B | | |
| APPROVED | | SCALE | 1:30000 |
| DATE | APR. 2010 | DWG No. | FIG 8 |
| JOB No. | 0942-07 | | |

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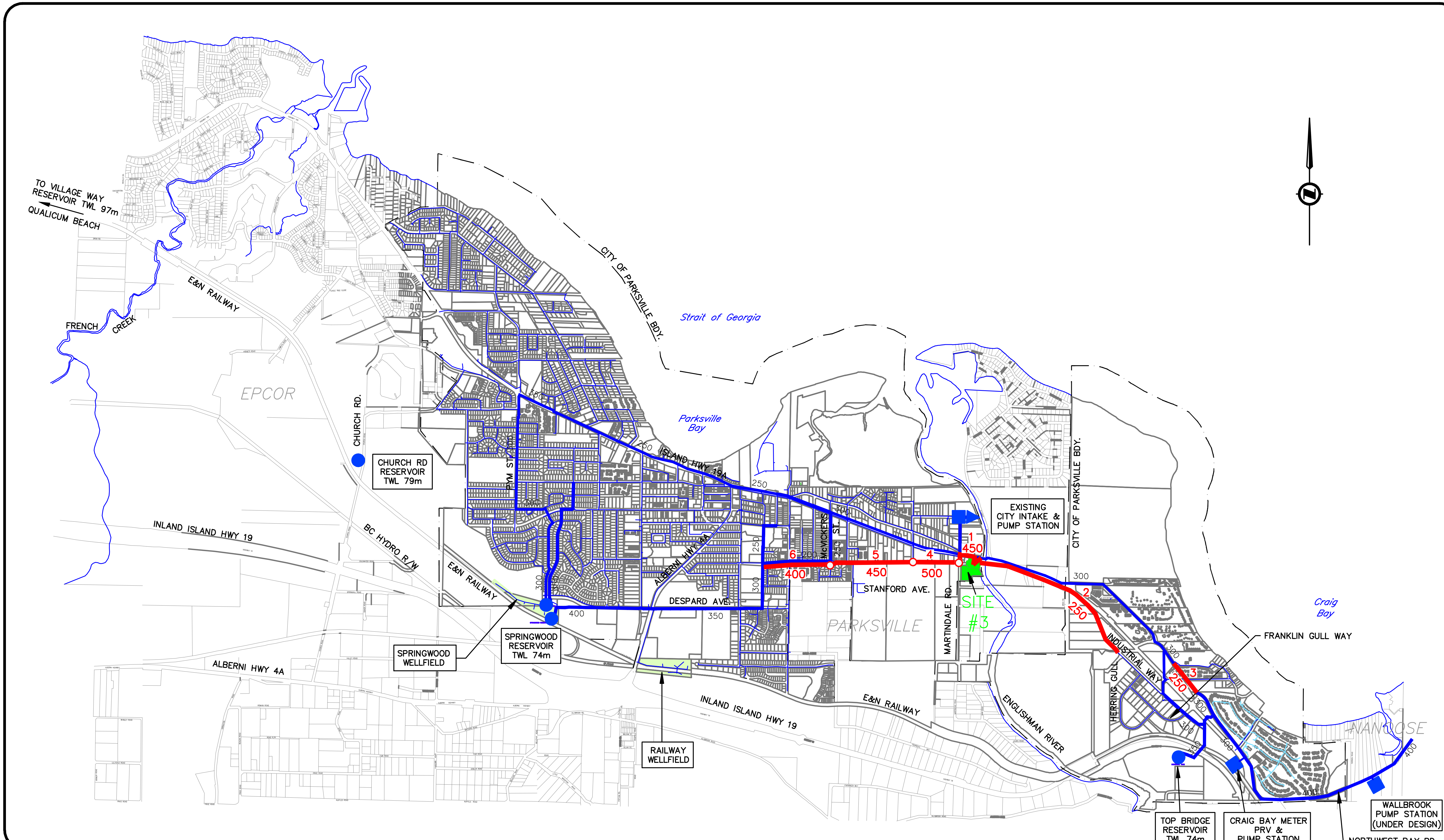


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| CLIENT | ASSOCIATED ENGINEERING (BC) LTD. |
| PROJECT | ENGLISHMAN RIVER INTAKE STUDY |

| TITLE | TRANSMISSION MAIN IMPACTS INTAKE / W.T.P. SITE #3 | | |
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| DATE | APR. 2010 | DWG No. | FIG 9 |
| JOB No. | 0942-07 | | |

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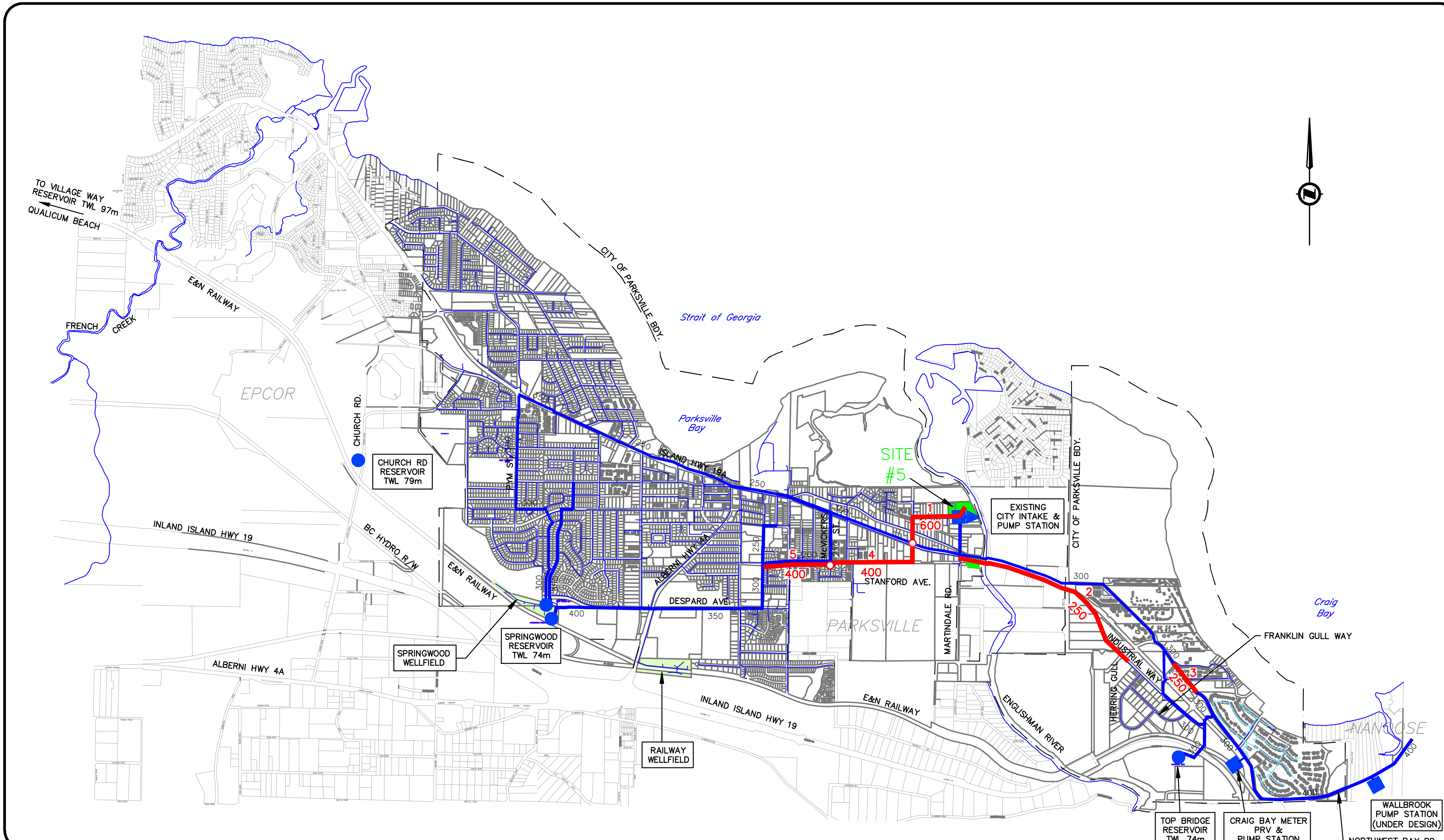


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| CLIENT | ASSOCIATED ENGINEERING (BC) LTD. |
| PROJECT | ENGLISHMAN RIVER INTAKE STUDY |

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| TITLE | TRANSMISSION MAIN IMPACTS INTAKE / W.T.P. SITE #5 | | |
| APPROVED | | SCALE | 1:30000 |
| DATE | APR. 2010 | DWG No. | FIG 10 |
| JOB No. | 0942–07 | | |

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# Appendix C - EBA Technical Memorandum

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# TECHNICAL MEMO

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**TO:** Mr. Rick Corbett, M.A.Sc., P.Eng.
Associated Engineering (B.C.) Ltd.

