psturje

# BRITANNIA BEACH SOUTH

## SITE DEVELOPMENT MASTER PLAN

## VOL 3 OF 5 - ENGINEERNG

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# Britannia Beach South
# Site Development Master Plan
# Vol 3 of 5 - Engineering

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PROFESSIONAL PROVINCE OF PAUL S. TURJE BRITISH COLUMBIA ENGINEER

*Study Limitations:*

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# BACKGROUND

## Scope

This document is a site development master plan for a new community referred to as Britannia Beach South, located in the Squamish Lillooet Regional District (SLRD) beside Howe Sound and flanking Highway 99 (the Sea-to-Sky highway). The owner and proponent of the development concept is Tiger Bay Development Corporation.

## Objective

The objective of this master plan is to advance the investigations and planning to a sufficient level of detail to either completely confirm that an element is feasible (e.g. water supply and distribution) or that it is highly likely that a component can be resolved (e.g. debris flow).

The reader might wonder why the development team did not fully resolve all of the issues. The reasons are twofold:

- Some agencies wish to defer review or comment on a development proposal until the local government has ratified the development proposal. This leads to a classic “chicken and egg” dilemma. For example, the provincial environment ministry will only review the mitigation plan for riparian areas at an advanced design stage because they do not have the resources to comment on preliminary planning proposals. Other agencies include MoTI, CN Rail, Fisheries, Ministry of Health and others.

- The proponent wishes to receive an indication that the development proposal enjoys the conditional support of the SLRD before committing to additional expensive and lengthy technical studies. In other words, are non-technical issues (political, social, administrative, etc.) standing in the way of approval? For this reason, the proponent is seeking First Reading as an indication of conditional support for the project before completing the technical tasks.

## History

This document is a site development master plan for the proposed development of a new community referred to as Britannia Beach South, located in the Squamish Lillooet Regional District (SLRD) and flanking Highway 99 (the Sea-to-Sky highway). The site is approximately 55 kilometres (34 miles) north of the city of Vancouver, 33 kilometres (21 miles) north of Horseshoe Bay, and 12 kilometres from Porteau Cove. The development area is immediately south of Britannia Beach (Britannia Beach North), a community of approximately 300 residents and associated historical mining facilities, including the Britannia Mining Museum.

Taicheng Development Corporation purchased the subject properties in 2011. They retained a development consulting team between 2011 and June of 2013, led by Folio Architecture (Folio) as project planners and coordinators, to develop a Master Plan and submit an Application to the Squamish Lillooet Regional District (SLRD) for an OCP and Zoning Amendment.  They also conducted a series of 8 workshops to present and receive comments on evolving design concepts for a 2500 to 4000 residential unit development with supporting commercial and institutional uses. The final workshop was conducted in June 2013. The SLRD declined to accept the prepared documentation for consideration of the required OCP and Zoning Amendment.

Taicheng retained MVH Urban Planning and Design (MVH) in February 2014 (Michael von Hausen, planner and Paul Turje, civil engineer) to assemble a new planning team to prepare a revised Master Plan and Application to support the required OCP and Zoning Amendment. Taicheng retained some of the previous consulting team, as well as a new marketing/economics consultant, to complete the technical studies required to support the Application. MvH and Taicheng submitted a revised Master Plan in draft form to the SLRD in June 2014, and then in final form in November 2014.

The SLRD replied with comments and invited Taicheng to resubmit the development concept with requested revisions and more detailed technical studies. Revised concepts were reviewed in a series of workshops with SLRD staff and the SLRD planning advisor. A revised application dated May 2016 was submitted, but the review was deferred at the request of Taicheng to allow for a change of concept.

Taicheng subsequently rebranded itself as Tiger Bay Development Corporation ( Tiger Bay) and retained EcoSign Mountain Resort Planners Ltd. to prepare a new development concept with both a residential and tourist recreational focus. This concept includes the OCP designated number of residential units in townhouses and apartments plus substantially increased resort and commercial components. Tiger Bay retained its association with Turje to prepare this engineering summary document.

## Work in Progress

Technical studies are in progress, and this document reflects information available at the date of publication. The documentation will be amended in the future to reflect the information provided by studies completed after the publication date.

## Documentation

The Master Plan consists of the following four documents:

**Volume 1 of 5: Summary** – This volume extracts the summaries and phasing plan from the Details volume. The reader should reference the Drawings volume when reading this summary.

**Volume 2 of 5: Master Servicing Plan** – This volume extracts only the phasing plan from Volume 3 together with the drawings *Site Plan – Interim* and *Site Plan-Final* .

**Volume 3 of 5: Engineering (this document)** – This volume contains the full text of the master plan together wilth many figures that will aid the reader’s understanding. The reader intrepid enough to wade into this volume should also refer to the Drawings and Reference volumes.

**Volume 4 of 5: Drawings** – This volume includes full-sized drawings.

**Volume 5 of 5: Reference** – This volume contains consultant reference reports.

### Site Development Master Plan, Volume 1 of 4: Summary

Volume 1 is a Master Plan summary that should be read together with Volume 3 of 4: Drawings. The reader wishing an enhanced understanding of the plan should refer to Volume 2 of 4: Details.

### Site Development Master Plan, Volume 2 of 4: Engineering (this document)

This document, Volume 2, is a description of the natural site features and the proposed development in support of the application to amend the *Squamish-Lillooet Regional District (SLRD) Official Community*

*Plan* (OCP). The OCP for this area is the *Howe Sound East Sub-Area Plan* (Schedule C to the SLRD Area D OCP Bylaw 1135-2013). The application also provides the basis to amend the *Zoning Bylaw* (Bylaw 540) to accommodate the proposed development.

This report is submitted to support initial approvals and is conceptual but with sufficient detail to confirm the feasibility of the proposal. Future “pre-design” studies will provide a detailed description of each system, which will be implemented by the “design” and “construction” phases.

This report uses the term “Interim Development” for the initial phase that services the Wavegarden and “Final Development” to describe the complete development proposal that includes the residential and resort components. As such, it does not conform to the planning phases described in the planning submissions because most of the infrastructure must be implemented with the first phase of residential development, therefore phasing is not applicable to the infrastructure development.

The chapters each deal with a specific service or issue and culminate in a summary with recommendations for next steps. The reader who wishes to avoid the technical slog might choose to read only the summary but should also refer to the figures in each chapter as these are essential to an understanding of the content. The pdf version of the report is bookmarked to aid the reader in moving between chapters and topics.

### Site Development Master Plan, Volume 3 of 4: Drawings

Volume 3 contains the following drawing sheets:

Dwg 1 - Orthophoto

Dwg 2 - Site Plan, Existing

Dwg 3 - Site Plan, Interim

Dwg 4 - Site Plan, Final

Dwg 5 - Existing and Final Streams/Riparian

Dwg 6 - Parcel Plan

Dwg 7 - Easements, Rights of Way and Setbacks Plan

### Site Development Master Plan, Volume 4 of 4: Reference

Volume 4 of this report is a compilation of background technical documents related to environmental setting, servicing concepts and other supporting documentation. Each section is preceded by a brief introduction to the content. The document is submitted in pdf format where the sections are bookmarked to aid the reader in finding relevant information. The reader should read the introductions to understand the context of the information presented in that section.

The technical reports were variously prepared by the Folio, MVH and then the EcoSign teams. We acknowledge that many of the technical reports address previous development concepts. However, the underlying analysis remains relevant and changes to reflect the current development proposal are incorporated in the plan.

## Summary

Each chapter of this report ends with a summary and recommended next steps. The summaries in this volume are in some cases more detailed than the summaries in Volume 1

# SITE DESCRIPTION

The drawings titled *Orthophoto* and *Site Plan, Existing* illustrate the location and features of the site.

The site borders the eastern shores of Howe Sound and is bisected by Highway 99 and the CN Rail line, separating the proposed community from the waterfront. The possible Highway 99 bypass and existing hydro right-of-way, located on the lower part of the mountainside, shape the eastern boundary of the site. Most of the waterfront (Lots 5208 and 5210) is owned by the Province of British Columbia (the Crown), except for the Minaty Bay area in the southwest corner of the property.

The total land owned by Tiger Bay Development Corporation is approximately 203 hectares (503 acres). This Master Plan includes approximately 53.4 hectares (132 acres), which represent approximately 26% percent of the gross property area. Most of the developable area is located on the lower gradient slopes and previous gravel extraction operations area as well as the Minaty Bay area.

The lots which comprise the development areas include the following, all owned by Tiger Bay Development Corporation and which are approximately located at Lat 49.61555 degrees and Lon 123.20611 degrees.

*Table 1: Lots in the development area*

| Lots | Property Identification (PID) |
|---|---|
| Parcel 1 DL 2001 | 010-025-901 |
| Parcel 1 DL 1583 | 010-025-952 |
| Lot A DL 1583, 201 & 7034 | 010-077-227 |
| DL 1583 | 010-026-151 |

The Master Plan conforms to the development limits within the Official Community Plan as included in the Howe Sound East Sub-area Plan (Schedule C to SLRD Area D OCP Bylaw 1135-2013). The Master Plan does not include the uplands parcels owned by Tiger Bay, except for minor trail and access road connections to a possible future restaurant and to the proposed water reservoir.

The proposed development consists of three areas that are separated by the highway and the CN Rail line that impose limits on both extent and timing of development and having the following land areas:

*Table 2: Development Areas*

| Area | Land area, m2 | % |
|---|---|---|
| Area A | 324,816 | 60% |
| Area B | 141,026 | 26% |
| Area C | 68,525 | 14% |
| Gross Land Area | 534,367 | 100.0% |

These Development Areas are described below:

### Development Area A – North Bowl

Most of this Development Area consists of the former gravel pit that is highly disturbed. It is bounded to the east by steep slopes, the BC Hydro right of way and a proposed highway bypass reserve. It is bounded to the north by steep rock slopes that separate it from the property occupied by the Britannia Mine Museum and the Britannia Beach North townsite. The south and west borders are defined by Highway 99. Gravel Creek, Thistle Creek and their associated wetlands and riparian areas, are located in this development area.

