Land suitability for a wastewater attenuation tank in Saanich East-North Oak Bay

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September 2010

WESTLAND RESOURCE GROUP

SUMMARY

The purpose of this report is to identify suitable areas for a storage tank to attenuate the wastewater flows entering the East Coast Interceptor. An attenuation tank is needed to temporarily store flows of wastewater that exceed system capacity during wet weather periods and discharge it when the East Coast Interceptor can accommodate the volumes, to eliminate downstream overflows up to a 1:5 year rainfall event.

Previous siting studies conducted in the Saanich East-North Oak Bay area for the Core Area Wastewater Treatment Program sought sites for a wastewater treatment facility. In June 2010, the CRD revised the configuration of the wastewater system and now an attenuation tank, instead of a wastewater treatment facility, is needed in this area. The current estimate for the volume of wastewater storage needed is approximately 12,000 m^3.

The attenuation tank will be constructed underground, and will be accompanied by an above ground pump station control building. The land atop the tank can be revegetated for use as a park or playfield, or paved for use as a road or parking area. The operation of the attenuation tank will result in few adverse effects because of their intermittent use during wet weather periods of the year, the project footprint is small, and the land above the tank could be developed for other purposes.

The following steps were taken to identify areas suitable for an attenuation tank in Saanich East-North Oak Bay:

- a set of site selection criteria was developed based on factors considered important in siting an attenuation tank,
- information was collected and reviewed (plans, reports, past CRD studies, and spatial data),
- land suitability was rated for each siting criterion and eight siting criteria maps were produced, and
- the siting criteria maps were overlaid using a Geographical Information System (GIS) spatial analysis to produce a map that identifies areas having different levels of suitability for an attenuation tank.

For the purposes of this analysis, the site selection criteria focused on reducing or avoiding operational impacts. Construction impacts were also included, such as geotechnical conditions, slope stability, ecological integrity, and archaeology and heritage.

Section 2 of this report describes the methods and suitability maps for each siting criterion. Section 3 presents the results of the combined suitability analysis. Dark areas are considered more suitable than light areas for an attenuation tank.

The information contained in this report is intended to aid in selecting candidate sites for further study. This report provides a coarse, high level investigation and should not be construed as identifying specific sites for facilities. The results of this analysis need to be considered in combination with other important siting factors, such as the ability to acquire the land (described in Section 3). Section 4 recommends the next steps to identifying and acquiring a suitable site. Detailed investigations are needed to assess sites that are technically feasible. An Environmental Impact Study will need to be conducted for the selected attenuation tank site, to satisfy CRD and provincial requirements.

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1.0 INTRODUCTION

In 2007, the Capital Regional District (CRD) began technical siting investigations for a wastewater treatment facility in Saanich East-North Oak Bay as part of the Core Area Wastewater Treatment Program. A short-list of candidate sites was developed and an Environmental and Social Review was conducted on three candidate sites (Westland July 2009). An Environmental Impact Study was prepared for the preferred treatment facility location (Westland December 2009). In 2010, the CRD reconfigured the wastewater treatment system, making a wastewater treatment facility unnecessary in Saanich East-North Oak Bay. The CRD is now seeking suitable sites for an attenuation tank in Saanich East-North Oak Bay to attenuate wet weather flows of wastewater.

An underground attenuation tank will be built in Saanich East-North Oak Bay to temporarily store wastewater flows to prevent downstream overflows for the 1:5 year storm event. Stored wastewater will be released when there is adequate capacity in the East Coast Interceptor Sewer Trunk and conveyed to Penrhyn Pump Station. A parcel approximately 0.5 ha or larger is needed to accommodate the tank and associated infrastructure. As an alternative, multiple smaller facilities could be constructed in the study area, though costs would be higher.

This report describes the results of land suitability investigations conducted in Saanich East-North Oak Bay in 2010. The study area for the investigation is presented in Figure 1. Information obtained during the previous siting studies was used where appropriate. Section 2 presents a series of suitability maps for the study area based on a set of siting criteria. The combined overlay analysis map in Section 3 identifies areas that may warrant further consideration. The information contained in this report is intended to aid in selecting candidate sites for further study. The results of the report's analysis should be used in combination with other considerations during the site selection process.

The project involves the construction of an underground storage tank and above ground pump station to empty the tank. The shape and footprint of the tank will depend on the conditions of the site that is selected. The main facilities have the following features:

- Attenuation tank. The required total capacity of the attenuation tank is 12,000 m^3. The depth of the tank would be between 5 m and 7.5 m, resulting in an area of between 2,400 m^2 and 1,600 m^2 respectively. The dimensions of the tank will be largely determined by the configuration and location of the selected site. The tank will be covered to contain odours, and foul air will be directed to an odour treatment system. The top of the tank will be planted with grasses or shrubs, or paved for other uses, such as parking.

- Pumps. The pumps to empty the tank will be below ground with the electrical and controls housed in an 8 m by 8 m building on or near the attenuation tank.
- Standby generators. The generator equipment will be housed in the same building as the pumps. These generators will operate only during power outages when the tank is in use or during scheduled maintenance of the facility.

Detailed facility design will commence after the site selection is finalized. Facility construction is expected to begin in February 2015 and will be completed by August 2016.

Figure 1. Study area for the Saanich East-North Oak Bay attenuation tank

2.0 CRITERIA-BASED ANALYSIS

This section describes the methods and results of the siting analysis for attenuation tank sites in Saanich East-North Oak Bay.

A study area was defined that includes areas near the East Coast Interceptor sewer trunk, where flows would be intercepted by gravity during wet weather periods. Studies conducted by Kerr Wood Leidal and CRD staff, and analysis of 10 years of flow data determined that wastewater storage is required to prevent the upgrading of substantial sections of the East Coast Interceptor (ECI) sewage collection system. The preferred location of the storage facility would either be immediately upstream of the siphon (roughly at Rowley Road) or along the alignment of the siphon (along Maynard, Hobbs, and Penrhyn streets). Because hydraulic control of sewage storage facilities can be complicated, it is recommended that the preferred location be upstream of the siphon near the Arbutus Flume (northwest of Haro Road). This upstream location would provide the simplest control scheme and the potential to reduce pumping costs (Johnston, pers. comm.). Locating the tank in areas outside of this study area where inflow pumping would be needed could increase the project budget by more than $20 million.

A set of criteria was developed to identify areas that are technically, socially, and environmentally suitable during attenuation tank operation. Effects of constructing the tank were also considered, such as challenges posed by geotechnical construction conditions and slope stability, and effects on ecological integrity and archaeology and heritage. Additional construction effects will be considered during future steps in the site selection process.

CRD staff worked with Westland personnel to develop the land suitability criteria. Table 1 summarizes the criteria for the Saanich East-North Oak Bay attenuation tank.

Table 1. Site selection criteria for the Saanich East-North Oak Bay attenuation tank

Topic	Criteria	Definition
Land use	Land use compatibility	Areas where existing and planned land uses are compatible with facility operations, avoiding areas sensitive to nuisance effects.
Resource recovery	Nearby heat demand	Potential for heat recovered from wastewater to be used in nearby facilities.
Archaeology and heritage	Archaeology and heritage features	Likelihood of encountering archaeological or heritage features.
Biology	Ecological integrity	Areas where facilities would avoid adverse effects on sensitive or important habitat.
Geotechnical	Construction conditions	Suitability of the surficial material, site drainage, and levels of seismic and liquefaction risk to allow facility construction and operation.
	Slope stability	The stability of slopes for facility construction and operation.
Conveyance	Requirement for pumping	Areas where gravity can be used rather than pumps to transport wastewater, thereby conserving energy and improving reliability.
	Proximity to East Coast Interceptor	Areas near the East Coast Interceptor, reducing the need for conveyance facilities.