**DATE:** May 21, 2010

**FROM:** Shelley Higman, M.Sc., P.Eng./P.Geo.

**FILE:** N13101242.001

**SUBJECT:** **Englishman River Intake and Treatment Plant Project Preliminary Geotechnical Assessment of Short-listed Sites (Site 1, Site 3, and Site 5) - CONFIDENTIAL**

## 1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was retained by Associated Engineering (B.C.) Ltd. (Associated) to provide geotechnical and hydrotechnical engineering services regarding the siting and design for a new water intake on the Englishman River in Parksville, BC as requested by the Arrowsmith Water Service (AWS).

The first phase of this study involved a broad, overview assessment of a 10 km section along the Lower Englishman River that extends upstream from the estuary. This 10 km section had been divided into 38 sites based on 19 reaches defined by Associated (Figure 1). This initial phase of the study involved evaluation of a set of geotechnical criteria in a "constraint mapping exercise" from which 12 sites were selected from a geotechnical perspective (EBA memo "*Englishman River Intake and Treatment Plant Project, Constraint Mapping Process for Long-list Site Selection, Geotechnical Perspective – Issued for Review*" dated March 2, 2010, prepared for Associated). Geotechnical and geomorphological criteria considered in this initial study included:

- Historic channel migration;
- Scour and bedload movement;
- Reach morphology (e.g. meandering, braided, straight, etc.);
- Reach type (e.g. alluvial, semi-alluvial, non-alluvial);
- Location relative to tributary junctions;
- Bank stability;
- Upslope hazards;
- Flood potential;
- Foundation conditions; and
- Constructability.



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Associated then evaluated this geotechnical information in connection with other land use information, such as fisheries, archaeological, etc. (evaluated by others), in a similar constraint mapping exercise from which Associated, in connection with the AWS, short-listed the sites to 3 possible locations – Site 1, Site 3 and Site 5. EBA notes that the third site, Site 5, actually consists of two sites – Site 5a and Site 5b (shown on Figure 1). Therefore, technically, there are four sites, but for simplicity, we will continue to refer to these as the 3 short-listed sites.

This memo addresses the results of the second phase of the study that involved a preliminary geotechnical assessment of the 3 short-listed sites. The purpose of this current study is to provide preliminary geotechnical comments regarding the suitability of these 3 sites for development of the proposed water treatment plant. This memo briefly discusses the methodology and results of this preliminary geotechnical assessment. EBA notes that this preliminary assessment focuses on local geotechnical issues specifically associated with the proposed water treatment plant, including seismic criteria, local flooding, slope stability, erosion, site drainage, local soil conditions, etc. It is based on a desktop study and visual data only. Once a single site or sites are selected, a detailed geotechnical investigation will be required to provide a detailed geotechnical evaluation of the site and to provide detailed design requirements.

Comments pertaining to the hydrotechnical suitability of each of these sites are provided in a separate memo prepared by Hay and Company – a Division of EBA (Hayco).

## 2.0 METHODOLOGY

EBA completed a preliminary geotechnical assessment of the 3 short-listed sites for the proposed new water intake and treatment plant along the Lower Englishman River between Highway 19 and the estuary. This assessment is based on a review of readily available background information (aerial imagery, surficial geology, bedrock geology, water well information, available reports, etc.), and a brief site reconnaissance conducted on April 12, 2010 in conjunction with a team site meeting with Associated and the civil consultant Koers and Associates Engineering Ltd. (Koers).

The following was reviewed in the preparation of this memo:

- Associated Engineering, Record of Meeting "*Short-Listed Site Visit (Re-Issued)*", dated April 12, 2010, prepared for Koers, EBA, Associated, and LGL Limited;
- Koers and Associates Engineering Ltd. Memorandum "*Arrowsmith Water Service, Englishman River Intake Study, Intake/Water Treatment Plant Site Shortlist*", dated March 23, 2010, prepared for Associated;
- Associated Engineering, Discussion Paper "*Discussion Paper 6-2 – Development of a List of Potential Intake Sites*", dated March 15, 2010, prepared for AWS;

- Associated Engineering, Discussion Paper "*Discussion Paper 4-4 – Water Treatment Plant Site Development Considerations*", dated March 12, 2010, prepared for AWS;
- Koers and Associates Engineering Ltd. Memorandum "*Arrowsmith Water Service, Bulk Water Supply - Capital Plan 2006, Project Memorandum #1, Lower Englishman River Intake/Treatment Site Options*", dated May 2006, prepared for AWS;
- Pacific Hydrology Consultants Ltd. Letter. "Results of Test Drilling Englishman River Intake Site", dated April 1, 1983, prepared for the Town of Parksville;
- Pacific Hydrology Consultants Ltd. Letter. "*Digging of Test Pits near the Englishman River Intake*", dated March 14, 1983, prepared for the Town of Parksville;
- Mueller, J.E. 1977. Geology of Vancouver Island, GSC Open File 463;
- BC Ministry of Environment, 1985. "Soils of South Vancouver Island, Soil Survey Report No. 44", Map Sheet 3, 1:100,000 scale.
- BC Ministry of Environment water well data and 200-year floodplain mapping from http://www.env.gov.bc.ca/wsd/data_searches/wrbc/;
- BC Geological Survey bedrock geology from http://webmap.em.gov.bc.ca/mapplace/minpot/bcgs.cfm; and
- GoogleEarth Pro 2005, 2006 and 2007 imagery.

## 3.0 PROPOSED DEVELOPMENT

EBA understands the proposed development will consist of the following:

- A 2600 $m^2$ 1-story post-disaster industrial building to house the water treatment plant with a structure density of 3600 $kg/m^2$ to 5200 $kg/m^2$. The footings are planned to extend 3.5 m to 4.2 m below the existing ground surface. The building configuration will vary depending on the particular site (rectangular at Site 1; divided into a few separate buildings at Site 3; and L-shaped at Site 5a);
- A 2000 $m^2$ residuals management facility with a structure density of 2600 $kg/m^2$;
- A 1400 $m^2$ industrial building to house a two chamber clearwell, where clearwells will extend below ground to a depth of 3 m with a structure density of 800 $kg/m^2$ to 3900 $kg/m^2$;
- A 400 $m^2$ pump station with a structure density of 1600 $kg/m^2$; and
- A 1000 $m^2$ overflow pond.

Based on these building size requirements, we understand that the treatment plant and supportive infrastructure will have a total footprint of approximately 7400 $m^2$. With the inclusion of space requirements for access roads and landscaping, Associated has estimated the overall area requirement at about 1.5 ha.

# 4.0 SITE DESCRIPTION AND GEOLOGY

## 4.1 GENERAL

Overall site conditions are described in EBA's previous memo "*Englishman River Intake and Treatment Plant Project, Constraint Mapping Process for Long-list Site Selection, Geotechnical Perspective – Issued for Review*" dated March 2, 2010, prepared for Associated). As described in this previous memo, the Englishman River is a fault zone. As such, all 3 sites are located along this fault, and are underlain by sedimentary bedrock of the upper Cretaceous Nanaimo Group.

Described in the sections below are the expected site conditions at each of the 3 short-listed sites. Where applicable, EBA has noted sub-surface conditions from near-by water well logs. We note however, that in fluvial environments, such as the Englishman River, sub-surface conditions can change rapidly such that the conditions encountered in the water wells may not be representative of the actual site conditions.

## 4.2 SITE 1

Site 1 is located on the north bank of the Englishman River, directly north of Highway 19 near the City of Parksville's Engineering and Operations compound (Figure 2). It coincides with reaches 12E and 13E from the "constraint mapping exercise" that ranked among the highest from the geotechnical perspective (Associated Engineering. 2010. Discussion Paper "*Discussion Paper 6-2 – Development of a List of Potential Intake Sites*", dated March 15, 2010, prepared for AWS).

The location for the proposed water treatment plant and supporting facilities is an inactive gravel pit site, as per the Koers 2010 memorandum. At this location, the site is terraced from previous gravel operations, and the elevation ranges from about 23 m to 29 m, with the topography sloping northwards. About half of this area is vegetated with mature second growth coniferous trees.