Elevations range from a low of 2 m around a few wetland ponds located along the western border of the area, to a high of 40 m along the eastern boundary of the site. Topographic slopes range from less than 1% in the bottom of the gravel pit to 66% (1.5H:1V) along the steeply excavated eastern slopes.

### Development Area B – Minaty Uplands

This Development Area is bounded by Highway 99 and the CN Rail right-of-way. It is also extensively disturbed by gravel extraction and overburden dumping from clearing to expose the gravel for extraction. The disturbed portion of the site has revegetated with alder. An area of older growth forest remains on the knoll at the south extremity of the parcel. Two creeks run through the site: Daisy Creek, the larger named creek, and a small unnamed watercourse referred to as Minaty Creek. The creeks flow through culverts beneath the CN Rail line and discharge independently into Howe Sound. An old single-lane corrugated steel pipe culvert underpass, installed during the original highway construction in the 1950s and located under Highway 99, connects this parcel to the North Bowl.

Elevations range from 20 to 60m. Topographic slopes range from near flat to 66% along the steep slope north of the Highway 99.

### Development Area C – Minaty Bay

This waterfront Development Area is bounded by the CN Rail line, Howe Sound and Highway 99. The waterfront of the Minaty Bay Area was the site of a community associated with the Britannia Beach mine when it was in operation. The houses have since been removed, but some foundations remain. The Minaty waterfront is a picturesque site with a small protected cove and a peninsula that affords excellent views to Howe Sound and the mountains beyond. Informal recreation use is evidenced by fire pits, sitting areas and a trail that follows the waterfront to Highway 99. Both Daisy Creek and Minaty Creek flow through the site and discharge into Howe Sound.

Elevations range from sea level to 50m at the top of the rock knoll on the south end of the site. Slopes are near flat on the seaside bench to very steep up the knoll.

# ENVIRONMENTAL SETTING AND PROTECTION

## Topography and Vegetation

The development area has a "bowl" like shape – flatter areas surrounded by the steep slopes of the mountains. The moderate to steep slope at the base of the mountains graduate to mostly flat terrain in the north gravel extraction area (Area A) and flat to moderate topography in the southern Minaty Bay area (Areas B and C), eventually sloping toward Howe Sound. The southern edge of Minaty Bay is defined by moderate to steep slopes to the water's edge. The lower slopes and flatter areas are excellent development sites, especially considering the general rugged nature of other sites between Horseshoe Bay and Squamish.

Vegetation in Area A has been removed and has only partially regenerated along Thistle Creek that runs from the base of the mountains to Howe Sound. Much of this regenerated vegetation are not significant species but are useful for restoring the productivity of the riparian areas along the creek. On the upper northern and eastern benches of the mountainside, more significant stands of second and third growth mixed forests emerge, with the most significant vegetation concentrated in the non-development areas.

Area B is mostly covered with deciduous species on the disturbed areas and coniferous trees on the undisturbed areas. A central mostly clear area remains due to the most recent soil extraction operations.

Area C is well treed throughout mostly with deciduous species in the flat areas.

Trees within the riparian areas of the creeks will be protected by setbacks. Trees in the proposed Minaty Bay Regional Park will be protected as part of the park development concept. Other areas will retain trees where possible. Trees will be replanted as part of the site redevelopment program along streets, in proposed parks, in some riparian areas and along trails.

## Environmental Review

Cascade Environmental Resource Group (CERG) conducted a terrestrial ecosystem assessment following the standards developed by the provincial Resource Inventory Committee (1998). CERG also conducted an underwater survey of the Howe Sound foreshore using a towed waterproof camera. CERG delineated and assessed the streams and wetlands within the Development Areas. They confirmed wildlife habitats through direct observation and by using ecosystem suitability analysis.

## Terrestrial Ecosystem Mapping

The site contains a single biogeoclimatic subzone: Coastal Western Hemlock Dry Maritime subzone (CWHdm). This subzone is characterized by warm, relatively dry summers and moist, mild winters with little snowfall. The environmental assessment indicates that the site has mainly been influenced by gravel extraction, logging and electrical transmission lines, with approximately 25% of the site currently consisting of exposed soils or low growing shrubs/ground cover. The remaining vegetated portion of the site is further divided into four site series areas, which were further divided into 20 ecosystem units based on the site series, site condition modifiers, structural stage and stand composition. The site series include the following:

- CWHdm01 Western Hemlock – Flat Moss,
- CWHdm03 Douglas-fir Western Hemlock – Salal,

- CWHdm05 Western Red Cedar – Sword Fern, and
- CWDdm07 Western Red Cedar – Foamflower.

Site series CWHdm05 is blue-listed in British Columbia indicating that there is not an immediate threat. However, there is a special concern due to sensitivity to human activities or natural events. The proposed development layout avoids this unit.

## Wildlife and Wildlife Habitat

Wildlife and wildlife signs were observed and habitats could potentially exist on the site, based on habitat conditions. Ten bird, four mammal, three amphibian and three invertebrate species are identified by the BC Conservation endangered listed species that occur in the CWHdm biogeoclimatic zone within the SLRD. Two blue-listed species are confirmed to occur on the Britannia South site and four blue-listed species possibly occur on the site. Red-listed species are unlikely to be found on site. Of the two confirmed blue-listed species, the great blue heron occurs as a transient species (i.e., passing through or feeding at the site), but are not observed as breeding residents. The coastal tailed frog, the other confirmed blue-listed species, is found in Daisy Creek and is likely to occur in Thistle Creek as well. Tailed frogs live in steep mountain streams and in adjacent riparian forests, which are protected by the Riparian Areas Regulation (RAR). The northern red-legged frog and the western toad are other blue listed amphibians that potentially could occur, particularly in the wetlands. Two bird species, the band-tailed pigeon and the olive-sided flycatcher, also have the potential to occur on the site.

## Thistle Creek and Gravel Creek

**Thistle Creek** flows north-westerly from the steep slopes characterizing the eastern half of the property to discharge into Howe Sound approximately 490 metres (1,608 feet) north of Minaty Bay. Thistle Creek flows under Highway 99 through a culvert with an invert elevation of approximately 2 m. This discharge elevation and the backwater effects of the high tide (2.05m elevation) will govern the drainage of Development Area A.

The first two reaches of Thistle Ck within the gravel pit are fish-bearing (Coho salmon, rainbow trout and cutthroat trout). A significant waterfall located immediately upstream of the gravel pit prevents fish movements into the creek's steeper third reach.

Thistle Creek's first tributary consists of a series of two wetlands and two ponds, fed by Gravel Creek. Fish were captured in the first pond above Thistle Creek, but not further upstream, likely due to the ephemeral conditions, low flows and shallow depths. The shoreline elevations of the ponds were approximately 1.5 to 2.0 m at the time of the LIDAR survey.

**Gravel Creek** is dry in summer through early fall. Downstream of the creek's headwaters, between the powerlines and the gravel pit, Gravel Creek has been redirected through a series of roadside ditches. The pool/wetland complex that forms the lower reach of Gravel Creek is a remnant of past gravel extraction activities. The system consists of two pools that vary in depth from approximately 0.5 to 3 metres (2 to 10 feet) that are joined by a ditch and then discharge to Thistle Creek via a ditch and a small diameter culvert. The entire system, in its present condition, is poorly suited for fisheries or other aquatic habitat.

Rainbow trout were caught in the pool closest to Thistle Creek. Although this low gradient pool/ditch system is fish habitat due to its connectivity and lack of fish barriers, it is better suited to amphibian habitat.

The second tributary of Thistle Creek is a small channel that tends westward through the powerlines above the proposed development, before flowing into a north-south tending cut-off ditch. Water entering the cut-off ditch usually flows southward, although it was observed to flow to the north-west into Gravel Creek and occasionally flow overland into the gravel pit, causing erosion of the gravel and sand embankment. The water flowing in the channel southwards makes its way into Thistle Creek. The lowest reach (in the gravel pit) has no barriers to fish movement and should be considered potentially fish-bearing.

It is important to note that Gravel Creek was highly disturbed by past gravel pit operations, its riparian borders are either non-existent or of poor quality and that the development proposal includes rehabilitation of creek and its riparian area.

## Daisy Creek

Daisy Creek flows roughly parallel to Thistle Creek and discharges into Howe Sound approximately 210 metres north of Minaty Bay. Daisy Creek is fish-bearing upstream from its mouth to Highway 99. CERG captured cutthroat trout throughout this section of the creek, and the FISS database indicates unknown salmon species present in the drainage. Coastal tailed frogs have also been found throughout this creek, but particularly upstream of Highway 99.

## Minaty Creek

Minaty Creek flows approximately parallel to Daisy Creek and into Minaty Bay. The drainage is small with an approximate wetted width of 1 metre (3 feet) and flows from a culvert that drains lands upslope of Highway 99. Although stream gradient is not great enough to preclude fish presence, the small size of the drainage and very shallow depth does not present quality fish habitat. For this reason, this drainage is not likely fish habitat.

## Environmental Opportunities

Preserving or rehabilitating key ecosystem components, including Thistle and Daisy Creeks and their associated riparian areas, the pool/ wetland system, and large veteran trees will protect wildlife values and mitigate development impacts. The primary method of preservation is to establish undisturbed buffers/setbacks to preserve the riparian habitat beside the creeks. These Streamside Protection and Enhancement Areas (SPEAs) were determined for the various drainages within the development area using the Riparian Area Regulation (RAR) detailed methodology. The following are the setbacks determined by the site surveys conducted by Cascade Environmental, and which are used to delineate protective boundaries around the streams.