The siting criteria reflect technical, social, and environmental factors that are important in selecting sites. The criteria are based on technical expertise, public engagement information, experience gained in previous siting studies, and political direction.

- The land use compatibility criterion identifies areas where the operation of an attenuation tank would be compatible with existing and planned land uses.
- The nearby heat demand criterion identifies areas where buildings may be able to use heat recovered from the facility.
- The archaeology and heritage criterion identifies areas that have or may have archaeological or heritage features.
- The ecological integrity criterion identifies sensitive or important ecosystems.
- The geotechnical criteria identify the areas where soils or slopes could affect the construction and operation of an attenuation tank.
- The conveyance criteria identify areas where the amount of conveyance infrastructure could be reduced required by minimizing the facility’s distance to a sewer trunk or main, or by using gravity instead of pumps to convey the wastewater.

Maps were prepared showing the suitability of land according to each siting criterion. Areas that were highly suitable for an attenuation tank received a high rating and areas that were less suitable received a lower rating. The siting criteria maps were then electronically overlaid to create an overall rating for lands in the study area. This final step in the analysis is presented in Section 3. The following sections describe the methods and the results of the siting criteria analysis.

2.1 Land use compatibility

Methods

The land use component of the siting study involved a series of tasks to identify and map land uses in the study area, and to determine their compatibility with the Saanich East-North Oak Bay attenuation tank facility. The land use information builds on the database developed for the 2007 Phase 1 Wastewater Treatment Facility siting assessment ("Phase 1 assessment") and the environmental studies conducted in 2009 (Westland July 2009 and December 2009). Key tasks conducted for this Saanich East-North Oak Bay attenuation tank siting study ("tank study") include:

1. **Add CRD Actual Land Use Mapping data to the Phase 1 database.** Data from the Phase 1 assessment provided land use information for approximately 75% of the tank study area. Information from the CRD Actual Land Use dataset was used to create a single land use map layer for the entire Phase 1 area.

2. **Reclassify CRD Actual Land Use Mapping categories in areas outside of the Phase 1 study.** The CRD Actual Land Use Mapping database uses 209 land use categories. To facilitate the siting analysis, the actual land use classes occurring in the study area were reclassified into 10 categories that are relevant to attenuation tank site selection. This process was conducted in 2007 for the smaller Phase 1 assessment study area, and no additional reclassification was necessary to support the present study.

3. **Review the accuracy of land use information.** The most recent orthophotos available (2009) and field inspections were used to confirm the actual land uses in the study area. Revisions were made to the dataset to reflect present land use and to correct errors. Information was also obtained from the University of Victoria Google Earth Buildings and Playing fields dataset (2010).

4. **Assign compatibility ratings.** The current land use categories were each assigned a rating that reflects their degree of compatibility with the operation of an attenuation tank on the site.

In assessing the land use compatibility of sites, the following assumptions were made:

- The attenuation tank will be located underground.
- A pump station will be required on the site.
- No detectable odour will exist on the site under normal operating conditions. The tank will be covered to contain odours, and foul air will be directed to an odour treatment system.
- Grass and shrubs could be planted on top of the tank, but trees are not permitted.
- The land use compatibility ratings are based on the current use of a particular parcel or portion of a parcel. Adjacent land use was not considered in determining compatibility with an attenuation tank facility at this stage of the assessment.
- The study examines compatibility of land uses with operation of the facility. The study does not consider construction impacts. The construction period for the attenuation tank will be approximately 18 months. Construction impacts, such as restricted public access to parks and school playgrounds during construction, will be considered during later stages of the site selection process.

Table 2 explains the criteria used to rate the compatibility of land uses with an attenuation tank. The ratings for specific land use categories are presented in Table 3.

Table 2. Definitions related to land use compatibility

Land use compatibility	Site suitability rating	Definition
Compatible	High score: 3	Areas where existing and planned land uses are compatible with facility operations, avoiding areas sensitive to nuisance effects.
Somewhat compatible	Moderate score: 2	Areas where existing and planned land uses are somewhat compatible with facility operations.
Least compatible	Low score: 1	Areas where existing and planned land uses are not considered compatible with facility operations.

Table 3. Land use compatibility ratings

Current Land Use Categories	Land Use Compatibility Rating	Rationale
Active Parks	3	Playing fields are a suitable land use atop an underground attenuation tank. After construction is complete, the facility can support playfield use.
Commercial	1	The location of an attenuation tank in commercial areas would require the demolition of buildings. Parking areas are discussed separately.
Forested	2	Forested areas are moderately compatible, due to limited built infrastructure, but would require the removal of trees.
Institutional	1	The location of an attenuation tank in institutional areas would require the demolition of buildings.
Institutional fields and lawns	2	Fields and lawns are a suitable land use atop the underground attenuation tank.
Natural parks	1	The location of an attenuation tank in designated natural parks is considered incompatible with the existing use.
Parking	3	Parking lots can be constructed on top of the tank.
Residential	1	The location of an attenuation tank beneath residential buildings would require the demolition of the buildings, which is considered incompatible.
Utility	3	Utility land uses are considered compatible with the attenuation tank.
Vacant-cleared	3	Vacant cleared areas do not have extensive built infrastructure and are considered compatible.
Road rights-of-way	2	Roadways can be built atop the tank and therefore would not affect land use. However, road rights-of-way have limited width, which constrains design flexibility, and installation beneath roads entails increased project cost.

Results

The results of the land use compatibility assessment identified the following "Compatible" and "Somewhat Compatible" areas for an underground attenuation tank (Figure 2).

University of Victoria parking lots: The University of Victoria (UVic) has numerous large parking lots on the main campus and for support services and housing that would be compatible with an underground attenuation tank. After construction, parking lot use could resume.

Other parking lots: Parking lots for various institutions are distributed across the study area and are considered compatible. Some of these parking lots are small. Examples include Holy Cross Catholic Church, and the G.R. Pearkes Child Care Centre, and Queen Alexandra health facilities.

Vacant-cleared area: Much of the Cedar Hill Corner Property is currently a large open grassy field, used to store soil. Construction of an underground attenuation tank would be compatible with the current use, as limited built infrastructure exists on the site.

Utility: The Penrhyn Pump Station operates near Gyro Park, and a wastewater meter station operates in the Finnerty-Arbutus area. These land uses would be compatible with the operation of an attenuation tank.

Active Parks: Active parks, including playfields and open areas, are considered compatible because the existing park use can be restored after construction of the attenuation tank is complete. Examples include UVic's grass fields, the Queen Alexandra Centre for Children's Health playfield, Frank Hobbs School playfield, and Montague Park.

Forested areas: Remnant patches of mature forest are found in the study area. These areas may be somewhat compatible with the operation of the attenuation tank. Examples include the Finnerty-Arbutus site, the Saanich-owned parcel in Haro Woods, and portions of the UVic campus.

Institutional fields and lawns: These vegetated areas are not dedicated sports fields, but are typically associated with institutional uses. Some of these fields and lawns may be suitable for an attenuation tank.

Road rights-of-way: Roadways can be built atop a tank and therefore are considered a compatible land use. However, limited right-of-way width constrains design, the traffic is disrupted during construction, and costs of construction beneath roads are higher than many other locations.

The results of the land use compatibility assessment identified the following "Least Compatible" areas for an underground attenuation tank (Figure 2).

Commercial, institutional, and residential areas: The location of the attenuation tank in areas identified as commercial, institutional, or residential in the land use compatibility assessment would require the demolition of existing structures dedicated to these land uses. Such actions to install an attenuation tank are not considered compatible with the existing land use.

Natural parks: Natural parks are areas designated as protected areas due to their natural features. The location of an attenuation tank in these protected areas would alter the existing land use, and is not considered compatible.

Figure 2. Land use compatibility

2.2 Nearby heat demand

The Saanich East-North Oak Bay attenuation tank may provide an opportunity to recover heat from wastewater. The recovered heat could be conveyed to areas near the facility that can use the heat for space or water heating.