Should the site be moved to the north by about 100 m, most of the buildings could be located at the same elevation at about 23 m, and would likely require less earthworks for site leveling. Much of this area is non-vegetated, or vegetated with shrubs such as Scotch broom.

A relatively lengthy pipeline would be required to connect the water treatment plant and intake that is proposed to cross under the railway right-of-way, pass up the slope and follow the north side of the railway embankment to the proposed water treatment plant at the inactive gravel pit site.

Available soils information in connection with site observations at the proposed location of the water treatment plant indicates the following:

- The water treatment plant site is well drained;
- Soils within the area of the water treatment plant are mapped as Capilano sediments consisting of terraced fluvial deposits that reportedly consist of gravel and sand, commonly underlain by silt;
- Observed soils at the location of the proposed treatment plant consist of compact to dense, stratified sand and gravel with trace silt. No evidence of groundwater seeping from the previous cut slopes was noted;
- Water well data located 400 m to 750 m from the water treatment plant site indicate the soil consists of sand and gravel (that is dense in places) to depths of at least 20 m below ground surface, and static ground water level was at 14 m below ground surface;
- Sedimentary bedrock (sandstone and conglomerate) was observed at the proposed intake location (in the right-of-way of the highway and railway) at an elevation of about 10 m;
- Sandy silt with some gravel was observed at about the 16 m elevation at the northwest toe of the railway embankment;
- Curved tree trucks were noted in mature coniferous trees (about 300 mm in diameter) along the northwest slope of the railway embankment that slopes at an angle of about 85% over a slope distance of about 10 m to 15 m. This observation suggests a moderate to high rate of soil creep. The slope angle of the embankment decreases to the east to about 60%;
- The seismic Site Class is likely C to D; and
- Seismic parameters obtained from Natural Resources Canada, as tabulated below for Site #1:

| TABLE 1: NATIONAL BUILDING CODE INTERPOLATED SEISMIC HAZARD VALUES FOR SITE #1 | | | | |
|---|---|---|---|---|
| **2% / 50 years (0.000404 per annum, or 1 in 2475 years) Probability** | | | | |
| **Sa(0.2)** | **Sa(0.5)** | **Sa(1.0)** | **Sa(2.0)** | **PGA** |
| 0.891 | 0.623 | 0.328 | 0.170 | 0.434g |

## 4.3 SITE 3

Site 3 is located on the west bank of the Englishman River, directly south of Highway 19A (Figure 3). It coincides with reach 17W from the "constraint mapping exercise" that ranked among the highest from the geotechnical perspective (Associated Engineering. 2010.

Discussion Paper "*Discussion Paper 6-2 – Development of a List of Potential Intake Sites*", dated March 15, 2010, prepared for AWS).

The location for the proposed water treatment plant and supporting facilities is the portion of Lot 1 Plan 14815 and Lot 1 Plan 34439, as per the Koers 2010 memorandum, that is above the 200-year flood plain (as shown on Figure 3). As per the Koers 2010 memorandum, the available area for the proposed water treatment plant and supporting facilities is less than 1 ha (i.e. less than the desired 1.5 ha). The desired area could be achieved by building up the floodplain within the Shelley Creek wetland. As noted by others, some form of habitat compensation would likely be required.

At this location, the site slopes moderately to the southeast towards the Shelley Creek wetland, which occupies most of Lot 1 Plan 34439. At this location, the site ranges in elevation from about 5 m to 13 m. The area is occupied by the Englishman River Motel and a private residence. Much of the site is vegetated with mature trees.

Available soils information in connection with site observations at the proposed location of the water treatment plant indicates the following:

- The site above the 200-year flood plain is well drained;
- Soils are mapped as Salish sediments consisting of shore, deltaic and fluvial deposits that reportedly consist of gravel, sand, silt, clay and peat;
- Observed soils consist of compact to dense, stratified sand with some silt, and some gravel to gravelly, at least 2 m thick over conglomerate bedrock (exposed along the west bank of the Englishman River north of Shelley Creek);
- Water well data from a well located about 130 m to the south of the proposed site for the water treatment plant and associated facilities did not provide any useful soil information regarding the local site conditions, but did indicate the static groundwater level was at about 1 m below the existing ground surface;
- The seismic Site Class is likely C to D, but if the water treatment plant was founded on competent bedrock, could be Site Class B; and
- Seismic parameters obtained from Natural Resources Canada, as tabulated below for Site #3 (existing motel location):

| TABLE 2: NATIONAL BUILDING CODE INTERPOLATED SEISMIC HAZARD VALUES FOR SITE #3 | | | | |
|---|---|---|---|---|
| **2% / 50 years (0.000404 per annum, or 1 in 2475 years) Probability** | | | | |
| **Sa(0.2)** | **Sa(0.5)** | **Sa(1.0)** | **Sa(2.0)** | **PGA** |
| 0.882 | 0.618 | 0.326 | 0.170 | 0.429g |

## 4.4 SITE 5

Site 5 is located on the west bank of the Englishman River, directly north of the existing intake location (labelled Site 5a on Figure 4). Subsequent to our site review, we have been asked to comment on the area directly south of the existing intake (labelled Site 5b on Figure 4). Site 5a coincides with reach 19W and Site 5b coincides with reach 18W from the "constraint mapping exercise" both of which ranked among the top third of the 38 sites considered from the geotechnical perspective (Associated Engineering. 2010. Discussion Paper "*Discussion Paper 6-2 – Development of a List of Potential Intake Sites*", dated March 15, 2010, prepared for AWS).

The location for the proposed water treatment plant and supporting facilities is on the area above the 200-year flood plain, as per the Koers 2010 memorandum. However, the area available at Site 5a is only about 4000 $m^2$ and about 3500 $m^2$ at Site 5b, implying that some portion of the supporting facilities would need to be constructed on the flood plain. At both of these locations, the sites are moderate to gentle sloping from west to east towards the Englishman River, and the elevation ranges from about 4 m to 11 m. Site 5a is vegetated with mature second growth coniferous trees; whereas Site 5b is occupied by residential houses in the upland portion and mixed vegetation on the lowland portions.

Available soils information in connection with site observations at the proposed location of the water treatment plant indicates the following:

- Site 5a is well drained above the flood plain; Site 5b is likely well drained above the flood plain;
- Soils in the upland area (above the flood plain) of Site 5a are mapped as Capilano sediments consisting of terraced fluvial deposits that are deltaic in origin consisting of gravel and sand, commonly underlain by silt;
- Soils in the flood plain of Site 5a, and within all of Site 5b, are mapped as Salish sediments consisting of shore, deltaic and fluvial deposits that consist of gravel, sand, silt, clay and peat;
- Observed soils in the flood plain of Site 5a consist of loose, sand with trace silt and gravel;
- 2 testpits and a test well were completed in the flood plain about 50 m to the south of Site 5a in 1983 by Pacific Hydrology Consultants Ltd. (PHCL). Water well data from this study indicates the soil consists of about 2 m of silt and tight gravel (that EBA has inferred to mean dense), underlain by a 1.3 m thick layer comprised of loose, sand and gravel, that in turn, is underlain by a 10 m thick layer of cemented sand, gravel and boulders that EBA has inferred to mean glacial till that overlies sandstone bedrock at a depth of 14.3 m below existing ground surface. The static ground water level was at 1.5 m below ground surface. The 2 testpits, on the other hand, indicated the gravel layer was much thicker, at a minimum thickness of 4 m;

- A borehole drilled by EBA at the intersection of Shelly Road and Pioneer Crescent (i.e. about 600 m southwest of Sites 5a and 5b) indicates the presence of a compact to dense gravel layer that is about 1.85 m thick, where the consistency increases with depth. This gravel layer is underlain by about 2.85 m of compact to dense sand that in turn, is underlain by an undetermined depth of silt. Wet soil conditions were encountered at the interface between the gravel and underlying sand layer. According to the available mapping, this borehole was completed in the Capilano sediments and not the Salish sediments that reportedly occupy the flood plain;
- The seismic Site Class is likely C to D, but possibly E to F; and
- Seismic parameters obtained from Natural Resources Canada, as tabulated below for Site 5a and 5b (above the flood plain):

TABLE 3: NATIONAL BUILDING CODE INTERPOLATED SEISMIC HAZARD VALUES FOR SITE #5

| 2% / 50 years (0.000404 per annum, or 1 in 2475 years) Probability | | | | |
|---|---|---|---|---|
| **Sa(0.2)** | **Sa(0.5)** | **Sa(1.0)** | **Sa(2.0)** | **PGA** |
| 0.880 | 0.617 | 0.326 | 0.170 | 0.428g |

## 5.0 DISCUSSION

Discussed below is the geotechnical suitability of each site for supporting the proposed water treatment plant and supporting facilities.