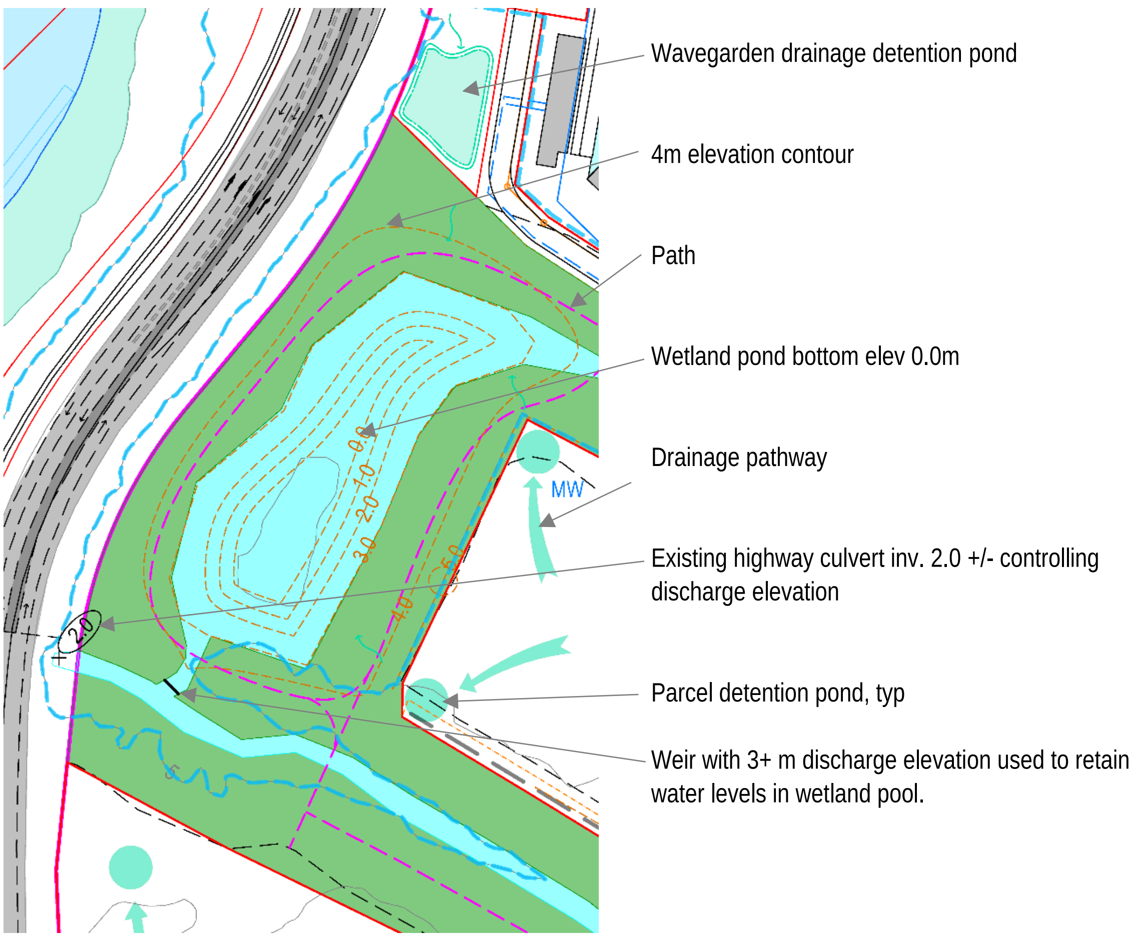
*Table 3: SPEA setbacks on creeks*

| Creek | Minimum setbacks from creek bank from CERG survey, m |
|---|---|
| Gravel | 13 |
| Thistle | 15 |
| Daisy | 15 |
| Minaty | 10 |
| Gravel Creek Wetlands | 15 |

The drawing labelled *Site Plan, Existing* illustrates the location and areas of water features (stream and pool) and other environmentally sensitive areas such as wetlands and riparian boundaries, that were flagged by Cascade Environmental and subsequently surveyed by Bunbury Land Surveying. The total existing area of aquatic plus sensitive habitat within the proposed Development Areas is 98,418 m2.

The drawing labelled *Site Plan, Final* and *Interim & Final Streams & Riparian* illustrates the location of proposed aquatic habitat and environmentally sensitive areas that are a combination of existing habitat and creation of new areas to compensate for the removal of existing areas. <u>The reconstruction will, in all cases, provide a higher quality environment than the existing environment.</u> The total future area is 100,399 m2 or 102% of the existing. The distribution of land area between the various types of habitat (aquatic and riparian) will be refined during the next phase of design. The proposed wetland area provides a large 3 m deep pool with a bottom elevation of 0m with a broad marginal riparian area. The pool elevation is retained by a weir during the wetter season. Unfortunately, due to the ephemeral nature of both Gravel and Thistle Creeks, the pool water level will gradually be reduced during the dry season to the elevation of the seasonal low water table.

*Figure 1: Proposed Gravel Ck wetland pool (conceptual)*



The retention and/or enhancement of the aquatic habitat and associated riparian habitat will also ensure the continued presence on site of the confirmed coastal tailed frog, and the likely presence of the northern red-legged frog and western toad (all species of special concern).

The Wildlife Act requires the protection of nesting birds. This will include the following:

- Vegetation clearing will be conducted outside the typical bird breeding window of April 1 to July 31, OR
- A songbird nest survey will be conducted by a qualified professional to identify and establish buffers around any active nests until the young have fledged.

These measures will also protect the Olive-Sided Flycatcher (threatened) and the Band-Tailed Pigeon (special concern) should they occur on site. The Great Blue Heron (special concern) is known to visit the site, and will continue to do so, providing the aquatic and riparian habitat is maintained or enhanced.

## Environmental Permitting

As proposed, there are no identified Canadian Environmental Assessment Act (CEAA) triggers associated with the project, and therefore, a CEAA review/application is not required

The British Columbia Environmental Assessment Act (BCEAA) will not be triggered by the project as the maximum proposed groundwater extraction rate 75 l/s which does not exceed the legislated trigger of 75 l/s.

The project will have to conform to various federal and provincial environmental legislation with specific applications submitted under the Fisheries Act and Water Act for any works in and about creeks and watercourses, and an application under the Wildlife Act for salvage and inventory permits.

The development proposes to occupy some of the poor quality Streamside Protection and Enhancement Area (SPEA) in the old gravel pit and replace it with expanded SPEA plus an extensive enhanced wetland and pool complex.  A SPEA compensation rate of 100% is a necessary condition of approval.  However there is no fixed formula and Fisheries and Oceans Canada can require upgrading greater than 100% at their discretion. The proposed SPEA exceeds the minimum Design Setback distance noted in Table 2 in all cases and the proposed enhanced SPEA + stream + pool area is 102% of the existing lower quality SPEA + stream + pool area.

The Gravel Creek channel in the steep upland area is unstable and the lowland area of the channel has no riparian value (it is bare gravel pit). Therefore, construction of a stable channel with an enhanced SPEA should be approvable as it is a major enhancement to the existing condition.

The response of the review agencies to the reconfiguration and enhancement of the wetland and streams is uncertain, suggesting that early consultation would be valuable.

The agencies generally do not respond to a request for comment early in the planning process as they expect the submission of a formal application at Development Permit (DP) stage based on a specific plan. It is important to remove the uncertainty earlier than DP, therefore it might be necessary to submit an application based on planning that is pre-DP and then repeat the process at DP for each development parcel once the purchaser of the parcel has developed their plan for their parcel. It will be important that agencies accept the mitigation and compensation plans for the entire project in concept and not only for each development parcel.

The drawing *Interi & Final Stream/Riparian* illustrates the riparian loss and compensation areas. Much of the compensation area is in the form of width added to the existing riparian borders. The proposed constructed wetland pool and its surrounding habitat will be constructed to provide a richer habitat than presently exists.

Gravel Ck and the wetland pool reconstruction are included in the first interim phase of the development. Therefore, Tiger Bay should retain the environmental consultant (CERG) to prepare a prescription for the creek and wetland reconstruction and initiate environmental agency consultations early in the Phase 1 planning process.

## Summary

The site contains a single biogeoclimatic subzone: Coastal Western Hemlock Dry Maritime subzone (CWHdm). This subzone is characterized by warm, relatively dry summers and moist, mild winters with little snowfall. The environmental assessment indicates that the site has mainly been influenced by gravel extraction, logging and electrical transmission lines

Wildlife and wildlife signs were observed and habitats could potentially exist on the site, based on habitat conditions. Ten bird, four mammal, three amphibian and three invertebrate species are identified by the BC Conservation endangered listed species that occur in the CWHdm biogeoclimatic zone within the SLRD. Two blue-listed species are confirmed to occur on the Britannia South site and four blue-listed species possibly occur on the site. Red-listed species are unlikely to be found on site.

The proposed development site includes four streams and a wetland area.

The **natural wetland** area will be highly disturbed and compensated by construction of a higher quality deep pool and wetland area.

**Gravel Ck** currently flows along an unstable alignment down the steep slopes of the gravel pit, through barren gravel pit with no natural riparian border, through the poor quality natural wetland and discharges to Thistle Ck near the highway culvert outlet. Gravel Ck will be provided with a stable armoured alignment down the steep slope and an enhanced riparian border.

**Thistle Ck** occupies a stable alignment to the gravel pit floor and then follows a stable alignment to its outlet through the highway culvert. The creek was highly disturbed by the gravel pit operations but has reestablished a natural though poor quality riparian vegetated border. Thistle Ck will remain undisturbed and the riparian border will be widened and enhanced by appropriate plantings.

**Daisy Ck** will require armouring along its upper reach downstream of the highway culvert crossing. The disturbed areas will be reinstated and the riparian border will be expanded and enhanced. The creek downstream of this disturbed area will remain untouched and will be provided with a widened riparian border.