Methods

Several resource recovery studies have been conducted for the Core Area Wastewater Treatment Program (Stantec January 2010a, Stantec January 2010b, Associated Engineering *et al.* December 2008). These studies identified potential areas of heat demand from wastewater facilities. The Associated Engineering *et al.* study identified the University of Victoria and a few other areas in Saanich East-North Oak Bay as high potential heat demand areas. In 2010, Stantec conducted detailed investigations of the potential for heat recovery at the University of Victoria (2010a). The Stantec study determined that many University of Victoria buildings were heated using high-temperature boilers that were not compatible with the heat recovered from a wastewater facility. The two exceptions were the boiler in the Cadboro Commons building and the heating of the McKinnon pool. The Cadboro Commons boiler heats several residences and other buildings, including the Student Union Building.

Commercial and institutional buildings, and areas identified as potential high demand areas (Associated Engineering *at al* December 2008) were identified to map heat demand in the study area. A 100 m buffer was applied around the demand areas. Areas of known heat demand (the Cadboro Common Building and McKinnon pool) were rated “3” (highly suitable). Areas within 100 m of other commercial and institutional buildings, including the rest of the University of Victoria, were rated “2” (moderately suitable). Further investigation is needed to determine if the heating system in these buildings would be compatible with the heat recovered at the attenuation tank facility. All other areas were rated “1” (low suitability) because they have low heat demand. Table 4 explains the criteria used to rate nearby heat demand.

Table 4. Definitions related to nearby heat demand

Nearby heat demand	Site suitability rating	Definition
Less than 100 m to a known heat demand area	High score: 3	Less than 100 m to an area with high heat demand that has been evaluated as suitable to use recovered heat from a wastewater facility.
Less than 100 m to a potential heat demand area	Moderate score: 2	Less than 100 m to an area with high heat demand, but it has not been evaluated for its suitability to use recovered heat from a wastewater facility.
More than 100 m to a demand area	Low score: 1	More than 100 m to a high heat demand area.

Results

Figure 3 presents the results of the nearby heat demand assessment. Approximately one third of the study area is within 100 m of the high heat demand area. The area around the eastern portion of the University of Victoria is considered the most suitable to use recovered heat from the Saanich East-North Oak Bay attenuation tank. Other areas were considered moderately suitable, including the commercial area in Cadboro Bay and institutions such as the Queen Alexandra Hospital, Queenswood Centre, the western portion of the University of Victoria, schools, and churches. Although these areas have high heat demand, more investigations are needed to determine if buildings' heating systems are compatible with use of the recovered heat. The remaining areas are mainly residential, and have a relatively low demand for heat.

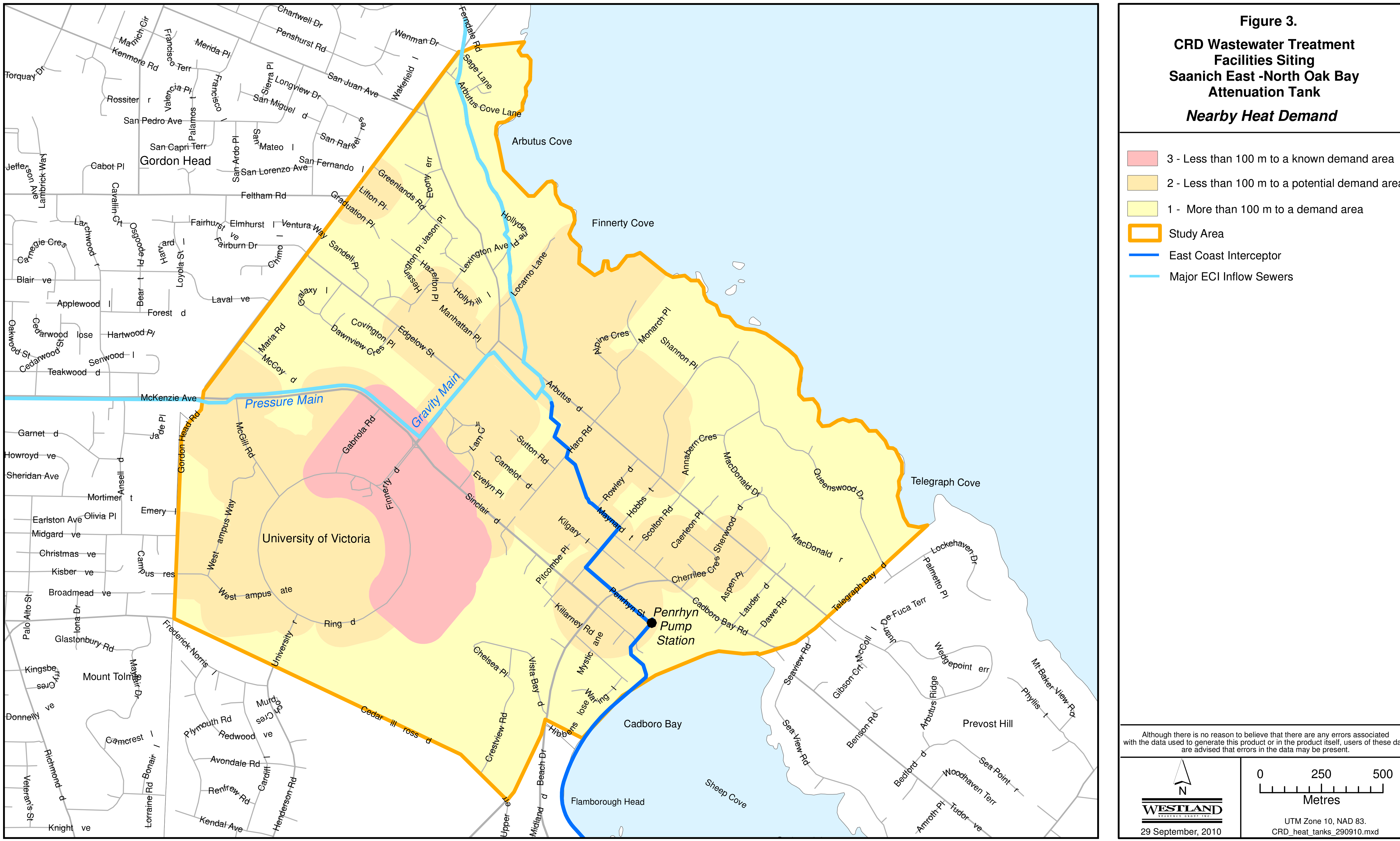

Figure 3. Nearby heat demand

2.3 Archaeology and heritage

Methods

The British Columbia Archaeological Site Registry was reviewed to identify registered archaeological sites in the study area. Archaeological potential mapping prepared by Millennia Research Ltd. (2008) was reviewed to identify areas of high archaeological potential. Two previous studies (Westland July 2009 and December 2009) conducted for the Core Area Wastewater Treatment Program were reviewed to obtain additional archaeological and heritage information for the study area. Registered heritage sites in the study area were identified by reviewing the District of Saanich heritage database and the BC Archaeological Site Registry. The District of Saanich database contained point data that showed specific locations of heritage features. These points were linked to the CRD parcel database covering the study area.

Table 5 explains the criteria used to rate the archaeological potential and heritage features of the study area. The areas rated as “1” (low suitability for an attenuation tank) contain registered archaeological or heritage sites. Areas rated as “2” (moderate suitability) have recorded archaeological potential, but specific sites have not been identified. Areas rated as “3” (high suitability) have no known archaeological potential or heritage sites.