## 5.1 SITE 1

The 200-year flood plain mapping provided by Koers indicates the location of the proposed treatment plant is well above the 200-year flood levels. Soils observed on site in connection with inferred water table levels suggest this site would be suitable for the proposed treatment plant and supporting facilities. The key concern is the consistency of the native soil that can be determined by a subsequent sub-surface investigation. Preliminary observations, however, suggest that the native soils should have the required bearing capacity to support the proposed structures. Preliminary observations concerning groundwater levels suggest that there may be a potential for liquefaction in the silt layer underlying the thick deposit of sand and gravel. Since the water treatment plant at Site 1 is elevated relative to the intake, should liquefaction occur within the silt layer, a significant length of penstock could be affected as well as the water treatment plant.

Similarly, a seismic event could cause the railway and highway embankments to fail, depending on how they were constructed.

Based on our observations indicating that the railway embankment is potentially unstable, the supply pipeline should be positioned at a sufficient distance from the toe of the slope such that:

- construction of the pipeline will not undermine the toe of the embankment; and
- the supply pipeline is buried at a sufficient depth such that any potential future slope instability associated with the embankment does not negatively impact the pipeline, or any impacts from a potential train derailment.

Last, a small portion of the supply pipeline will be located within the 200-year floodplain near the location of the intake, and may be susceptible to erosion.

## 5.2 SITE 3

The 200-year flood plain mapping provided by Koers indicates the location of the proposed treatment plant is above the 200-year flood levels. Soils observed on site suggest this site would be suitable for the proposed treatment plant and supporting facilities. The key concern is the consistency of the native soil and groundwater levels that can be determined by a subsequent sub-surface investigation. Preliminary observations, however, suggest that the native soils should have the required bearing capacity to support the proposed structures. Our preliminary assessment concerning groundwater levels suggests that liquefaction potential may be a concern at this site depending on footing depths relative to groundwater levels. However, footings may possibly be founded on bedrock, in which case, liquefaction is not a concern. Alternatively, soil improvements, such as densification, are likely possible, especially given the relatively shallow soil depths over bedrock.

A small portion of the supply pipeline will be located within the 200-year floodplain near the location of the intake, and may be susceptible to erosion. Otherwise, no other geotechnical concerns were noted concerning the supply pipeline.

## 5.3 SITE 5

The 200-year flood plain mapping provided by Koers indicates a significant portion of the proposed treatment plant would be located within the 200-year flood levels for both Sites 5a and 5b. Soils observed on site in connection with inferred water table levels suggest this site may be susceptible to liquefaction, and therefore be unsuitable for the proposed treatment plant and supporting facilities without building up either of the areas with an engineered fill. The Hayco report concludes that any future infill development of the floodplain on the west bank has the potential to impact flood levels further upstream. Soil improvements, such as densification, may be a possible alternative to infilling the flood plain at this site.

EBA is aware that a drilling investigation for the proposed new Canadian Tire building was conducted by others upstream of Site 5, just downstream of the Highway 19A bridge. The

City of Parksville may have access to this data, which may assist in our overall understanding of the sub-surface conditions within the flood plain at Site 5.

In contrast, the soils mapped at the upper elevations of Site 5a suggest that the upper elevation of Site 5a would potentially be suitable for the proposed treatment plant and supporting facilities. The key concern is the consistency of the native soil and groundwater levels, which can be determined by a subsequent sub-surface investigation. Preliminary observations, however, suggest that the native soils should have the required bearing capacity to support the proposed structures. Our preliminary assessment concerning groundwater levels suggests that liquefaction potential may be a concern at these upper site elevations depending on footing depths relative to groundwater levels.

A significant portion of the supply pipeline, at either Site 5a or 5b, will be located within the 200-year floodplain, and may be susceptible to erosion.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on our desktop review and our site reconnaissance, EBA concludes and recommends the following concerning the suitability of each of the three short-listed sites for the proposed intake and water treatment plant along the Englishman River:

- <u>Site 1:</u>
  - potentially suitable, but would require a sub-surface investigation to confirm. Specifically, the sub-surface investigation would determine the foundation conditions for footings bearing on native soil, liquefaction potential, seismic design parameters (e.g. Site Class, Fv and Fa), etc;
  - advantages of the site:
    - large site that can easily accommodate the water treatment plant and supporting facilities;
    - well above the 200-year flood plain;
    - apparently low groundwater levels; and
    - well drained.
  - disadvantages of the site:
    - depending upon where the water treatment plant and supporting facilities are located, substantial earthworks may be required;
    - the pipeline supply route would require placement beyond the toe of the railway embankment to minimize the potential for disturbance to the embankment and to minimize the potential for slope stability related impacts to the pipeline;

  - the railway embankment and the Highway 19 bridge embankment may become unstable during a seismic event; and
  - liquefaction may be an issue at depth, especially with the elevation difference between the intake location and water treatment plant location.

- **<u>Site 3:</u>**
  - potentially suitable, but would require a sub-surface investigation to confirm. Specifically, the sub-surface investigation would determine the foundation conditions for footings bearing on native soil and/or engineered fill placed over the native soil, liquefaction potential, and seismic design parameters (e.g. Site Class, Fv and Fa), etc.;
  - advantages of the site:
    - the proposed structures can be located above the 200-year flood plain;
    - relatively little earthworks required; and
    - well drained above the 200-year flood plain.
  - disadvantages of the site:
    - the available area for the treatment plant and supporting structures is tight, suggesting that the Shelley Creek wetland may potentially be impacted, likely requiring compensation in the form of wetland enhancements.
- **<u>Site 5:</u>**
  - Without building up the flood plain above the 200-year flood level, Sites 5a and 5b are unsuitable for the proposed treatment plant and supporting facilities.
  - Should either of the sites be built up, a fill depth of 1 m to 2 m would be required, and a sub-surface investigation is required to understand the subsoil conditions on which the engineered fill would be placed (in particular to determine if peat is present at depth). However, the Hayco report concludes that any future infill development of the floodplain on the west bank has the potential to impact flood levels further upstream. Alternatively, soil improvement measures (e.g. densification) may be possible on the flood plain.
- EBA notes that at all sites, a portion of the supply pipeline will be located within the 200-year flood plain, and is therefore susceptible to erosion. For Sites 1 and 3, this is not a significant portion; however, at Sites 5a and 5b, most of the supply pipeline will be located within the flood plain; and
- From a geotechnical perspective Site 1 and Site 3 appear to be the most suitable for supporting the proposed structures. As such, additional geotechnical site investigation is required to determine the sub-surface conditions at each site in order to select the optimal site location.

## 7.0 LIMITATIONS OF REPORT

This memo and its contents are intended for the sole use of Associated Engineering (B.C.) Ltd. and their agents. EBA does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the memo when the memo is used or relied upon by any Party other than Associated Engineering (B.C.) Ltd., or for any Project other than the proposed development at the subject site. Any such unauthorized use of this memo is at the sole risk of the user. Use of this memo is subject to the terms and conditions stated in EBA's General Conditions (attached).

## 8.0 CLOSURE

We trust this memo meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

Respectfully Submitted;

EBA Engineering Consultants Ltd.