**Minaty Ck** will remain undisturbed and will be provided with an extended riparian border.

Recommended work includes:

- Retain CERG to update their 2012 report and provide a preliminary prescription for relocation of the wetland and upgrading the SPEA bordering the creeks.

- Retain CERG to initiate consultations with environmental agencies as soon as possible to confirm that the proposed project mitigation measures are acceptable.

## Section References

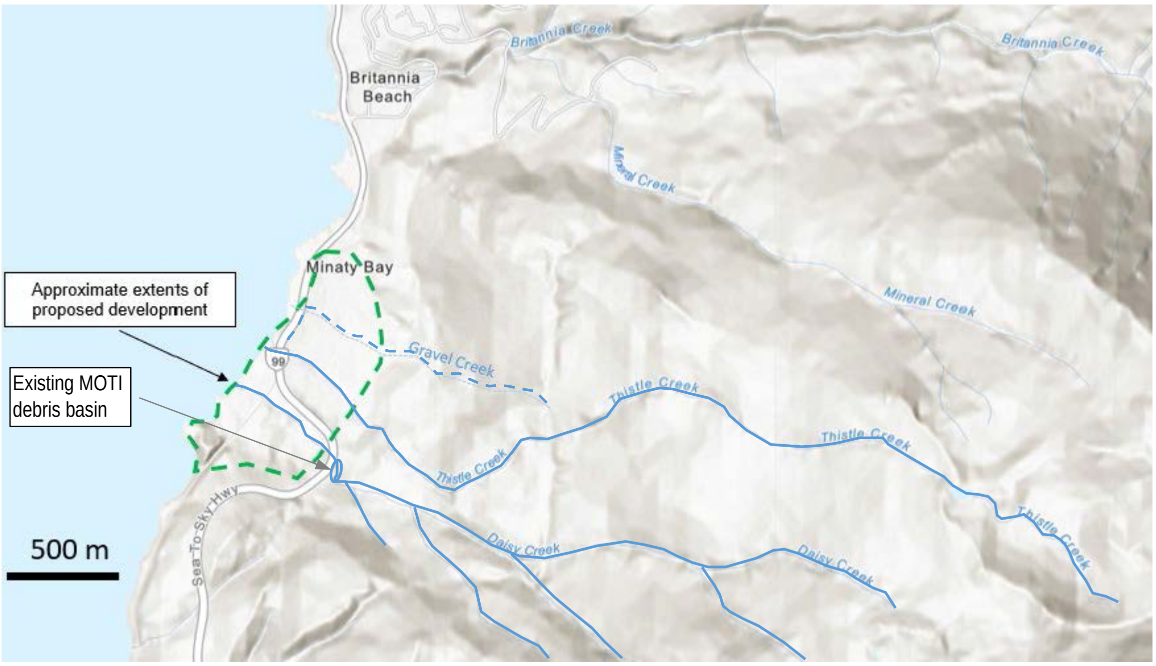
1) South Britannia Beach, British Columbia, Initial Environmental Review – Revision 1, Cascade Environmental Resource Group Ltd., File # 454-01-06, July 28. 2014.

## STREAM FLOOD AND DEBRIS HAZARD

This section discusses water only flood flows, or water plus debris flood flows, in streams. The requirement for environmental protection zones around streams is discussed in the preceeding chapter.

The development area is traversed by four watercourses that vary in flood and hazard potential. The locations of Gravel Ck, Thistle Ck and Daisy Ck are illustrated on the following figure provided by BGC Engineering Ltd. The fourth unnamed stream that we refer to it as Minaty Ck. is small and passes through the southern portion of Development Area B. Its location is illustrated on the drawing entitled *Site Plan, Existing.*

*Figure 2: Stream Locations (from BGC Engineering Inc. proposal to Tiger Bay Development Corporation, 2020)*




### Hazard and Risk Framework

A flood is a condition in which a watercourse or body of water overtops its confines and covers land not normally underwater. When a flood causes harm, it becomes a hazardous flood. The following flood-related hazards apply to the proposed development:

- Conventional floods caused by higher than normal water levels
- Debris flow
- Channel avulsion (stream changes its course)
- Bank erosion

The term "flood hazard" refers to the probability (likelihood, frequency) of a hazardous flood occurring but also refers to a physical condition (eg high water flood). The term "flood risk" combines the probability of a hazardous flood occurring and the potential consequences to elements at risk. Flood management refers to mitigation to reduce the effects of a hazardous flood, either by changing the probability or by changing the consequences. The term “flood assessment” can include flood hazard assessment, flood risk assessment or flood risk mitigation assessment. [1]

The legislative environment in BC gives local and regional governments the authority to implement bylaws and other measures for natural hazard mitigation, with due consideration of any applicable provincial guidelines or standards. However, while some local government and Regional Districts have adopted bylaws with simple setback and elevation requirements, very few have adopted advanced bylaws to address steep mountain creeks, debris flow hazards, and Flood Risk considerations. This development proposal presents a “target-rich environment” to flood hazards, and as such, it is important to deal explicitly with both the hazard and risk.

This planning report provides a preliminary assessment of flood and debris flow hazards and identifies the potential locations of avulsion and stream bank erosion hazards. This report also identifies possible structural mitigation measures (debris basins, training berms, stream bed armouring, land raising, structure raising) <u>with the intent of demonstrating that mitigation is both possible and practical</u>. The detailed design of the structural mitigation and the residual risk after mitigation will be defined by the proponent by further study once the approving authority has provided an indication that they are willing to entertain this development proposal.

Both hazard and risk are described as a physical condition with an associated probability or frequency of occurrence. Hazard and risk are, however, not the same. A flood can have a hazard frequency of occurrence of 1:200 years but if substantially mitigated the risk can be very much lower depending on the nature of the consequence. For example, the risk of property damage can be high (equal to the hazard frequency), the risk of property loss can be moderate and the risk of life loss can be very low.

The following components of risk are worth noting:

> **Risk**: Risk is a measure of the probability and severity of an adverse effect to life, health, property, or the environment. Risk is often estimated by the product of probability and consequence. A more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.
>
> **Tolerable Risk**: A risk that society is willing to live with to secure certain benefits in the confidence that the risk is being adequately controlled, kept under review, and further reduced as and when possible.
>
> **Vulnerability**: The degree of loss to a given element(s) within the area affected by the flood hazard. Vulnerability is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons it will be the probability that a particular life will be lost given that the person is subject to the flood, debris flood or debris flow.

[1] Pharaphrased from *Legislated Flood Assessments in a Changing Climate in BC*, version 2.1, Professional Practice Guidelines, Engineers & Geoscientists British Columbia, August 28, 2018.

A widely accepted standard for flood risk is mitigation of the 1:200 year flood hazard. Debris flow hazards should be subject to greater than a 200-year design return period with at least a 500-year and preferably a 2,500-year return period being discussed by the *Legislated Flood Assessments…* noted in footnote 1 previous. Attempting a hazard assessment for a return period greater than 1:500 years is difficult and fraught with inaccuracy and the practical limit might be 1:2,500 where any assessment beyond is likely to be meaningless.

The appropriate level of risk (as opposed to hazard) must be determined by society. Recent studies for debris flow on the Chekamus River and for slope failures in North Vancouver suggest hazard mitigation to reduce the risk of loss of life to a return period of 1:10,000 years or a probability of occurrence in any one year of 0.0001. The approving authority (MOTI) has noted in preliminary discussions that a similar standard might be applied to this project.

BC has not developed a formal flood risk tolerance criteria and professional practice standards have emerged that imply some level of risk tolerance. This level of risk tolerance is, however, open to discussion. Therefore, for this planning study, we will adopt the standards-based approach where standards exist (flood, avulsion and channel bed erosion) and suggest a risk-based approach where explicit standards do not exist. Our initial approach will consist of:

- structural mitigation for the 1:200 year stream flood, stream bank erosion and stream avulsion hazard, and
- structural mitigation for the 1:2,500 year debris flow hazard with a Quantitative Risk Assessment (QRA) after mitigation to be completed by further study to determine the risk. The QRA might lead to the requirement of further structural mitigation measures.

A QRA typically includes the following steps (from BGC Engineering proposal to Tiger Bay, 2020):

1. Identify priorities
2. Characterize hazards
3. Characterize elements at risk
4. Estimate level of risk
5. Evaluate society's risk tolerance
6. Develop risk reduction plan (design)
7. Implement risk reduction plan (construction)

## Water Flood

The provincial Flood Hazard Area Land Use Management Guidelines (2004) address official community planning, bylaws, development permits, subdivision approval and other issues in flood-prone areas. Under the guidelines, all streams in the development area are "smaller streams" or less. The following general recommendations are based on that document or specifically recommended by the writer for this site.

- **Crossings** – design the hydraulic capacity of existing and proposed new stream crossings to pass the design flood complete with sedimentation allowance and provision for fish passage.
- **Flood protection setbacks** – locate buildings a minimum of 15m from the active bank of "smaller streams".