Table 5. Definitions related to archaeological and heritage

Archaeological potential and heritage	Site suitability rating	Definition
No known archaeological potential	High score: 3	Little or no archaeological potential was identified. No archaeological sites were identified. No heritage features were identified.
Archaeological potential	Moderate score: 2	The archaeological potential database identifies the area as having potential for archaeological features.
Registered archaeology or heritage sites	Low score: 1	A registered archaeological or heritage site has been identified at the site.

Results

Figure 4 presents the results of the archaeological and heritage assessment. Most of the areas of high archaeological potential and known archaeological sites are near the marine shoreline, and are associated with shell middens, pre-contact village sites, or natural resource or traditional use areas. Thirteen registered archaeological sites were identified in the study area. The sites are mainly on private property or along the shoreline. Residential development, road and utility construction, and beach erosion have disturbed many of the sites.

A review of archaeological potential mapping by Millennia Research Ltd. (2008) identified areas that have high potential (low suitability for an attenuation tank), including:

- Haro Creek,
- Mystic Vale,
- Cadboro Bay shoreline,
- Gyro Park,
- specific Cadboro Bay inland areas (such as Killarney Road, Waring Place, Beachview Place, Bermuda Place, and Hibbens Close),
- Queen Alexandra Hospital grounds,
- Arbutus Cove,
- Finnerty Cove, and
- Telegraph Bay.

The Provincial Heritage Registry lists five heritage sites in the study area:

- Goward House,
- Maritime Naval Communication Centre,
- Hamsterly Farm Water Tower and Pease Jam Factory,
- Nine army huts at the University of Victoria, and
- Bay Breeze Manor (also called Ira Wilson House and Westward Ho).

The District of Saanich heritage database lists an additional twenty heritage sites in the study area, mainly residences.

Figure 4. Archaeology and heritage

2.4 Ecological integrity

Methods

Ecological integrity was assessed on the basis of amount and extent of human induced disturbance of terrestrial and aquatic habitats. Site disturbance may be a direct result of human action, such as clearing for infrastructure (*i.e.,* roads, buildings, sea walls, parking lots) or an indirect effect, such as introduction of invasive plant species or ground disturbance by high levels of human use.

Ecological integrity was classified into the following three categories (Table 6):

- **High** (score: 1). Level of past disturbance is relatively low, and the area contains relatively intact natural vegetation communities, wildlife habitat features, or important riparian or marine foreshore habitats.
- **Moderate** (score: 2). Some disturbance has occurred as a result of clearing or ground disturbance, or construction of infrastructure or buildings. Despite the disturbances, a moderate potential for wildlife habitat features, areas with native plant communities, moderately intact riparian habitat, or moderate marine foreshore habitat remains.
- **Low** (score: 3). The area has been disturbed or permanently altered. Though some limited potential exists for wildlife habitat, native vegetation, or riparian or marine foreshore habitat, such areas are generally isolated and not thought to contribute to a functional, natural ecosystem.

A GIS layer depicting the ecological integrity of the study area was generated. Several databases were used in combination with ortho-photography and professional opinion to classify the landscape features of the study area and develop subjective ecological integrity ratings. Existing GIS databases used include:

- Sensitive Ecosystem Inventory data for east Vancouver Island,
- Victoria Natural History Society atlas of important wildlife habitats,
- federally defined important bird areas or migratory bird areas (Canadian Wildlife Service),
- known occurrences of species at risk (BC Conservation Data Centre),
- fish bearing streams (FISS data), and
- Harbours Ecological Inventory and Rating (HEIR) project (Capital Regional District Harbours Atlas)

Table 6. Definitions related to ecological integrity

Ecological integrity	Site suitability rating	Definition
Low	High score: 3	The area has been disturbed and altered. Though some limited potential for wildlife habitat features or areas with native vegetation may exist, these areas are isolated and fragmented and are not thought to contribute to a functional "native" ecosystem.
Moderate	Moderate score: 2	The land has been previously disturbed (cleared, obvious ground disturbance, infrastructure, or buildings present), but a moderate potential for wildlife habitat features or areas with native vegetation communities remain.
High	Low score: 1	The area displays a relatively low level of past disturbance. The area contains relatively natural vegetation communities or wildlife habitat features.

Results

The ecological integrity of the Saanich East-North Oak Bay attenuation tank study area was mapped at a scale of 1:1,500 (Figure 5). The Ecological Integrity category reflects the extent of human-induced disturbance to natural terrestrial and aquatic ecosystems.

Portions of the study area mapped as having low ecological integrity represent the most disturbed and modified areas. These areas include commercial properties, housing subdivisions, institutions, paved areas such as roads and parking lots, and playfields. These areas are considered the most suitable for the construction and operation of the attenuation tank. Approximately 70% of the Saanich East-North Oak Bay study area is classified as having low value for ecological integrity.

Areas mapped as having moderate ecological integrity have been disturbed by past land uses, but are now recovering, or could be restored to functioning natural ecosystems. These areas are generally found in association with areas of high ecological integrity. Portions of the study area classified as "Moderate" are located along McGill Road, south of McKenzie Avenue, and on the Saanich-owned portion of the Haro Woods where the forest has been disturbed near the Arbutus Meter Station. The few locations mapped as having moderate ecological integrity represent less than 5% of the total study area.

The areas having the highest ecological integrity in the study area include the mature forested areas and habitat connectivity corridors near the University of Victoria, such as Mystic Vale and Haro Woods (which includes the Finnerty Arbutus property), plus the forested areas along the shoreline between Arbutus cove and Telegraph Bay (*e.g.,* Queenswood). These areas have low suitability for a tank location (Figure 5) from an ecological perspective. The construction and operation of an attenuation tank in the 20% of the study area rated as having high ecological integrity would result in the greatest environmental impacts.