Reviewed by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA 05.21.10 S.L. HIGMAN

GEOSCIENTIST 05.21.10 S. L. HIGMAN BRITISH COLUMBIA

Shelley Higman, P.Geo./P.Eng.
Senior Geotechnical Engineer

Jerry Schmidt, P.Eng.
Senior Geotechnical Engineer

Attachments:

Figure 1 - Englishman River Reach Layout and Short-Listed Sites Map
Figure 2 – Site 1 Location Map
Figure 3 – Site 3 Location Map
Figure 4 – Site 5 Location Map
EBA General Conditions

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# ATTACHMENTS

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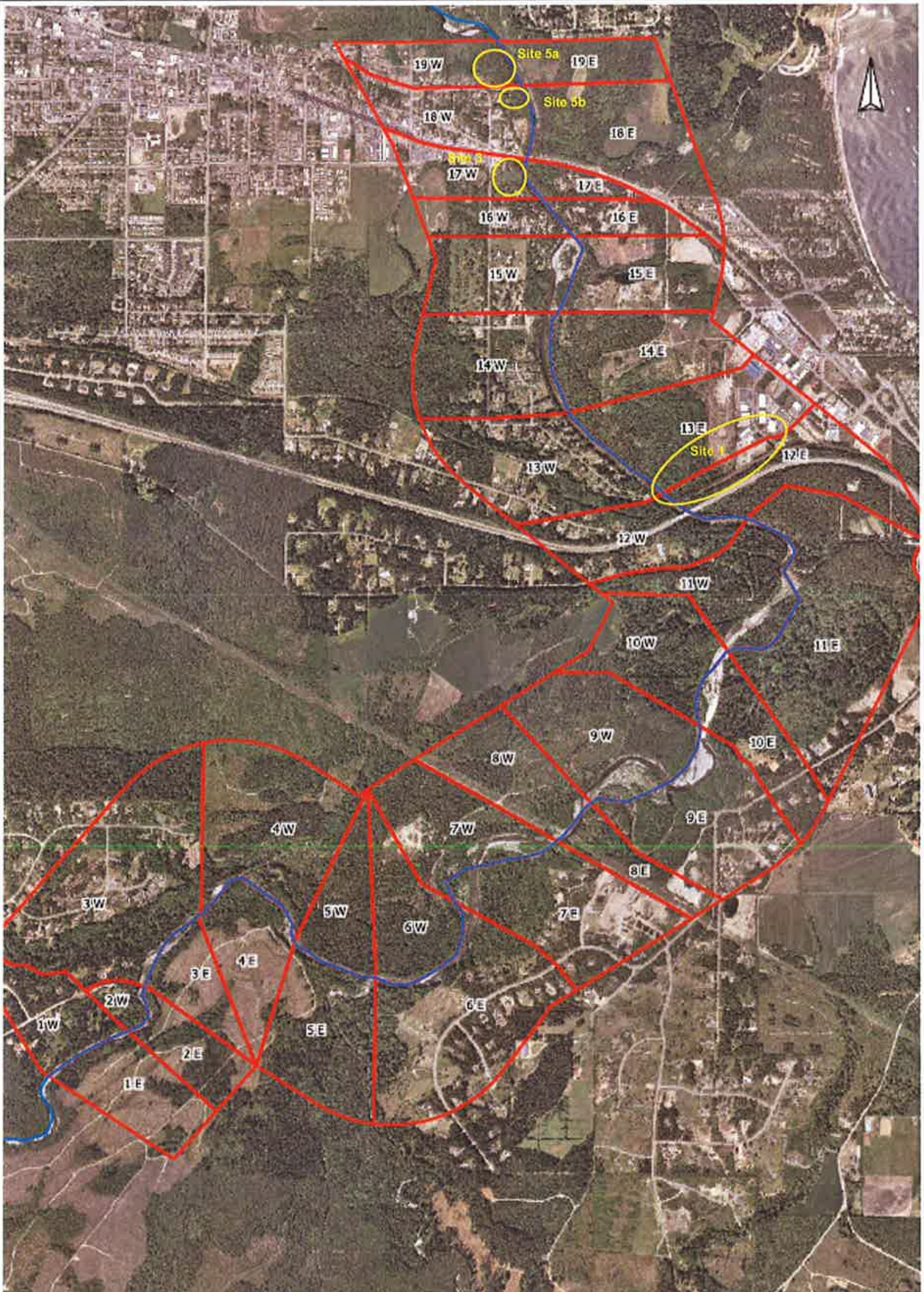



**LEGEND**

River Reaches
Englishman River
Short-listed Sites

NOTES Not to scale

CLIENT

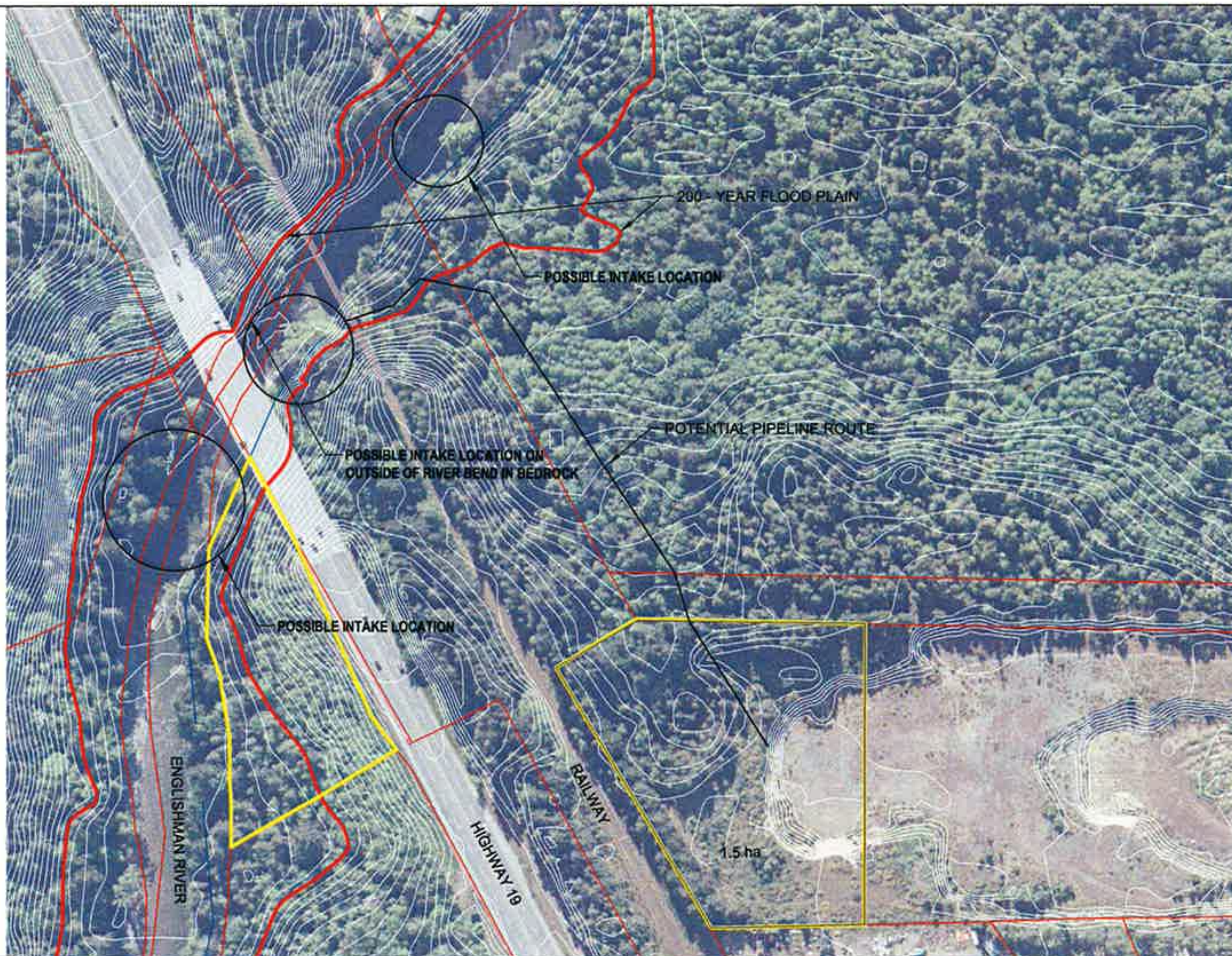
Associated Engineering Ltd.

EBA Engineering Consultants Ltd.