- **Riparian Area Regulation (RAR) setbacks** – establish RAR (riparian) setbacks as determined by a detailed environmental survey.
- **Zoning setbacks** – the SLRD requires "principal" and "accessory" building setbacks of 25m and 15m, respectively, which is a more stringent requirement than the Guidelines. The attached drawing entitled *Easement, Right of Way & Setback Plan*, illustrates the proposed final configuration of the streams, riparian areas, training berms and the SLRD zoning setbacks. It might be appropriate to seek a relaxation of this 25m principal building setback requirement given that the streams will be contained within floodways and armoured training berms where overtopping or avulsion might occur, rendering the setback unnecessary. Therefore, the need for the principal building setback shown on the drawings is subject to further review.
- **Flood Construction Level (FCL)** – the FCL is determined by adding the design flood elevation + sedimentation allowance + freeboard (usually 0.6m) of streams that can impact the site and is the required elevation of the underside of a wooden building floor system or the top of slab of a concrete building slab for habitable buildings. KWL's preliminary analysis indicates that the depth of flow can vary from 0.5m to 1.4m depending on the stream and the location. To this must be added sediment allowance and freeboard to arrive at the FCL due to streams. Detailed site grading and channel designs are required to establish the FCL and design response, which can include: raised site, raised building or set-back dyking of streams. These elevations will be established during the next stage of the design process.
- **Streamside easements** – The development plan includes 5m wide stream-side easements outside of riparian areas that are used to contain low-level flood /erosion protection earthworks where needed and to provide access for maintenance of these dykes or other channel maintenance. The zoning setback already restricts accessory building construction to a distance of 15m from the creek bank. Zoning will prohibit all hard construction (pavements, walls, buildings, etc) within this easement.
- **Trail allowances** – 2m trail allowances are added to each side of the stream riparian set-back to compensate for 2m wide pedestrian paths (wider, hard-surfaced) and trails (narrower, soft-surfaced) that are routed along one side of the riparian areas.

There are no historical flow records for these creeks; therefore, KWL (2012) undertook a regional flood analysis summarized in the following table:

*Table 4: Creek flow summary*

| Creek | Drainage Area, km2 | Mean Annual Flood, m3/s | 200-year Instantaneous Peak Flow, m3/s |
|---|---|---|---|
| Gravel | 1.0 | 1.3 | 9.2 |
| Thistle | 2.1 | 2.5 | 17.0 |
| Daisy | 3.3 | 3.7 | 25.0 |
| Minaty | 0.2 | 0.4 | 2.5 |

From Reference 2

In small drainage basins (<50 km2) such as those on the subject site, the most severe flood events might be generated by rainfall events from convection cells incorporated into squall lines on cold fronts, especially if these occur on snow pack. Just such an event appeared to occur in January 2016 when a “flash flood” caused a minor debris flow on Daisy Ck. with a resultant clear water overflow, from the discharge channel, that flowed down Highway 99. This same event caused a “blow out” of the Gravel Creek channel with a significant flow down the steep embankment onto the development area. This evidence supports the need for a second and more detailed assessment of stream flows to identify possible outlier events.

## Debris Flow

Debris flows are a common hazard on steep mountain streams caused by entrainment of sediment, rocks and woody debris in flood flows. The resulting fluidized flow mobilizes accumulated stream-bed material and transports a potentially significant volume of material before it settles out on an area of reduced gradient.

Debris flows in the subject streams can be triggered by intense rainfall or snowmelt, or by landsliding that may or may not be associated with intense rain or earthquakes. In all cases the chief conditions required for debris flow initiation include the presence of slopes steeper than about 25 degrees, the availability of abundant loose sediment, soil, or weathered rock, and sufficient water to bring this loose material to a state of almost complete saturation (with all the pore space filled). Debris flows can be more frequent following forest fires. Debris flows are accelerated downhill by gravity and tend to follow steep mountain channels that discharge onto alluvial fans. The front, or 'head' of a debris-flow surge often contains an abundance of coarse material such as boulders and logs that impart a great deal of friction. Trailing behind the high-friction flow head is a lower-friction, mostly liquefied flow body that contains a higher percentage of smaller sediments. These fine sediments help retain high pore-fluid pressures that enhance debris-flow mobility. In some cases the flow body is followed by a more watery tail that transitions into a hyperconcentrated stream flow. Debris flows tend to move in a series of pulses, or discrete surges, wherein each pulse or surge has a distinctive head, body and tail.

Debris flows are typically controlled by intercepting the flow in a basin with an outlet structure that sieves out the larger entrained debris while allowing passage of smaller sediment and water. This can be accomplished with dams with sieved outlets or more recently by debris nets that use wire rope or cable rings to form a water porous flexible barrier that sieves out and retains large gravel, rock and woody debris. The net systems are designed for both static loads and also to absorb dynamic impact loading using deformable brake elements.

The design of the debris flow mitigation works must include a definition of long-term roles and responsibilities for operations and maintenance of the structures. The responsible parties would initially include the Ministry of Transportation and Infrastructure (MoTI) and the Squamish Lillooet Regional District (SLRD). Local government (municipal) would also be involved, if and when it is established.

## Creek Hazard Mitigation

The following sections discuss the possible hazard mitigation for each creek.

### Gravel Creek

Gravel Creek, a tributary of Thistle Creek, was diverted during gravel mining operations into local road ditches and overland across the gravel pit floor, feeding a seasonal wetland that developed naturally in a depressed area of the gravel pit floor. The creek channel is indistinct within the BC Hydro R/W east of the development area, and it appears to be fed by a combination of flow in access road ditches, small streams and groundwater discharge from steeper soil banks. Overflow from the wetlands joins Thistle Creek and is conveyed across Hwy 99 through a concrete box culvert. The creek within the development area is totally disturbed and will be re-routed, with restored riparian border to a more natural location that will also assist neighbourhood definition. The steep portion of the creek will be contained by armoured setback dykes and streambed armouring to control erosion.

The existing Riparian Area Regulation (RAR) (or just “riparian”) setback is 13m.  Use a minimum 15m setback, which includes a trail compensation allowance of 2m.

Thurber Engineering carried out a debris flow hazard study in 1997 and recognized a potential for Gravel Creek to form a debris flow or flood. Their updated 2016 debris flow study identified a small hazard potential described as:

> Debris flow yield rates within Gravel Creek will be limited to point releases from blocked culverts and, if sufficiently large and mobile, woody debris may be entrained resulting in yield rates of between 1 m3/m of stream length to 3 m3/m of stream length.

*Table 3 – Estimated Debris Flow Magnitudes for Gravel Creek (Thurber 2016)*

| Return Period (years) | Debris Flow Volume (m3)* |
|---|---|
| 200 | 700 |
| 500 | 1100 |
| 1000 | 1600 |
| 2500 | 2400 |

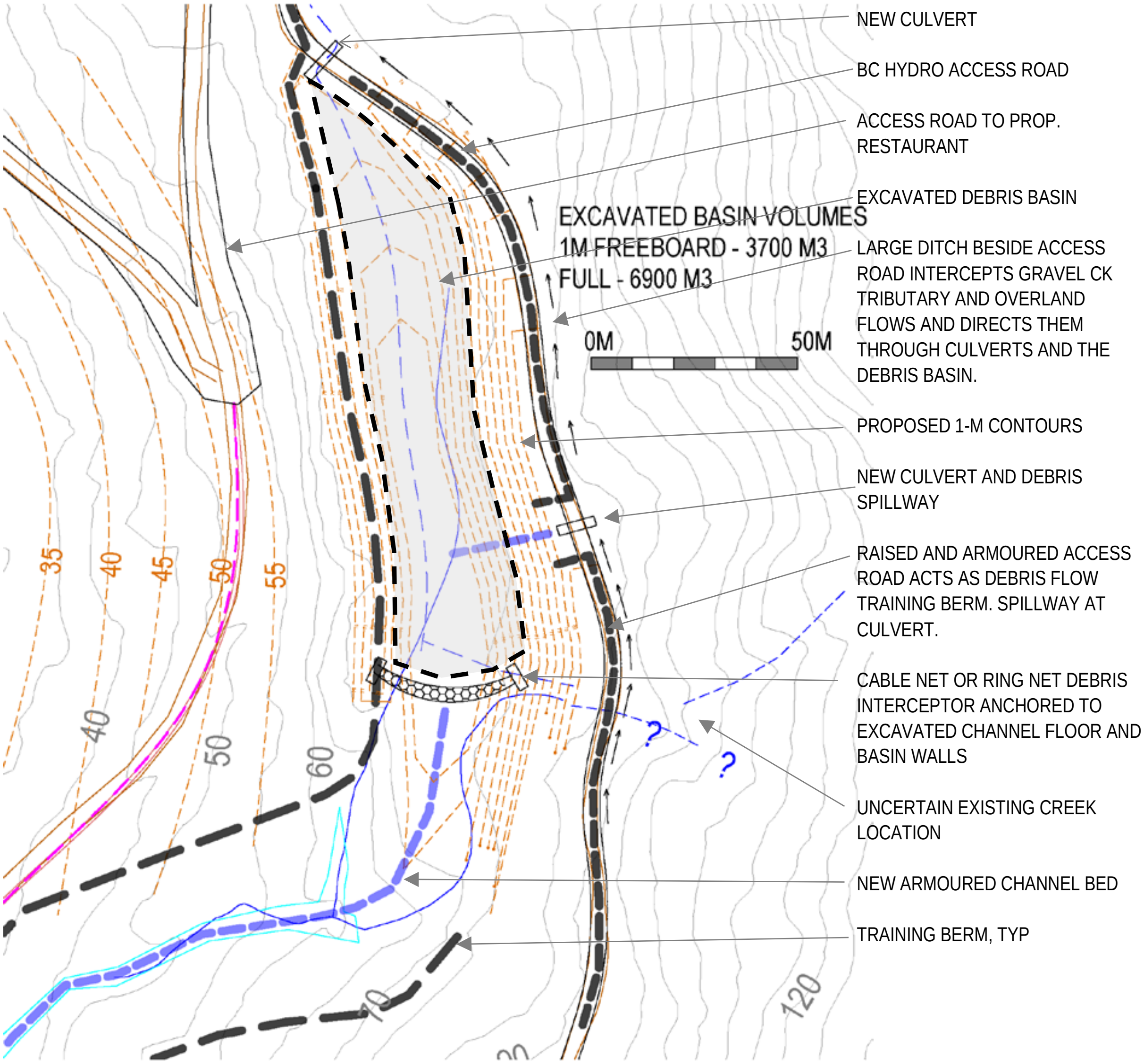
* estimated debris flow volumes are +/- 500 m3

The following figure illustrates a conceptual design of a debris basin on Gravel Creek. The basin must have a minimum storage volume of (2400 m3 estimate plus 500m3 estimate variance = ) 2,900 m3. A basin can be located on a small bench area immediately upstream of the steep slope that leads to the development area at elevation 70m. A preliminary design at this location yields a basin with a storage capacity of 3,700 m3 with 1-metre of freeboard or 6,900 m3 full. The debris flow can be retained by a rock fill dam with flow relief culverts where the void space between the rock can also drain water from the basin. Alternatively, the basin can use the more modern alternative of a debris net embedded into the discharge channel floor and walls. The following figure illustrates the conceptual design that appears on the drawing *Site Plan,Final*.