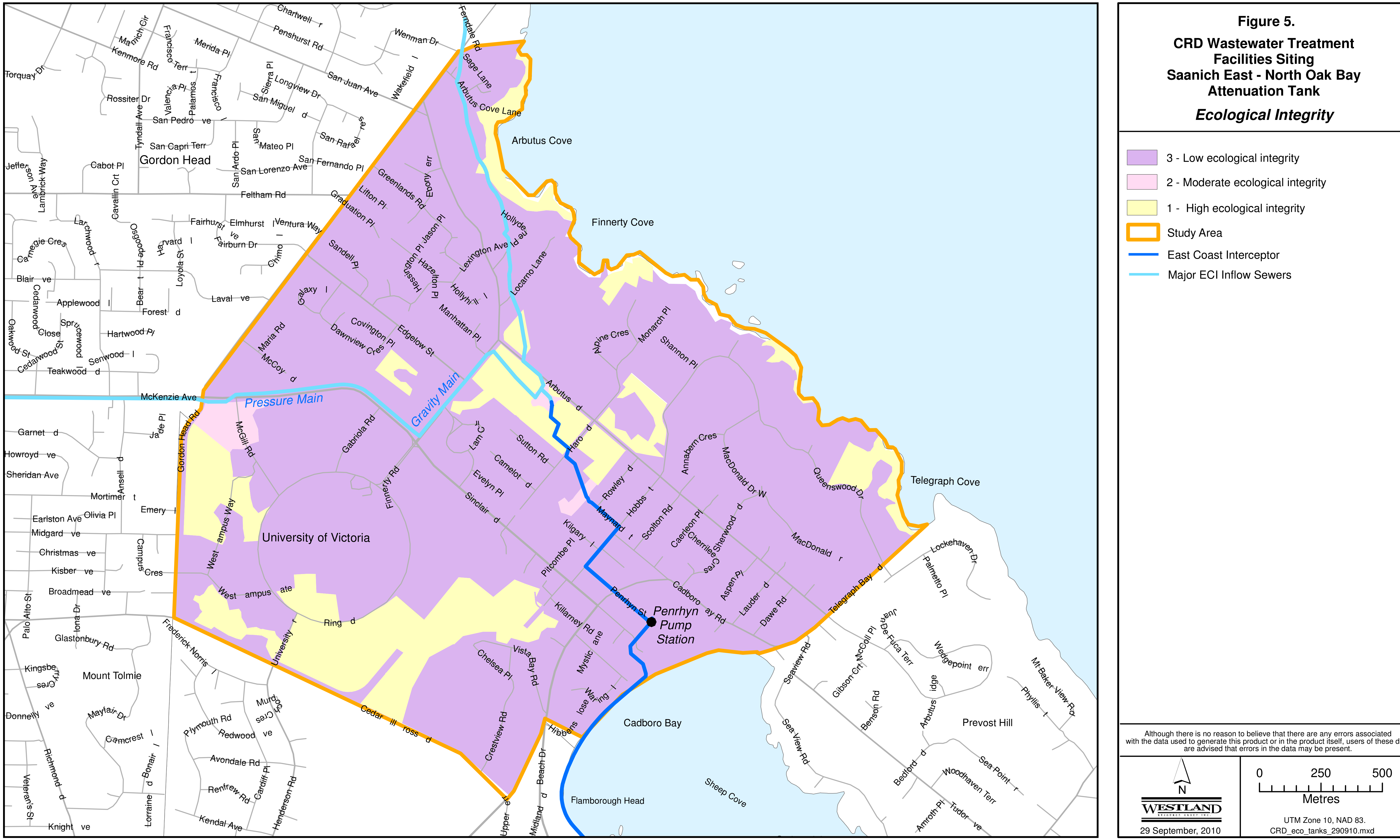

Figure 5. Ecological integrity

2.5 Geotechnical conditions

Methods

Investigation of geotechnical conditions in the study area consisted of collecting and reviewing available information. Sources included previous reports covering the study area, regional maps detailing bedrock (Muller 1980) and Quaternary geology (Monahan & Levson 2000), and earthquake hazard maps for Greater Victoria (Monahan *et al.* 2000a, Monahan *et al.* 2000b, McQuarrie & Bean 2000). This information was supplemented with interpretation of historical air photos, and knowledge of local soils conditions and their engineering properties by C.N. Ryzuk & Associates Ltd. Several sites were visited as part of the Environmental and Social Review of the Saanich East-North Oak Bay area and the Environmental Impact Study of the Saanich East wastewater treatment facility. No additional field work was conducted as part of the present study.

The published map data relating to geotechnical conditions has limitations. The boundaries between units are inferred between points of known conditions, and the interpolation between points may not reflect actual soil conditions. Additionally, the relative accuracy of the information depends on the quantity and coverage of available information. More information is available for urbanized areas than for undeveloped or rural areas.

The results of the geotechnical investigations are shown in Figure 6 and 7. The following section describes the interpretation and assessment of the mapped information. It should be noted, however, that the map layers and report are not intended for facility design because the actual site conditions are unconfirmed. A site-specific geotechnical investigation of candidate sites will be required to better assess soil and groundwater conditions, and to subsequently provide design parameters for the proposed facility.

The construction constraints for the proposed facility are based on a variety of geotechnical factors, including soil conditions, groundwater conditions, and seismic considerations. Inherent in each of these factors is an increasing cost of constructing the attenuation tank associated with increasing constraint level. Explanations of the factors and ratings follow.

- Soil conditions: The primary geotechnical constraints are imposed by poor soils, such as organic-rich soils (including peat), thick normally consolidated clays, and thick non-select fills. These soils typically are of concern geotechnically, and may necessitate the use of deep foundation elements.
- Groundwater conditions: A detailed investigation of groundwater conditions was not undertaken for this report, though organic-rich soils and thick soft clays are typically associated with relatively high groundwater tables. Accordingly, general groundwater conditions can be inferred from available mapping of Quaternary geology. A higher groundwater table would cause buoyancy issues for an

underground tank extending below the groundwater surface, and would require anchors to provide uplift resistance. Higher groundwater would also cause construction difficulties associated with excavation dewatering and potential destabilization of open cutslopes. The severity of these problems will depend on the types of soil present.

- Seismic Considerations: The study area is located in a region that will be affected by ground motions associated with a Cascadia subduction event, with the potential effects of such a seismic event being a major constraint to development. The effects of relative amplification of ground motions and potential for liquefaction were considered in this study. Both ground motion and liquefaction are products of, and are related to, soil conditions.

Table 7 summarizes the criteria used to rate the construction conditions in the study area. Soil, groundwater, and seismic factors were considered together, and the following three classes of construction constraints were established:

- considerable constraints,
- some to minor constraints, and
- minor to no constraints.

Considerable constraints occur mainly on organic-rich soils, peat, and some fill areas, all of which have high relative seismic amplification and possible liquefaction potential. Areas with these soils can also have an elevated groundwater table, which could increase the complexity of design and construction, along with the associated cost. These soils typically have poor bearing capacity and deep foundations would likely be required. Specialized design and alternative construction methods would be required, although in some areas it may not be possible to fully mitigate the impacts.

Some to minor constraints were identified primarily in areas with soils believed to consist of thick, soft clay deposits. These soils have moderate relative seismic amplification and low liquefaction potential. However, they are susceptible to consolidation settlement when subjected to substantial surface loading from new building loads or fill placement. The softer clays also have lower bearing capacity, and generally are accompanied by higher groundwater levels. Construction in these soils requires special considerations. Potential impacts are usually mitigable, although the required actions may increase the associated construction and design costs.

Areas having minor to no construction constraints have few geotechnical concerns. Soils in this classification are either thin soils overlying bedrock, competent granular soils, or locations where bedrock is exposed at the surface. In general, no unique geotechnical issues are expected for these areas, and issues encountered could likely be easily resolved.

Table 7. Definitions related to geotechnical construction considerations

Construction considerations	Site suitability rating	Definition
Minor to no constraints	High score: 3	In general, no unique geotechnical issues are expected for these areas, and issues encountered could likely be easily resolved.
Minor to some constraints	Moderate score: 2	Construction in these soils requires special considerations, but potential impacts are usually mitigable, although the required actions may increase the associated construction and design costs.
Considerable constraints	Low score: 1	Specialized design and alternative construction methods would be required, although in some areas it may not be possible to fully mitigate the impacts.

Slope stability was considered specifically in terms of the potential for seismically induced slope failure. Potential instability is affected by the overall slope height and steepness, the characteristics of the soil and rock comprising the slope, and the presence of groundwater seepage. Higher slopes, steeper gradients, weaker soils, highly fractured rock, and groundwater are destabilizing conditions. Slopes may experience instability through a variety of mechanisms, including under static conditions, but ground accelerations due to seismic events create excess stresses and strains in the slope materials that can cause larger failures. Additional considerations for rockslopes include the potential for rockfall, the presence of adverse fractures or joints in the bedrock, and the time frame – short-term (occurring only during construction) and long-term. Slopes were classified according to their probability of seismically induced failure.

Table 8 explains the criteria used to rate the slope stability of the study area. The categories are:

- no to limited concern,
- limited to moderate concern, and
- concern.

Slopes categorized as no to limited concern have a very low or low probability of failure. Slopes of limited to moderate concern have a moderate probability of failure, and slopes of concern have a high to very high probability of failure in a design seismic event.

The depth to bedrock was not taken into consideration during preparation of the map overlays. Bedrock is capable of providing excellent bearing capacity and is not susceptible to ground amplification, although rock is more difficult and costly to excavate than soil. In the Core Area municipalities, the bedrock profile is notoriously erratic over even small distances. In general, topographic highs correspond to thinner soils, shallower bedrock, and exposed bedrock knolls, whereas basins and lower elevations may have thicker soils and greater depth to bedrock.

Table 8. Definitions related to slope stability

Slope stability	Site suitability rating	Definition
Of no concern to limited concern	High score: 3	Slopes categorized as no to limited concern have a very low or low probability of failure.
Of limited to moderate concern	Moderate score: 2	Slopes of limited to minor concern have a moderate probability of failure.
Of concern	Low score: 1	Slopes of concern have a high to very high probability of failure in a design seismic event.