ENGLISHMAN RIVER INTAKE AND TREATMENT FACILITIES

Englishman River
Reach Layout and Short-Listed Sites Map

| PROJECT NO. | DWN | CKD | REV | |
|---|---|---|---|---|
| N13101242.001 | SH | JS | 1 | Figure 1 |
| OFFICE | DATE | | | |
| EBA-Nanaimo | May 5, 2010 | | | |




**NOTES**

Drawing is based on Associated Engineering Project No. 20092356,
Drawing 2356-01-SK1 sent on April 30th, 2010

- Proposed property required for project
- Proposed water treatment plant Location
- Parcel boundaries

SCALE 1:2000

20 0 20 40 80m

CLIENT

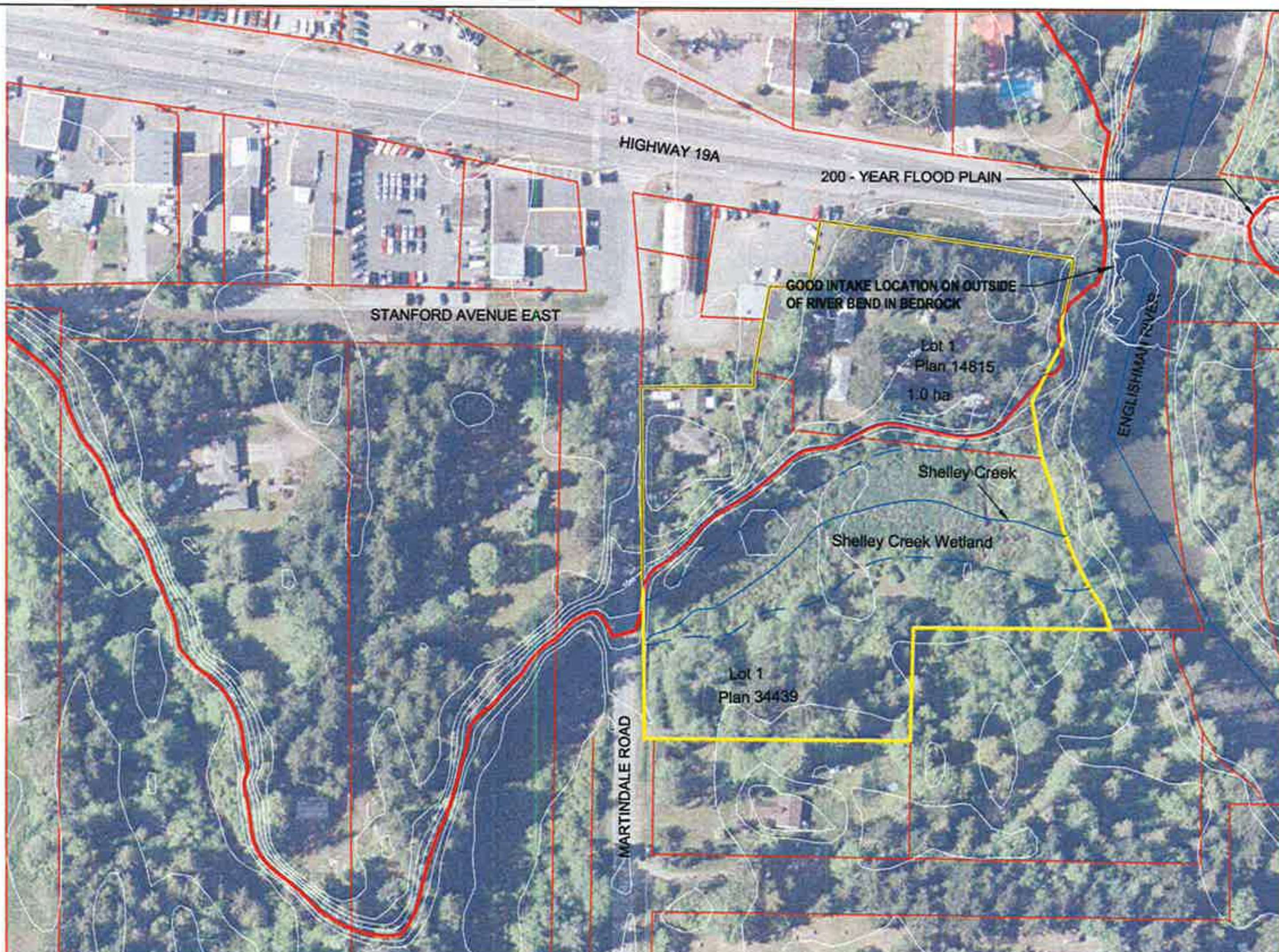
Associated Engineering

EBA Engineering Consultants Ltd.

**ENGLISHMAN RIVER INTAKE AND TREATMENT FACILITIES**

**SITE #1**

| PROJECT NO. | DWN | CKD | REV | |
|---|---|---|---|---|
| N13101242.001 | EP | SH | 0 | **Figure 2** |
| OFFICE | DATE | | | |
| VANC | May 20, 2010 | | | |




NOTES

Drawing is based on Associated Engineering Project No. 20092356, Drawing 2356-01-SK3 sent on April 30th, 2010

- Proposed property required for project
- Proposed water treatment plant location
- Parcel boundaries
- Wetland boundary (Approximate)

SCALE 1:1500

10 0 10 30 60m

CLIENT

Associated Engineering

EBA Engineering Consultants Ltd. eba

ENGLISHMAN RIVER INTAKE AND TREATMENT FACILITIES

SITE #3

| PROJECT NO. | DWN | CKD | REV | |
|---|---|---|---|---|
| N13101242.001 | EP | SH | 0 | Figure 3 |
| OFFICE | DATE | | | |
| VANC | May 6, 2010 | | | |


**NOTES**

Drawing is based on Associated Engineering Project No. 20092356, Drawing 2356-01-SK5 sent on April 30th, 2010

- Proposed property required for project
- Proposed water treatment plant location
- Parcel boundaries

SCALE 1:1500

10 0 10 30 60m

CLIENT

Associated Engineering

EBA Engineering Consultants Ltd.

ENGLISHMAN RIVER INTAKE AND TREATMENT FACILITIES

SITE #5

| PROJECT NO. | DWN | CKD | REV |
|---|---|---|---|
| N13101242.001 | EP | SH | 0 |
| OFFICE | DATE | | |
| VANC | May 6, 2010 | | |

Figure 4

## GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

### 1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's Client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

### 2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

### 3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

### 4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

### 5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

### 6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

## 7.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgemental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

## 8.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

## 9.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

## 10.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

## 11.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

## 12.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

## 13.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

## 14.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

## 15.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

# Appendix D - Hayco Technical Memorandum

# TECHNICAL MEMO

CREATING AND DELIVERING BETTER SOLUTIONS

www.eba.ca

**TO:** Mr. Rick Corbett, P.Eng.
Associated Engineering (BC) Ltd.
300 – 4940 Canada Way
Burnaby BC V5G 4M5

**DATE:** May 27, 2010

**FROM:** Bob Wallwork, P.Eng. and
Alexander C. Bath, P.Geo.

**FILE:** N13101242.001

**SUBJECT:** **Englishman River Intake/Water Treatment Plant Shortlist**
**April 12, 2010 Site Visit and River Stability Assessment**

**ATTENDEES:** The site visit was attended by:

Bob Wallwork, P.Eng. ................................ EBA Engineering Consultants Ltd.
Shelley Higman, P.Eng./P.Geo................. EBA Engineering Consultants Ltd.
Matt Henney, P.Eng.................................. Associated Engineering (B.C.) Ltd.
Keith Kohut, P.Eng. .................................. Associated Engineering (B.C.) Ltd.
Tony Koers, Ph.D., P.Eng. ........................ Koers & Associates Engineering Ltd.



## 1.0 INTRODUCTION

The three proposed intake sites were discussed briefly at Koers' offices prior to the site visit which commenced about 9:45 a.m. The sites were visited starting at the uppermost site (#1) and working downstream. The Englishman River near Parksville (Sta 08HB002) was in recession following a recent storm event which saw the river peak at 52 $m^3/s$ on April 8th at 3:00 a.m. The flow had dropped to 13.6 $m^3/s$ at noon on April 12th and was falling at about 0.06 $m^3/s$ per hour during the site visit.

The floodplain has been reviewed based on the 1985 Provincial Floodplain Mapping for the Englishman River including sheets 3 and 4, which cover the lower two sites (#3 and #5) and sheet 7, which covers the upper site (#1).

**Site #1**

The river intake for this site is near the Highway 19 Bridge and the Esquimalt and Nanaimo Railway (ENR) Bridge, now operated by CP. Koers surveyors were in the field surveying a river cross-section between the bridges using an inflatable boat and tether line across the river. This site is in a stable, bedrock controlled river reach and near the downstream end of a moderate river bend. The bed comprised gravel, cobble and small boulders on the right side (viewing in the downstream direction) of the channel with bedrock exposures all along the left bank, as well as some within the wetted channel. This reach of the Englishman River is relatively steep and fast flowing with several rapids in the reach. Preliminary site plans had indicated an intake location on the right bank upstream of the bridges and adjacent to the highway embankment, however, that location lies mostly in the floodplain, on the inside of the river bend, and is therefore not suitable due to the potential for sediment accumulation at the intake.