Recommended actions for Gravel Creek, based on current information:

- Retain a specialist consultant (BGE Consultants have been retained) to update the Thurber 2016 report, update the hazard assessment, provide detailed mitigation recommendations with risk assessment.
- Conduct geotechnical assessment to identify if the debris basin will saturate the ground and increase risk of slope failure.
- Construct a debris basin on the first bench upstream of the gravel pit floor with a storage volume of 3000 m3 or as determined by the updated study.

*Figure 3: Gravel Ck debris basin conceptual design*




- Relocate the existing poor quality aquatic, wetland and riparian habitat along the lower reaches in the gravel pit, to a location that better suits the development layout. Excavate a new wetland pool to 0m elevation and construct the pool and wetland bases using lower permeability soils to retain water and enable the establishment of a richer wetland environment.
- Construct a minimum 15m wide artificial riparian zone bordering the stream, pools and wetlands together with a 2m pedestrian path in the flat area and trail in the steep area. The riparian zone is in many cases wider than the minimum.
- Reconstruct and redirect the creek bed into the debris basin to capture the debris flows. This can be done by building an interception channel on the uphill side of the BC Hydro access road. The channel collects and directs clear water flows through two culverts and into the basin. Raise and

armour the access road to act as a training berm with two debris spillways at constructed low points.

- Design a stable alignment for the creek bed down the steep slope to the gravel pit floor. Line the relocated creek channel, down the steep slope, with graded angular blasted rock erosion protection to protect against channel avulsion and erosion. Used armoured training berms to protect against stream avulsion.

### Thistle Creek

Thistle Creek drains the mountainous slopes above the development site, flowing over a steep falls in a bedrock gorge before moving through the lower fan and into Howe Sound. Upstream of the BC Hydro R/W, the creek crosses a bedrock bench that is covered by glacial drift. The creek channel is poorly confined on the bench, and there are several points where avulsion could occur. Upstream of the bench, the creek traverses further bedrock benches, separated by bedrock controlled steps. A large bench at around elevation 300 m forms a gravel filled flat area that is also the location of a 5m high concrete gravity dam that is founded on bedrock and is completely backfilled by gravel. The creek channel branches above this point and becomes narrow.

The upper reach of Thistle Creek, between the gravel pit and the falls, occupies an incised channel that can contain flood flows. The lower reach of the creek has been substantially disturbed and rerouted by gravel mining but has since re-naturalized. The creek is well confined by natural banks and man-made berms that are well vegetated but might require protection against erosion. The creek flows through a concrete box culvert under Hwy 99 to ocean discharge and preliminary calculations by KWL indicate that the culvert has sufficient capacity to convey the flood flow. The performance of the culvert under maximum ocean flood conditions was not reviewed and might result in inadequate conveyance capacity due to backwater effects.

The RAR setback is 15 m. An additional 2m path compensation allowance will result in a minimum design setback of 17m.

Thurber Engineering carried out a debris flow potential study in 1997 and recognized a small potential for Thistle Creek to form a debris flow or flood. Debris generated in the upper watershed would mostly deposit on the bench at elevation 330m. A small amount of debris could be generated below this level, but this would deposit on the bench upstream of the BC Hydro R/W, where it could divert the channel. Only normal bedload sediment is considered capable of reaching the lower fan. The 1997 Thurber study recommendes construction of a 2,000 m3 sediment basin immediately upstream of the highway culvert to protect the culvert from blocking. This has not been done, but instead, a larger culvert was installed to presumably pass the sediment.

Thurber Engineering noted in their 2016 report that they have advised the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) of the location of the 5m dam. The MFLNRO is in the process of decommissioning the numerous dams within the operating limits of the old Britannia mine and they reported to Thurber that they will likely decommission the 5m Thistle Creek dam in the near future.

Thurber 2016 estimated the following debris flow volumes for Thistle Creek:

*Table 5: Estimated debris flow magnitudes for Thistle Creek (Thurber 2016)*

| Return period, years | Debris flow volume, m3 * |
|---|---|
| 200 | 500 |
| 500 | 900 |
| 1,000 | 1,300 |
| 2,500 | 2,000 |

* estimated debris flow volumes are +/- 500 m3

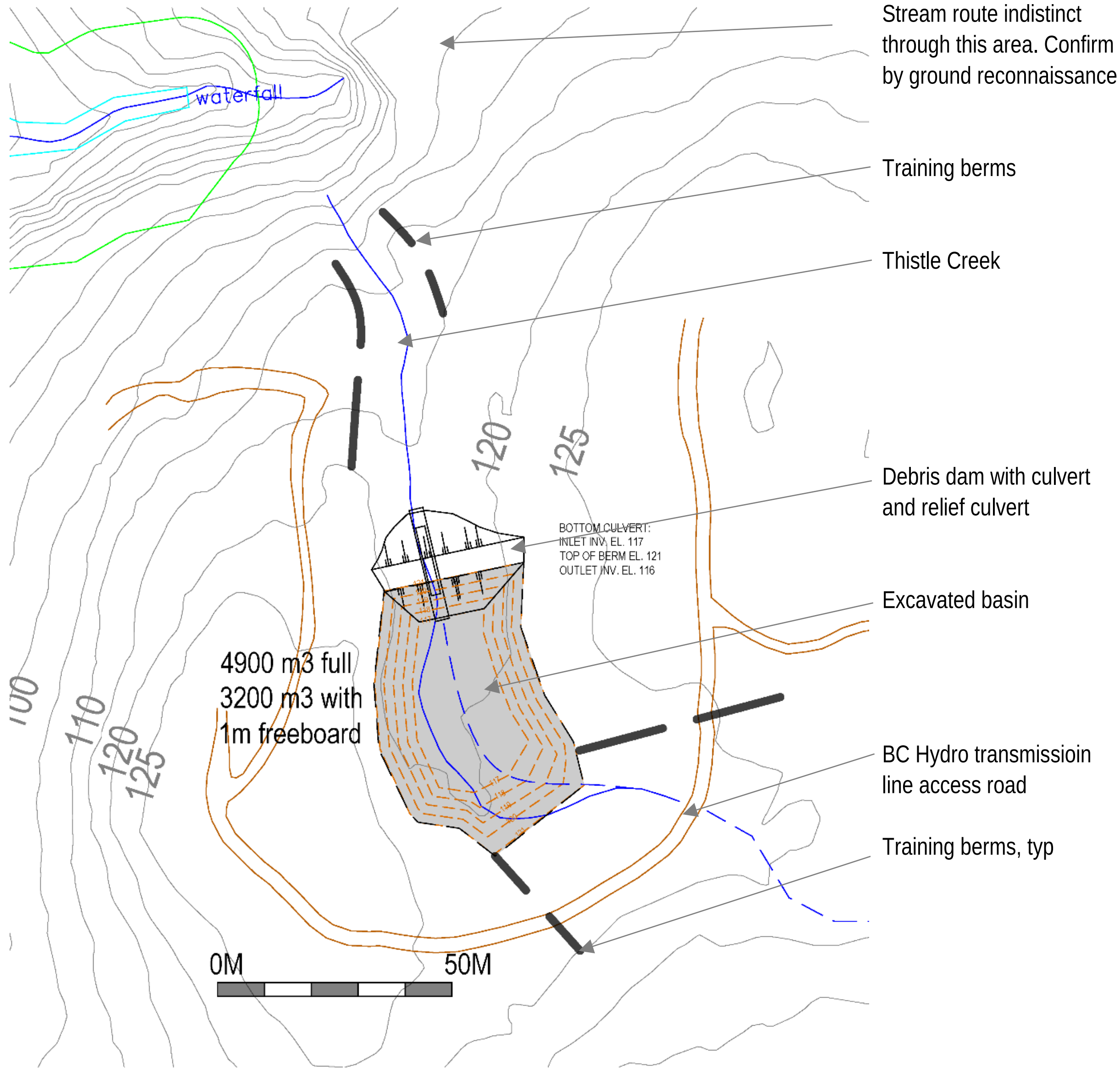
Recommended mitigation measures for Thistle Creek, based on current information:

1. Construct a debris catchment basin with a storage volume of (2000 m3 estimate plus 500m3 estimate variance = ) 2,500 m3 located on a small bench area immediately upstream of the falls at elevation 120m. A preliminary design at this location indicates a basin with a storage capacity of 3,200 m3 with 1-metre of freeboard or 4,900 m3 full. The basin volume can be expanded if necessary. The basin can use a porous rock dam with flow relief culverts where the porous rock can drain water from the basin. Alternatively, the basin can use the more modern alternative of a debris net embedded into the discharge channel floor and walls.

- Confirm removal of the 5m dam by MFLNRO.
- Block natural avulsion points and old constructed diversion points upstream of the BC Hydro R/W, using erosion-resistant earthworks. Refer to Thurber 2016 and carry out new site reconnaissance to confirm the potential avulsion points.
- Confirm that the Thistle Ck culvert under Hwy 99 has sufficient capacity to pass the combined flow from Thistle and Gravel Creeds while backwatered during high ocean levels (current and future due to sea-level rise). If capacity is lacking, request MoTI to upgrade (likely twin) the culvert.
- Carry out flood flow modelling to confirm channel capacity and requirements for flood & erosion protection.
- Maintain a minimum 17m environmental setback, that includes a 2m path or trail allowance within the RAR boundary.