Results

The results of geotechnical categorization are shown graphically on Figures 6 and 7: Geotechnical Construction Constraints and Slope Stability.

High groundwater tables in low lying areas require effort during construction to maintain a dry excavation (by dewatering) and to prevent instability of open cutslopes due to seepage. Prolonged construction pumping can cause dewatering of nearby soft clay strata, leading to possible subsidence of adjacent properties. This problem was experienced during construction of the addition to the Penryhn Pump Station.

Although thick soft clays have the potential to undergo consolidation settlement, the infrequent filling of the attenuation tank and the relatively light loads caused by the tank itself are considered unlikely to induce this type of settlement. Additionally, consolidation settlement can be avoided by providing full compensation for the new facility, meaning that a weight of soil equivalent to the new building load would be excavated. Because the tank will be situated underground, full compensation should be provided. Hydrostatic pressures on the tank and buoyancy also need to be considered. Peat and organic-rich soils are not capable of providing stable support to structures, due to long-term decay and associated settlement of the soils, and would have to be removed before construction, unless deep foundations are utilized.

In general, shallower bedrock is anticipated to be present in the Arbutus Road area and south of Finnerty Cove. Soils there generally consist of a discontinuous veneer of silty clay and till up to 3 m thick, overlying bedrock. Constructing an underground tank in such conditions would likely require rock blasting. Most seismic concerns would be alleviated in such conditions, provided the site is not overly steep (less than 50% grade). The cost of blasting could be reduced by decreasing the required underground tank depth. If permanent open rock cuts are created by blasting, they would need to be assessed in terms of their long term stability, and some remediation measures may be required.

Soils throughout the remainder of the study area are quite thick, although variable in composition. Near the University of Victoria and other upland areas, soils consist of variable thickness of silty clay, including limited softer clays at depth, overlying older glacial sediments, with bedrock located at a depth of up to 65 m. Although consolidation settlement of the softer clays due to significant increased surface loading can be a concern in this area, the excavation required for the tank should fully compensate for the added loads. Special consideration may be required with regard to buoyancy and anchorage of the tank, depending on the elevation of the groundwater table.

In low-lying coastal areas, such as Cadboro Bay and Finnerty Cove, thicker deposits of soft clay and organic-rich soils are present, in addition to higher groundwater tables. These soils have reduced bearing capacity, and it is likely that deep foundation elements would be required for support of the tank. Shoring and dewatering during excavation and construction would also require special attention.

Construction in areas categorized as having slopes of concern have substantial geotechnical risk, and should be avoided where possible. Such sites have slope stability issues that may not be easily overcome. In areas with slopes of minor concern, construction is feasible if remediation measures are implemented. The cost associated with facility construction areas of minor concern will reflect the expense of enhanced foundations, drainage, and slope remediation actions.

Seismic slope instability affects only a few areas. Mystic Vale, Arbutus and Finnerty Coves, and a portion of Cadboro Bay in the southernmost tip of the study area are over-steepened soil slopes that experience ongoing downward movement of surficial soils, and are prone to periodic shallow landslips and less common deep-seated landslides.

Most sites throughout the study area are geotechnically suitable, although the level of effort required for construction will be higher for sites that have more constraints. Some map areas are designated as having minor or considerable construction constraints, though these sites are not necessarily unbuildable. Rather, as more constraints are imposed on a site or a project, the complexity of design and construction also increases, which translates into higher cost.
The following sites are less favoured from a geotechnical perspective:

- Mystic Vale. Steep slopes and soil conditions produce high potential for ongoing and seismic induced slope instability.
- Cadboro Bay and Gyro Park. Presence of fill materials over top of thick peat deposit and high groundwater table pose variety of challenges.

- Arbutus Cove. Steep shoreline slope areas are not suitable due to potential for seismic induced slope instability.

Figure 6. Geotechnical construction conditions

Figure 7. Slope stability

2.6 Requirement for pumping

Methods

As a high-flow detention facility, the attenuation tank in Saanich East-North Oak Bay needs to be able to operate under storm conditions. The ability for the tank to fill by gravity (without using pumps) greatly reduces capital costs and improves the reliability of the facility. If it becomes necessary to pump into the tank, large pumps (and associated large backup generators) would be needed so that the tank can operate during high-flow periods.

The tank must be capable of being emptied in no more than two days, to ensure that capacity is available for repeated winter storm events. The ability to empty the tank by gravity would reduce cost, but it requires a site to be constructed in a specific topographic area. If pumps are needed, careful site selection can allow the tank to be emptied using a considerably lower pumping rate.

The methods used to determine the requirement for pumping are relatively simple, though the operation of the wastewater system in Saanich East-North Oak Bay is complex. The steps in conducting the analysis of pumping requirements were:

- **Develop detailed topographic mapping of the study area**. One-metre contour interval data covering the study area were obtained from the CRD.
- **Confirm wastewater system configuration and operation**. CRD staff provided detailed information on the operation of the wastewater system in the study area. The East Coast Interceptor flows by gravity from a high point at Haro Woods to a low point at the Penrhyn Pump Station and up again to pass through the Uplands area along Beach Drive. The pipe functions as an inverted siphon and is therefore surcharged under all operating conditions. The elevation of the surcharges upstream of the Penrhyn Pump Station can reach elevations of 12 m above sea level (asl) under normal operating conditions and considerably higher under extreme flow conditions.[1] The location of this surcharge area under normal conditions is near Kilgary Place and Hobbs Street.

  During wet weather events, wastewater can "back up" in the sewer main to an elevation of approximately 22 m.[2] This elevation is reached at the meter station just south of Arbutus Road in the Saanich-owned Arbutus-Haro property, at which point wastewater begins to overflow to the Finnerty Cove outfall.

[1] The pipe invert elevation near Kilgary Place is 12 m ASL. The ground elevation above the pipe at this point is 14 m ASL.
[2] The pipe invert elevation is 22 m. The ground elevation above the pipe is 25.4 m.

- **Map inflow areas.** Using the topographic information and the facility operation descriptions from the CRD, maps were prepared showing the ability to operate an attenuation tank with no or little pumping, outflow pumping only, or inflow pumping. Table 9 explains the parameters used to rate the requirement for pumping.

Table 9. Definitions related to the requirement for pumping

Requirement for pumping	Site suitability rating	Definition
No or minimal pumping required	High score: 3	Areas that have the potential to fill and empty the tank by gravity, requiring little or no pumping. These areas are below 31 m elevation (everything below this elevation flows by gravity) and above 19 m asl (allowing for tank depth above the surcharge elevation). Between 19 and 31 m elevation, a tank would have sufficient head that pumping would not be required to empty the tank.
Outflow pumping required	Moderate score: 2	Areas where the tank could fill by gravity, but would require pumps to be emptied. These areas are below 19 m elevation.
Inflow pumping required	Low score: 1	Areas that would require pumps to fill the tank. These areas are above 31 m elevation or would require siphons to fill the tanks and pumps to empty the tanks.

Results

Figure 8 presents the results of the analysis of the requirement for pumping. The following results can be reported.

- Most of the western portion of the study area would require inflow pumping to fill the attenuation tank.
- Areas south of Mystic Vale in the western portion of the study area would require inflow and outflow pumping because they are below the surcharge elevation.
- Several areas in the eastern portion of the study area would not be suitable because they would require a siphon for filling the tanks and pumping to empty the tanks.
- The areas near Penrhyn Pump Station in the eastern portion of the study area are below 19 m ASL. These areas could use gravity for inflow, but would require substantial pumping effort to empty the tank from this low elevation.
- The remaining areas in the centre of the study area have a high potential to maximize the use of gravity to convey wastewater. These areas are below 31 m ASL, so wastewater can flow in by gravity, and above 19 m ASL, so the tank can be emptied with minimal pumping.