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The intake would be located on the left (west) side of the river on the outside of the bend where the river thalweg is located, Figure 1. Several possible intake locations are being considered for Site 1 extending from about 60 m upstream of the Highway 19 centreline to about 60 m downstream of the centreline. Deep pools along the left bank would provide good locations for a riverbank intake on a stable rock foundation. Exact siting of the intake would be determined based on the river cross section surveys undertaken by Koers together with access permissions from the ROW holders. The water supply pipeline would cross under the river bed, possibly within the ENR right-of-way, pass up the slope and follow the north side of the railway embankment to the proposed water treatment site in an old gravel pit site. The 200-year flood level at the intake site is approximately 15.5 m (GSC) at the west pier of the highway bridge. The intake would be notched into the bedrock slope with an upstream guide wall transitioning into the slope. Screens would be parallel to the flow to minimize debris and fish attraction.

Rapids in this fast flowing river reach could potentially generate frazil ice which could enter the intake area. Frazil ice occurs in turbulent water that has become supercooled by a small fraction of a degree. When first produced, frazil ice particles are very adhesive and can adhere to one another, forming large masses which can adhere in turn to other objects such as metal trashracks or intake screens. With considerable lakes in the Englishman River system and the Arrowsmith Reservoir, there will be some moderation of winter temperatures and it is unclear what risk frazil ice may pose in the intake design. In most years the mean flows during the winter appear to be in the 15 $m^3/s$ to 30 $m^3/s$ range, with rain and rain on snow events dominating the hydrograph regime. Low winter flows are in the 2 $m^3/s$ to 3 $m^3/s$ range and therefore more susceptible to ice development during a prolonged cold snap.

Measures to control potential frazil ice should be considered for the Site #1 intake due to the presence of rapids in close proximity to the proposed intake location. Such measures can include development of a diversion pool to drown out the rapids and reduce velocities to 0.6 m/s or less during winter operation and thereby permit development of a stable ice cover. The diversion pool could be developed by means of a submerged sill or weir across the river. The provincial floodplain mapping does not extend upstream of the highway bridge although there does not appear to be any existing development which could be impacted by backwater effects associated with development of a diversion pool at Site 1. Alternatively, the diversion pool could be developed by excavation of the riverbed to create a pool which would perhaps be more favourable from a fisheries perspective and would also eliminate potential backwater effects. The downside to excavation is that it could be largely in rock and thus expensive.

Sediment transport is expected to be higher in this reach; however, spiral flow currents should direct much of this material to the inside of the bend opposite the intake.

All in all, this is a good location for a river intake, the only major concern being the potential for frazil ice due to the presence of rapids near the intake site.

**Site #3**

This site is located on the left (west) bank, immediately upstream of the Highway 19A Bridge, and is currently occupied by a motel complex. The intake site on the west bank is also on the outside of a river bend in a stable reach of the river, Figure 2. For a distance of approximately 70 m upstream of the bridge, the left riverbank is characterized by a steep, undercut bedrock exposure which extended approximately 2 to 3 m above the river level during the site visit. The bedrock is obviously erodible, likely a conglomerate rock, and the undercut appears to extend about a metre back from the vertical bank face, near water level. Protruding portions of the bankline result in some flow separation along the bank and consequently some weak back eddies were observed. This would make a very good location for a riverbank intake and is some 160 m downstream of the nearest rapids, which should be sufficient distance to eliminate potential frazil ice issues. The location on the outside of a river bend is also favourable as surface flows, low in sediment concentration, are directed to the outside of river bends while bottom flows, with higher sediment content, are directed to the inside of the bend, away from the intake location.

The bedrock on the left bank peters out about half-way along the river frontage for the subject property as evidenced by a leaning tree which is being undermined by the river. Approximately 60% of the proposed site is within the 200-year floodplain of the Englishman River. The development area on the proposed site may not be sufficient to satisfy the requirements for the water treatment plant. A small tributary, Shelley Creek, enters the river along the left bank near the upstream limit of the proposed site. The associated Shelley Creek wetland coincides with the Englishman River floodplain on this property and extends in a southwest direction beyond Martindale Road, which forms the west boundary of the lot. While this wetland area is not currently slated for development, the developable area is tight and it may be necessary to encroach into the Shelley Creek wetlands. Should this be the case, enhancement of the wetlands will be provided as compensation. Based on EBA experience, such encroachments into sensitive areas could prove to be problematic in terms of development approvals from the regulatory agencies.

The Englishman River is highly confined at the Highway 19A Bridge crossing, which will likely govern backwater flood levels throughout this area. Consequently, any infill of the floodplain deemed necessary for development of the water treatment plant is expected to have only a very minor impact, if any, on river flood levels further upstream.

The riverbank intake at this site would be similar to that proposed for Site #1. The supply pipeline would not have to cross the river at this location but would likely follow the floodplain boundary around the Shelley Creek wetland or run up the bank to the proposed water treatment site.

Considering all factors, from a hydraulic standpoint, this is probably the most favourable of the three sites under consideration as it has little impact to floodplain conditions and is at low risk with respect to frazil ice issues.

**Site #5**

The last site inspected, north of Turner Road at the north end of Martindale Road, is immediately downstream of the existing river intake on a relatively straight reach of the river, Figure 3. This reach has a very gradual bend towards the west so the proposed intake would be on the inside of the proposed bend and potentially susceptible to sediment accumulation at the intake. The existing intake is an infiltration gallery type which relies on air back flushing to maintain flow capacity. We understand there are some operational issues in terms of siltation at this site, though all sites will likely experience the same problem given that the silt source (believed to be the silt till bank confining the Englishman River at Reach 6E) is upstream of all sites under consideration. The riverbed in this area is gravel and cobbles and the adjacent riverbank (west side) shows an abundance of sand. The property is vacant and well treed. An overflow channel appears to run through the middle of the property, parallel to the river, as indicated on the floodplain mapping. Some bank erosion is evident in this reach likely due to the abundance of sand in the channel banks. Riprap has been used to stabilize the channel banks in this reach, particularly the east bank.

Over 80% of the site is within the 200-year floodplain of the Englishman River leaving less than 4,000 $m^2$ for the water treatment plant. The floodplain in this reach is broad and includes a large region with indeterminate flood levels on the right bank that is up to 600 m wide, although just downstream of the subject property the floodplain is restricted to a width of approximately 115 m on the right overbank. While the floodplain is labelled as indeterminate, the flood level isograms for this river reach terminate at Plummer Road which hugs the right riverbank downstream of the Highway 19A Bridge crossing. The road crest elevation is lower than the Flood Construction Level (FCL) but approximately equal to the 200-year flood level without the freeboard allowance. Therefore the 200-year flood appears to be effectively constricted by the road grade on the east bank such that the only effective floodplain is that on the west side of the river. Consequently, any future infill development of the floodplain on the left bank has the potential to impact flood levels further upstream. Such impacts would be less for infill in the northwest corner of the property which is furthest from the river channel. The east riverbank adjacent to Plummer Road has been partially armoured with riprap so the right bank can be considered a hard edge at this location. Some riprap is also evident along the west riverbank at the existing intake.

Based on the above floodplain assessment, infill of Site #5 to develop the water treatment plant will likely have an impact on upstream flood levels though the magnitude of the impact will depend on the location and extent of the floodplain infill. Minor encroachments, well removed from the channel, will likely not have significant impacts. Residential property between this site and the Highway 19A Bridge crossing is all outside of the floodplain so minor changes in flood level are unlikely to have significant impacts to these properties. However, any increase in flood levels will likely prove to be detrimental to Plummer Road, which is within the active floodplain.

Floodplain analysis using a numerical model, such as HEC-RAS, is recommended to evaluate potential floodplain impacts should this site be chosen for development. Considering the operational problems with the existing intake, this is probably the least favourable of the three sites under consideration.

## 2.0 DESK-TOP HYDROGEOLOGICAL ASSESSMENT

EBA reviewed the following information to assess the potential for subsurface conditions within Englishman River Site #5 to be suitable for supplying municipal water:

- Description of the existing municipal intake near Site #5 by Rick Corbett in his email to Shelley Higman dated April 29, 2010;
- Associated Engineering (Associated) *Record of Meeting* dated April 12, 2010 for Associated file no. 092356.01.P04.00;
- Associated *Record of Meeting* dated March 17, 2010 for Associated file no. 092356.01.E03.00;
- Associated Discussion Paper dated March 12, 2010 regarding *Arrowsmith Water Service, Englishman River Water Intake Study, Phase 1 – Conceptual Planning, Discussion Paper 4-4 – Water Treatment Plant Site Development Considerations*;
- Koers & Associated Engineering Ltd. (Koers) memorandum dated March 23, 2010 for Koers file no. 0942 regarding *Arrowsmith Water Service, Englishman River Water Intake Study, Intake/Water Treatment Plant Site Shortlist*;
- BC Ministry of Environment (MoE) logs for registered water well tag nos. 19140, 27387, 36426 (near Site #1), 21837 and 98010 (near Site #3), and 51959 (near Site #5);
- Pacific Hydrology Consultants Ltd. (Pacific Hydrology) letter dated April 1, 1983 to Town of Parksville regarding *Results of Test Drilling, Englishman River Intake Site*;
- Pacific Hydrology letter dated March 14, 1983 to Town of Parksville regarding *Digging of Test Pits near the Englishman River Intake*;
- Geological Survey of Canada Map 1112A *Surficial Geology, Parksville, Vancouver Island, BC* (1962, scale 1:63,360).