The following figure illustrates a preliminary debris basin concept using a dam, bottom culvert and higher relief culvert instead of a cable net. A spillway (not shown) over the dam crest provides a “safe fail” route for clear water overflows in the event of culvert plugging. This design concept is intended to illustrate that it is both possible and practical to provide the required debris basin storage recommended by Thurber, and it is not intended to be a recommended configuration.

*Figure 4: Thistle Creek debris basin*



### Daisy Creek

Daisy Creek has the largest catchment of the four streams. The creek received extensive study during the pre-Olympic Hwy 99 upgrading studies and is identified as having a debris flow risk.

Thurber Engineering carried out numerous studies of Daisy Creek for MoTI and for the proposed development. The two most relevant reports, cited in the Reference section, were completed in 2012 and 2016.

The creek is confined in a deep bedrock gorge lined with talus aprons from just above Hwy 99 up to El.400, well above the property boundary. The steep slope of the channel, along with coarse debris accumulations in the channel, suggests that the creek bed is susceptible to sediment movement. Large trees grow undamaged on the margins of the channel, suggesting that large debris flow discharges are infrequent.

A partially breached 1.2m high dam is located at about 280m elevation. One side of the dam contains a small amount of sediment and Thurber (2016) reported the location of the dam to the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), who advised that they had no plans for removal.

Thurber noted two potential avulsion points on the lower section of Daisy Creek at distances of about 300 m and 350 m upstream of the debris basin inlet. The debris flow runout modelling confirms the potential for avulsion at these points, and Thurber recommends that these be blocked by erosion-resistant earthworks. A recent study conducted by BGC Engineering (personal communication with Lauren Hutchinson and Matthias Jakob, May 2020) for the SLRD indicates that debris runout from these avulsion points might travel overland across most of the extent of the gravel pit floor. This suggests that the proposed first phase of development of the Wavegarden (discussed later in this report) in the area north of Daisy Creek must include mitigation of this possibility.

The Thurber (2016) debris flow study indicated the following debris flow volumes.

*Table 6: Estimated debris flow magnitudes for Daisy Creek*

| Return Period (years) | Debris Flow Volume (m3) (1) |
|---|---|
| 200 | 8,000 |
| 500 | 13,000 |
| 1000 | 18,000 |
| 2500 | 23,000 |

(1) Estimated debris flow volumes are +/- 2,000 m3

A debris catchment basin was built by MoTI in 2007, immediately upstream of Hwy 99, which has a debris storage volume of 25,000 m3. This basin was designed to protect the highway, but it also protects the Britannia South development for an event up to the 1:2,500 year event. A larger event will overtop the existing debris basin and flow over the highway and down the highway into the downstream properties.

The existing basin provides a high level of protection in terms of volume storage for the sediment component of the debris flow. However, the dynamic fluid behaviour of the debris flow might cause overtopping of the basin with a resultant hazard to the proposed development. Thurber Engineering

(2016) further evaluated the effectiveness of the existing basin, by using a numeric model that simulates the flow of water entrained sediment and debris, to assess runout behaviour of a debris flow. The results indicate that the existing basin is generally effective at mitigating the debris flow hazard. However, there are conditions (variations in the nature of the debris flow, very high volumes and/or improper basin maintenance and cleanout) in which the basin can be overtopped, leading to:

- overflow onto the flat area north of the basin and east of the highway,
- travel northbound along the highway,
- flow down the highway embankment northward toward Thistle Creek, and
- flow down the highway embankment southward toward Daisy Creek

The highway debris basin provides a high degree of protection against the effects of a debris flow. However, due to the high variability of debris flow behaviour, Thurber recommends construction of secondary elements as a fall-back to the primary basin, including a secondary overflow basin and discharge channel, erosion-resistant dyke downstream of the basin, no development between the highway and Daisy Creek, raising of adjacent buildings, and design of the major drainage system to bypass overflows.

A proposed alternative response is illustrated on *Site Plan, Final*. This consists of a training berm to deflect and retain overflows on Highway 99 between the existing and extended Jersey barriers, where they would be conducted downhill to discharge in Howe Sound. A secondary measure includes using the development parcel located downstream of this overflow for a sports field and associated facilities, rather than housing, thus reducing risk of loss of life. The implications of this approach require further consideration.

Daisy Creek downstream of Hwy 99 has been heavily altered in the past by channelizing the creek to protect the historical mining community that lived in this area. The channel upstream of the highway underpass/tunnel is poorly confined and potentially subject to overflow and will require flood protection works. Recent extensive sediment deposits were noted in the creek channel, between the tunnel bridge and the highway culvert, likely caused by an unusual localized storm event at the end of January 2016 that also caused creek overflows onto Highway 99. The channel downstream of the highway underpass/tunnel is trained between high constructed berms and appears to be stable with sufficient capacity to contain flood flows.

The creek flows under a bridge near the highway underpass, a bridge under the railway and then exits to the ocean through a concrete box culvert. The bridge at the underpass will require replacement to suit development. The railway bridge has inadequate capacity due to sedimentation that might be mitigated by excavation or alternatively by replacement with a wider bridge (a higher bridge is unlikely to be acceptable as this would require regrading of the track). The undersized culvert at the foreshore no longer serves a useful purpose and should be removed to enhance fish passage.

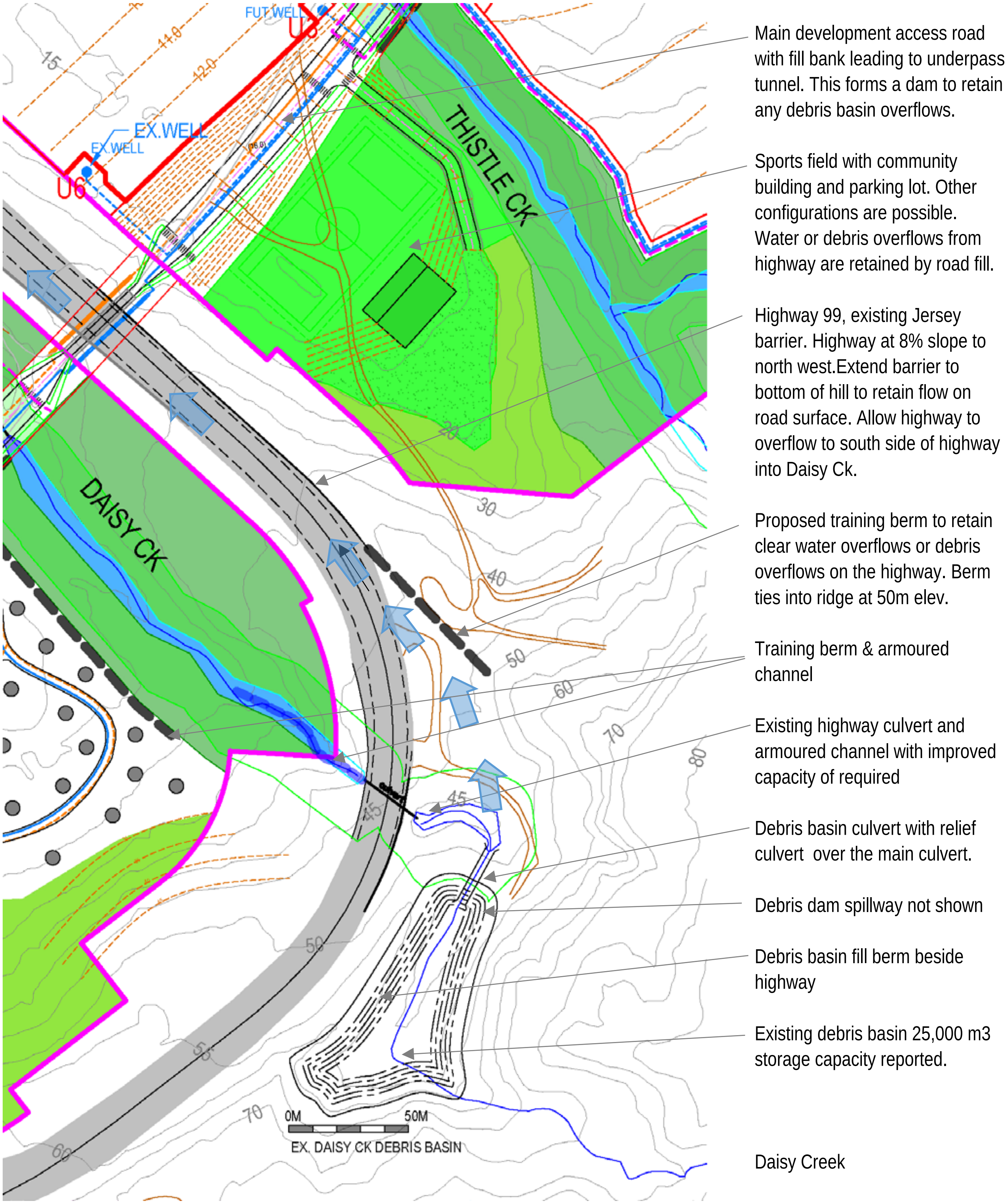
The existing RAR setback is 15 m. A 2m trail compensation allowance will result in a minimum design setback of 17m.