Figure 8. Requirement for pumping

2.7 Proximity to East Coast Interceptor

Locating the attenuation tank near existing wastewater infrastructure reduces the cost of construction and improves reliability of operation. Locating a tank near the East Coast Interceptor (ECI) would allow all of the upstream flow to be captured using shorter lengths of new pipe.

Methods

The CRD's integrated sewer database and interviews with CRD engineering staff identified the main routes and volumes of wastewater transported through the study area. The northern sewer main conveys flows south from the Gordon Head area to the ECI. The western sewer main conveys flows east from the Garnet Pump Station to the ECI. The Gordon Head sewer main and the Garnet sewer main each convey approximately half of the flows reaching the ECI at the Arbutus Flume. A single attenuation tank located between the Arbutus Road Metering Station and the Penrhyn Pump Station could capture all of the wet weather flows from the catchment area. Locating the tank near the ECI reduces the need for new wastewater pipes, with attendant cost and impacts on the community and the environmental.

Table 10 explains the criteria used to rate the proximity to the East Coast Interceptor. Areas less than 250 m to the ECI were rated "3" (highly suitable) because they would require the shortest length of pipe to transport the flows between the ECI and the attenuation tanks. Areas 250 m to 500 m from the ECI were rated "2" (moderately suitable) because longer lengths of pipes would be required. Areas more than 500 m from the ECI were rated "1" (low suitability).

Table 10. Definitions related to proximity to East Coast Interceptor

Proximity to East Coast Interceptor	Site suitability rating	Definition
Less than 250 m from a high volume sewer trunk or main	High score: 3	Areas closer than 250 m from the ECI would minimize the need for additional wastewater conveyance.
250 to 500 m from the ECI	Moderate score: 2	Areas 250 m to 500 m from the ECI would require some additional sewer infrastructure.
More than 500 m from the ECI	Low score: 1	Areas more than 500 m from the ECI. Would require the construction and operation of extensive conveyance pipes.

Results

Figure 9 shows the results of the proximity to the East Coast Interceptor analysis. Areas near the East Coast Interceptor sewer trunk received the highest suitability rating because wastewater from the entire catchment area could be captured using the shortest length of conveyance pipes.

Areas between 250 m and 500 m from the East Coast Interceptor sewer trunk were considered moderately suitable. Areas more than 500 m from the East Coast Interceptor received the lowest suitability rating because extensive conveyance pipes would be needed to connect the attenuation tank to the East Coast Interceptor.

Figure 9.
CRD Wastewater Treatment Facilities Siting Saanich East - North Oak Bay Attenuation Tank
Proximity to East Coast Interceptor

- 3 - Less than 250m from the East Coast Interceptor
- 2 - Between 250m and 500m from the East Coast Interceptor
- 1 - More than 500 m from the East Coast Interceptor
- Study Area
- East Coast Interceptor
- Major ECI Inflow Sewers

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Metres

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1 October, 2010

UTM Zone 10, NAD 83.
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Figure 9. Proximity to East Coast Interceptor

3.0 COMBINED SUITABILITY ANALYSIS

Section 2 discusses the criteria developed to identify suitable areas for an attenuation tank. The combined analysis overlays the maps of each of the foregoing criteria. Section 3 describes the results of overlaying the maps.

The criteria represented on the eight maps presented in Section 2 were assigned weights according to their perceived relative importance in determining a suitable location for an attenuation tank in Saanich East-North Oak Bay (Table 11). The total of all criteria weights equal 100. The total weight of criteria in each of the three "triple bottom line" categories is approximately one-third of the total, balancing environmental, social, and economic considerations.

A Geographical Information System (GIS) analysis was performed to calculate the combined scores for each area on the map.

3.1 Combined analysis results

Figure 10 presents the overlay siting analysis. Dark areas are considered the most suitable for an attenuation tank and light areas are considered the least suitable, on the basis of the criteria applied. Each of the top four classes represents 10% intervals, based on total combined scores. The middle classes represent 20% intervals and the lowest category represents all areas having scores in the bottom 40% of all scores. This approach allows greater refinement of the best areas, which is consistent with the goal of identifying the best site for an attenuation tank. The map does not show candidate sites, though it does show areas that require further investigation to determine their suitability for an attenuation tank.

Table 11. Triple bottom line site selection criteria for the Saanich East-North Oak Bay attenuation tank

TBL[3]	Topic	Criteria	Metric	Definition	Weights (%)
Social	Land use	Land use compatibility	3 = compatible 2 = somewhat compatible 1 = least compatible	Areas where existing and planned land uses are compatible with facility operations, avoiding areas sensitive to nuisance effects.	25
	Resource recovery	Nearby heat demand	3 = <100 m to a known demand area 2 = <100 m to a potential demand area 1 = >100 m to a demand area	Potential for reuse of heat recovered from wastewater in nearby facilities.	5
	Archaeology and heritage	Archaeology and heritage features	3 = no known archaeological potential 2 = archaeological potential 1 = registered archaeological or heritage site	Likelihood of encountering archaeological or heritage features.	5
Environmental	Biology	Ecological integrity	3 = low ecological integrity 2 = moderate ecological integrity 1 = high ecological integrity	Areas where facilities would avoid adverse effects on sensitive or important habitat.	30
	Geotechnical	Slope stability	3 = of no concern to limited concern 2 = of limited to moderate concern 1 = of concern	The stability of slopes for facility construction and operation.	5
Economic	Geotechnical	Geotechnical construction conditions	3 = minor to no constraints 2 = minor to some constraints 1 = considerable constraints	Suitability of the surficial material, site drainage, and levels of seismic and liquefaction risk to allow facility construction and operation.	10
	Conveyance	Requirement for pumping	3 = no or minimal pumping required 2 = outflow pumping required 1 = inflow pumping required	Areas where gravity can be used rather than pumps to transport wastewater, thereby conserving energy.	15
		Proximity to East Coast Interceptor	3 = <250 m to East Coast Interceptor 2 = 250 m to 500 m to East Coast Interceptor 1 = >500 m to East Coast Interceptor	Areas near East Coast Interceptor, reducing the need for conveyance facilities.	5