Information identified by the above sources and information identified by this memorandum indicates that:

- Surficial soil within and near Site #5 consists mainly of Pleistocene and Recent age Salish Sediments shoreline, deltaic, and fluvial deposits that overlie Pleistocene and Recent age Capilano Sediments marine and glaciomarine deposits. Such deposits, those of the Salish Sediments more than those of the Capilano Sediments, have a potential to contain aquifer materials capable, under suitable conditions, of supplying the volume of municipal water required, especially if such deposits are coupled hydraulically to a suitable surface water body, such as the Englishman River.

- At two test pits that were excavated near the river during 1983, a minimum of 4 m of water-bearing gravel is present. When the pits were excavated, the river was near flood stage and aquifer testing using the pits suggested that the pits yielded water at estimated rates of between 300 US gpm to 400 US gpm. During 1983, Pacific Hydrology estimated that during peak water demand the river stage could be approximately 2 m lower than when the pits were excavated and that under such conditions, presence of 9 m of saturated similarly-productive gravel would be required to justify completing a municipal water supply test well to meet (unspecified 1983) municipal water-supply requirements.
- During March 1983, based on presence of shallow permeable gravel in the two test pits identified above and for the City of Parksville, a borehole was advanced near the river to assess the potential for presence of a municipal water supply aquifer. At the borehole location 1.3 m of water-bearing gravel underlain by 10 m of "…cemented sand, gravel and boulders (till?)…" and underlying sandstone bedrock was present. The borehole was abandoned without installing a test well due presence of an insufficient gravel thickness.
- The Englishman River bed within Site #5 comprises gravel and cobble and the west river bank is sandy. Presence of these sediments within and adjacent to the river suggests that similar unconsolidated coarse sediments occur near and beneath the river. Such materials, if saturated in sufficient thicknesses, if present in sufficient volumes, and if connected hydraulically to a suitable water supply such as a surface water body, are capable of supplying the volume of municipal water required.
- Within Site #5, elevation of the Englishman River is approximately 4 m or less below mean sea level. Parts of Site #5 near the Englishman River are within the Englishman River 200-year floodplain. What appears to be a (natural) overflow channel occurs within Site #5. During spring 2010 and likely during fall and winter as well, sufficient river bank erosion was occurring within or was perceived to be capable of occurring within Site #5 that portions of the river bank were armoured with riprap. Historically, the location of the main river flow within Site #5 has shifted: currently river flow occurs mainly within the west part of the river bed but historically this flow was within the east part of the bed. Presence of these conditions suggests that on a time scale that is relevant to a municipal water supply (years to decades), the river bank location and the local hydraulic regime within the river may change.
- The existing City of Parksville Englishman River municipal water intake is upstream from Site #5. It consists of three 1.2 m to 1.5 m deep drain-rock-filled trenches that were excavated into the bed of the Englishman River, which is described to be "fairly dense impermeable till" where the trenches are excavated. Water is extracted from the filled trenches using buried perforated pipes. When water is extracted from

the filled trenches during summer peak withdrawal periods, fine sediment accumulates in the trenches and regular flushing of the accumulated silt from the trenches using compressed air is required. Due to the proximity of Site #5 to the existing City of Parksville intake, EBA infers that the river hydraulic regime and its propensity to deposit silt within similarly filled trenches used to supply water will be comparable to that at the existing water intake location.

The above information suggests that:

- If the existing in-river filled-trench infiltration galleries upstream from Site #5 are not suitable for supplying municipal water due to silt accumulation, such infiltration galleries will be similarly unsuitable within Site #5.
- Shallow "fairly dense impermeable till" or "cemented" sediment occurs near the river within Site #5. Widespread presence of significant thicknesses of such soil is likely to act hydraulically as an aquitard and hydraulically isolate the river water from deep aquifer materials with a potential to act as a municipal water source. Although deep aquifers suitable for municipal water supply development may be present within Site #5, additional information, such as that typically obtained from borehole investigations, is required to better assess the potential for such aquifers to be present.
- Shallow unconsolidated sand, gravel, and cobble deposits occur within and near the Englishman River within Site #5. Unconsolidated gravel thicknesses of up to 4 m are developed locally. Consistent with the manner in which such sediment particles are deposited by rivers, the lateral and vertical distributions of such gravel deposits may be variable. If suitable thicknesses of permeable shallow unconsolidated sand, gravel, and cobble are present within Site #5 and if such deposits are hydraulically connected to the Englishman River, they may be able to be developed as a municipal water supply source. Additional information is required to better assess the potential for such deposits to be present. Such information is typically obtained from one or more of test pit investigations, borehole investigations, pumping tests using test wells, and geophysical ground surveys. Typical water-supply development methods include conventional water supply wells, Ranney-type well systems, and "riverbank" filtration galleries, which may be located distant to actual river banks provided that the soil in which the galleries are installed is sufficiently permeable and sufficiently hydraulically connected to the river water.
- Depending on the site-specific subsurface and hydrogeologic conditions present within Site #5 and how a municipal water supply is developed within Site #5, and because the elevation of the Englishman River within Site #5 is both near mean sea level and near (approximately 1 km from) the Pacific Ocean, there may be a potential for global warming to affect water quantity and quality within Site #5 on a time scale of decades. Global warming effects with a potential to affect surface water or groundwater conditions within Site #5 include declining precipitation rates (which could cause

Englishman River flow rates to decline, water table elevations to decline, and aquifer recharge rates to decrease) and rising sea levels (which could affect the propensity for occurrence of salt water incursion within both the Englishman River and in the subsurface in response to groundwater extraction within Site #5).

- Identifying meaningful water supply works options and costs for Site #5 is not possible until subsurface conditions with Site #5 have been better characterized. Regardless of the character of the subsurface beneath Site #5, the potential for the position of the river to change with time, the potential for the river flow characteristics and hydraulic coupling to permeable subsurface soil members across the existing river bed to change with time, the potential for Site #5 to flood because it is within the 200-year floodplain, and the potential for the river water quality and coupled groundwater quality to be affected by activities completed upstream should be carefully considered before making a water supply development decision.

Based on the above, the following is concluded regarding the potential for Site #5 to be suitable for development of the required municipal water supply:

- If suitable subsurface soil and hydrogeologic conditions exist within Site #5, supplying the required municipal water demand using a river bank infiltration system employing vertical or horizontal wells or a conventional well field within Site #5 will be feasible.
- The reviewed information is not sufficient to conclude that suitable subsurface and hydrogeologic conditions exist with Site #5 to supply the required municipal water demand. To determine if suitable subsurface and hydrogeologic conditions exist within Site #5, additional investigations are required.
- One water supply assessment approach could involve completing geophysical ground surveys to help identify priority areas near the Englishman River where shallow gravel may be present, advancing two boreholes to test subsurface conditions at two priority geophysical targets to assess actual subsurface conditions, installing using cable-tool methods and developing one 15 cm (6 inch) diameter test well to allow aquifer testing and groundwater quality testing, completing step- 72-hour constant-head aquifer tests using the test well, and analyzing and reporting on the testing results. The estimated cost to complete such work, exclusive of road- and drilling-pad construction and restoration costs, is between $30,000 and $50,000.
- Because the elevation of the Englishman River within Site #5 is near mean sea level and because Site #5 is near the Pacific Ocean, there is a potential for global warming to affect the quantity and quality of surface water and groundwater within Site #5 on the time scale of decades. Whether such effects will affect a municipal water supply within Site #5 will depend on site-specific subsurface and hydrogeologic conditions and how such a water supply is developed. If conditions within Site #5 are determined to be

favourable for development of the required water supply system and when a preferred water supply development option has been identified, potential global warming effects on the system should be assessed to help confirm that the system will operate as required for the system's full scheduled operating life.

## 3.0 CLOSURE

EBA trusts that the content of this memorandum meets your immediate requirements on this project. If you have any questions, please do not hesitate to contact the undersigned.

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