[3] Triple bottom line

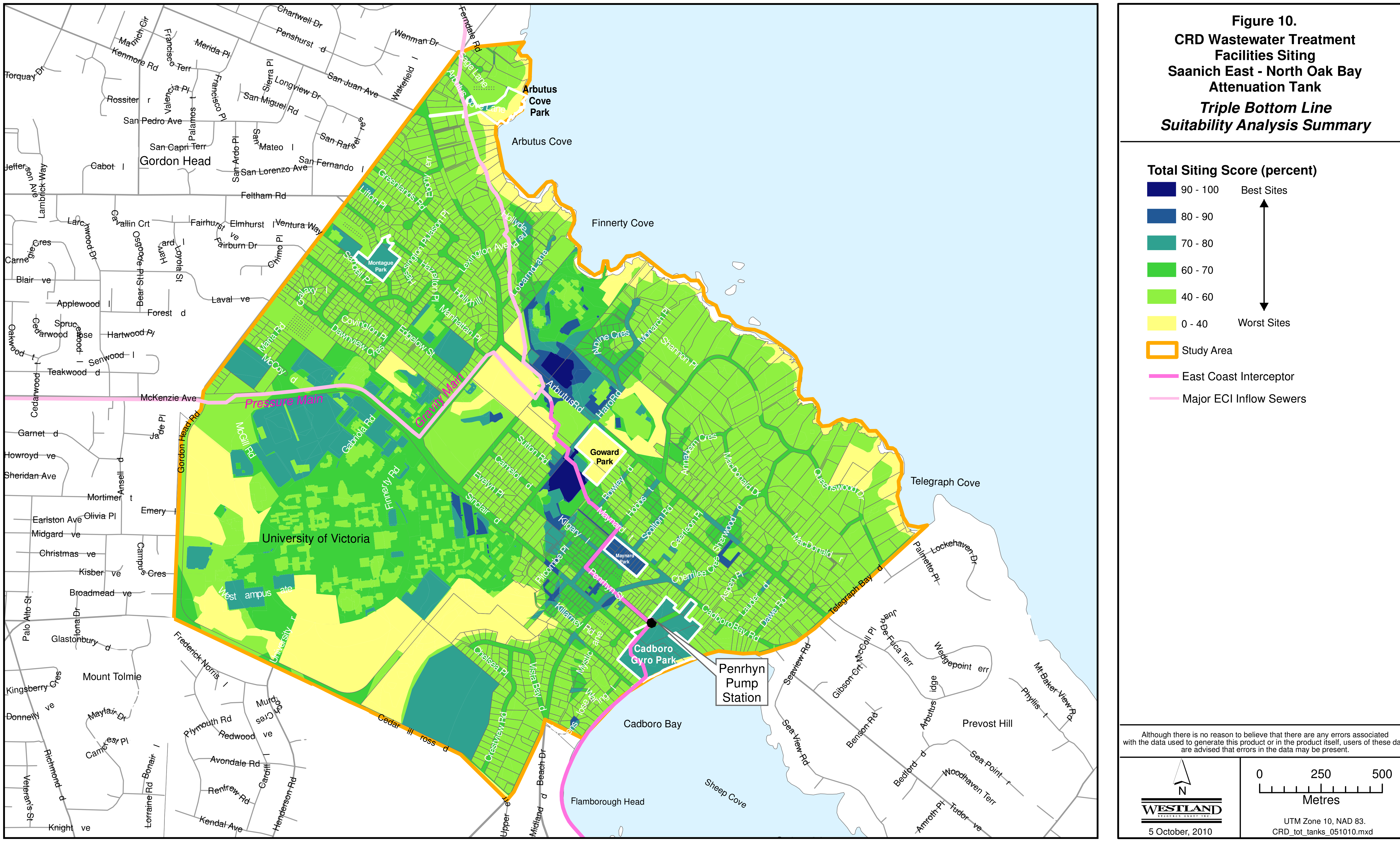

Figure 10. Triple bottom line suitability analysis summary

3.2 Ability to acquire land

Figure 10 shows the relative suitability of land for an attenuation tank in Saanich East-North Oak Bay on the basis of the criteria applied. However, some suitable sites may not be available for purchase or lease by the CRD. One of the most important variables in determining the ability to acquire land is its ownership. Figure 11 shows areas that have been rated according to the how easily the CRD could buy or lease the property.

CRD and municipally owned lands were rated “3” (high potential), because these properties owned by local governments are likely the easiest to obtain for an attenuation tank facility. This municipal land is used as parks, community centres, utilities, and roadways, or is vacant.

Private and non-government property, such as residential and commercial land is rated “2” (moderate potential). Private or non-government-owned property may be acquired through purchase, lease, or expropriation. Although the CRD may be able to acquire private land, the cost of doing so may be prohibitive. Most of the land in the study area is private or non-government.

Land owned or leased by the federal or provincial governments were rated “1” (low potential), because this land would likely be the most difficult to obtain for a facility. Federal land, for example, is subject to an extensive divestiture process that takes more than five years to complete. At the end of the five year period, it is not guaranteed that the CRD would receive the land. Provincial lands are also subject to an approval process, though the time required to determine whether the land can be obtained is typically faster than the federal process. The University of Victoria lands are protected from expropriation through the British Columbia *University* Act, so the university lands are considered provincial for the purpose of this study. Lands controlled by the Victoria School District 61 also are considered provincial.

Figure 11.

CRD Wastewater Treatment Facilities Siting
Saanich East - North Oak Bay Attenuation Tank

Ability to Acquire Land

- 3 - Property owned by CRD or municipality
- 2 - Property owned privately or by non-government organizations
- 1 - Properties leased or owned by UVic, Provincial, or Federal Government*
- Study Area
- East Coast Interceptor
- Major ECI Inflow Sewers

* Includes school district properties

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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29 September, 2010

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Metres

UTM Zone 10, NAD 83.
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Figure 11. Ability to acquire land

4.0 NEXT STEPS

The results of the land investigations in this study are intended to be an aid in identifying areas that may be suitable for an attenuation tank. Additional steps need to be taken to identify specific suitable sites. The following steps are recommended to select a site for an attenuation tank in Saanich East-North Oak Bay:

1. Review the findings of this study with CRD staff and consultants to identify suitable areas that meet the technical needs for efficient and reliable operation of the attenuation tank.
2. Specify candidate sites that should be subject to further study. Other considerations, such as size of parcel, ability to acquire land, and effects of tank construction on surrounding areas, should be part of this decision.
3. Contact the owner(s) of candidate site(s).
4. Pursue public engagement to review available information and obtain comment.
5. Conduct a rigorous technical analysis of the preferred site(s).
6. Acquire the preferred site.
7. Prepare an amendment to the Liquid Waste Management Plan and an associated Environmental Impact Study.

5.0 REFERENCES

Associated Engineering, Kerr Wood Leidal Associates Limited, CH2M Hill, and Westland Resource Group. December 8, 2008. *Core Area Wastewater Management Program: Discussion Paper 036-DP-1– Identification and Evaluation of Resource Recovery Opportunities*. Prepared for the Capital Regional District. Victoria, BC.

Johnston, Chris. Project Manager, Kerr Wood Leidal Associates Limited. Vancouver, B.C. Email correspondence. September 30, 2010.

McQuarrie, E. and S. Bean. 2000. *Seismic Slope Stability Map of Greater Victoria*, British Columbia Geological Survey, Ministry of Energy and Mines, Victoria, B.C., Geoscience Map 2000-3, Sheet 3C.

Monahan, P. and V. Levson. 2000. *Quaternary Geological Map of Greater Victoria*, British Columbia Geological Survey, Ministry of Energy and Mines, Victoria, B.C., Geoscience Map 2000-2, Sheet 2.

Monahan, P., V. Levson, P. Henderson and A. Sy. 2000a. *Relative Liquefaction Hazard Map of Greater Victoria,* British Columbia Geological Survey, Ministry of Energy and Mines, Victoria, B.C., Geoscience Map 2000-3, Sheet 3A.

Monahan, P., V. Levson, P. Henderson, and A. Sy. 2000b. *Relative Amplification of Ground Motion Hazard Map*, British Columbia Geological Survey, Ministry of Energy and Mines, Victoria, B.C., Geoscience Map 2000-3, Sheet 3B.

Muller, J. 1980. *Geology Victoria West of Sixth Meridian, British Columbia*, Geological Survey of Canada, Ottawa, ON, Map 1553A.

Stantec Consulting Ltd. January 2010a. *Core Area Wastewater Treatment Program: Effluent Reuse and Heat Recovery for the University of Victoria and Surrounding Area.* Prepared for the Capital Regional District. Victoria, BC.

Stantec Consulting Ltd. January 2010b. *Core Area Wastewater Treatment Program: Feasibility Study for Heat Recovery for James Bay and Downtown Victoria.* Prepared for the Capital Regional District. Victoria, BC.

Westland Resource Group. December 2009. *Environmental Impact Study of Core Area Wastewater Treatment Facilities: Terrestrial Environment. Part 1: Saanich East Facilities.* Prepared on behalf of the Capital Regional District for the Ministry of Environment.

Westland Resource Group. July 2009. *Comparative Environmental and Social Review: Saanich East-North Oak Bay Wastewater Treatment Facility Sites.* Prepared for the Capital Regional District. Victoria, BC.