Recommendations for Daisy Creek:

- Confirm the status of the 1.2m high dam with MFLNRO and plan removal if necessary.
- Block the upstream avulsion points using erosion-resistant earthworks. Complete debris flow

- Block the downstream overflow points using erosion-resistant earthworks.
- Clear accumulated sediment from the existing debris basin and replace the ineffective wire mesh sediment barrier on the inlet of the main culvert with a more effective barrier.
- Consider increasing the capacity of the existing debris basin using a debris net extended around the top perimeter of the basin berms.
- Build a training berm downstream of the debris basin extending from the small natural ridge to the highway Jersey barriers to deflect overflows back onto the highway where the overflow would continue to flow to the bottom of the hill.
- Locate the proposed sports field and community building to the development parcel immediately downstream of the existing debris basin to act as a secondary containment basin to intercept any overtopping flows. The raised roadbed of the main site road, as it rises to the underpass/tunnel, will function as a containment berm to trap sediment and deflect clear water to Thistle Creek. Model these clear water overflows to determine hazard and risk to the development.
- Avoid development between the highway and Daisy Creek.
- Block potential bank overflow areas on the south bank of Daisy Creek between the Highway and the tunnel bridge. Provide access points for clearing sediment from the stream bed.

*Figure 5: Daisy Creek debris basin*



- Raise potentially affected buildings on concrete foundations 1.2m higher than the surrounding ground level, or alternatively raise buildings on earth mounds 1.2m higher than surrounding ground level. The only buildings contemplated for this area are cabins located south of Daisy Ck behind a proposed berm and revetment.
- Develop a long-term operations and maintenance plan for the works and determine sharing of responsibility between MoTI and SLRD and the role of future local government.

### Minaty Creek

Minaty Creek has a small catchment area draining the southern portion of the site in the Minaty Neighborhood. It has low flows and is well entrenched and requires no mitigation. The plan retains the existing creek alignment.

The existing RAR setback is 10 m. A 2m trail compensation allowance will result in a minimum design setback of 12m.

## Summary

Four streams traverse the development site. The smallest, Minaty Creek, has low flood and hazard potential and requires no mitigation. Gravel, Thistle and Daisy Creeks have flood and debris flow hazard potential requiring mitigation.

**Flood hazards** consist of flooding, channel avulsion and erosion. These can be mitigated by structural measures to the usual 1:200 year return period. These mitigations include conventional responses such as training berms, dykes, channel armouring, setbacks, land raising and building raising.

**Debris flows** are a common hazard on steep mountain streams caused by entrainment of sediment, rocks and woody debris in flood flows. The resulting fluidized flow mobilizes accumulated stream-bed material and transports a potentially significant volume of entrained material before it settles out on an area of reduced gradient.

The term "flood hazard" refers to the probability (likelihood, frequency) of a hazardous flood occurring but also refers to a physical condition (eg high water flood). The term "flood risk" combines the probability of a hazardous flood occurring and the potential consequences to elements at risk. Flood management refers to mitigation to reduce the effects of a hazardous flood, either by changing the probability or by changing the consequences. The term "flood assessment" can include flood hazard assessment, flood risk assessment or flood risk mitigation assessment. [2]

The legislative environment in BC gives local and regional governments the authority to implement bylaws and other measures for natural hazard mitigation, with due consideration of any applicable provincial guidelines or standards. However, while some local government and Regional Districts have adopted bylaws with simple setback and elevation requirements, very few have adopted advanced bylaws to address steep mountain creeks, debris flow hazards, and flood risk considerations.

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[2] Pharaphrased from *Legislated Flood Assessments in a Changing Climate in BC*, version 2.1, Professional Practice Guidelines, Engineers & Geoscientists British Columbia, August 28, 2018.

A widely accepted standard for flood risk is mitigation of the 1:200 year flood hazard. Debris flow hazards should be subject to greater than a 200-year design return period with at least a 500-year and preferably a 2,500-year return period being discussed by the *Legislated Flood Assessments*. Attempting a hazard assessment for a return period greater than 1:500 years is difficult and fraught with inaccuracy and the practical limit might be 1:2,500 where any assessment beyond is likely to be meaningless.

The appropriate level of *risk* (as opposed to hazard) must be determined by society. Recent studies for debris flow on the Chekamus River and for slope failures in North Vancouver suggest hazard mitigation to reduce the risk of loss of life to a return period of 1:10,000 years or a probability of occurrence in any one year of 0.0001. The approving authority (MOTI) has noted in preliminary discussions that a similar standard might be applied to this project.

This report provides preliminary recommendations for mitigation of debris flow hazard for Gravel, Thistle and Daisy Creeks that are illustrated on *Site Plan, Final*. The intent of these recommendations is to illustrate that the hazards are potentially "mitigatable" to a degree that will reduce the risk to the yet to be determined return period (probability). These mitigation measures are subject to further study by BGC Engineering Inc., who have been retained by the proponent. This work will be completed prior to adoption of the zoning bylaw for the site.

The following are next steps:

1. Retain BGC Engineering to develop a debris and flood hazard assessment with mitigation recommendations of Gravel Ck to allow initiation of design for the Phase 1 (interim) works.
2. Retain BGC Engineering to develop a debris and flood hazard assessment of Thistle and Daisy Creeks followed by a Quantitative Risk Assessment to assess mitigation strategies and risks.

## Section References


1) Village at Britannia Beach, Interim Geotechnical Assessment, Thurber Engineering Ltd., February 15, 1012
2) South Britannia Beach, Concept Flood and Foreshore Protection, File 2957.001-300, Technical Memorandum by Kerr Wood Leidal Associates Ltd., March 5, 2012
3) Engineering Servicing for South Britannia Beach, Project No. 2957.006-300, Kerr Wood Leidal Associates, November 2014
4) Britannia South Development, BC, Detailed Debris Flow Hazard Assessment and Preliminary Evaluation of Mitigation Options, Project No. 19-5356-1, Thurber Engineering Ltd., June 2016.
5) Flood Hazard Area Land Use Management Guidelines, Ministry of Water, Land and Air Protection, Province of British Columbia, May 2004, Amended by Ministry of Forests, Lands, Natural Resource Operations and Rural Development, January 1, 2018

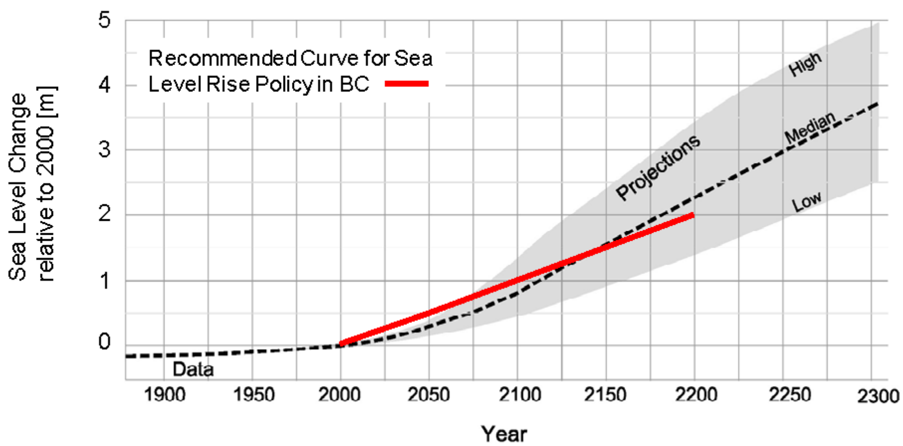
## COASTAL FLOOD HAZARD

Coastal flooding can encroach on the development lands by a combination of high tide, higher sea levels due to climate change, wind surge and wave runup on the beach fronting the site. Highway 99 is slightly raised in the reach fronting the development and will mostly protect the site from wave runup.

### Flood level estimate

The marine flood elevation presented in the 2012 KWL report was based on information provided in Ausenco Sandwell (2011) for the Squamish River Delta, incorporating estimated sea-level rise to the Year 2100 as illustrated in the following figure.

*Figure 6: Sea level rise estimate (from Ausenco Sandwell, 2011)*




The Squamish River Delta, located about 9 km to the north, is relatively near to the Tiger Bay Lands. The Year 2100 Flood Construction Level (FCL) is 5.6 m Canadian Geodetic Datum (CGD) as detailed below:

*Table 7: Year 2100 marine flood level estimate for Squamish River delta (from KWL and Ausenco Sandwell 2011)*

| Water Level Component | Description | Elevation or height (1)(2) |
|---|---|---|
| Tide | Higher High Water Large Tide Elevation: the average of the highest high waters, one from each of 19 years of predictions | 2.05 |
| Storm & wind surge | Estimated 1:500-year storm surge plus an allowance for local wind set. Return period based on consideration of extensive foreshore development in downtown Squamish, industrial development and high ecological value. A lower return period could be justified for Britannia due to the lower density of development, though the resulting reduction in water height is likely to be small. Therefore, we have adopted the values estimated for Squamish. | 1.30 |
| Sea level rise | An estimate of sea-level rise year 2100. (1) | 1.0 |
| Wave runup on beach | Allowance for wave run-up on the natural gravel-pebble beach, which is not representative of the development site but is used lacking better data and is likely to be conservative. Area A is set back from the shore and protected by the CN Rail line and the highway therefore wave runup can be omitted. Area C is exposed to waves and therefore wave runup must be used. | 0.65 |

| | | |
|---|---|---|
| Freeboard | Freeboard added as safety factor and for inaccuracy of estimate | 0.6 |
| Flood Level Area A | High tide + surge + sea level rise | 4.35 |
| Flood Level Area C | High tide + surge + sea level rise + wave runup | 5.0 |
| Flood Construction Level Area A | Flood level Area A + freeboard | 4.95 |
| Flood Construction Level Area C | Flood level Area C + freeboard | 5.6 |

(1) Subject to change by regulation and further studies
(2) Elevations in m to geodetic datum

In practice, the joint probability of a high tide occurring at the same time as a major surge and wave runup event is (very) small and would also only occur for a few hours during high tide. This adds a large degree of conservatism to the estimated sea flood elevations. Also, wave runup will have a greatly reduced effect on land set-back from the shore and can be omitted for Area A but should be included for Area C. The following are recommended minimum elevations with respect to the sea level flood:

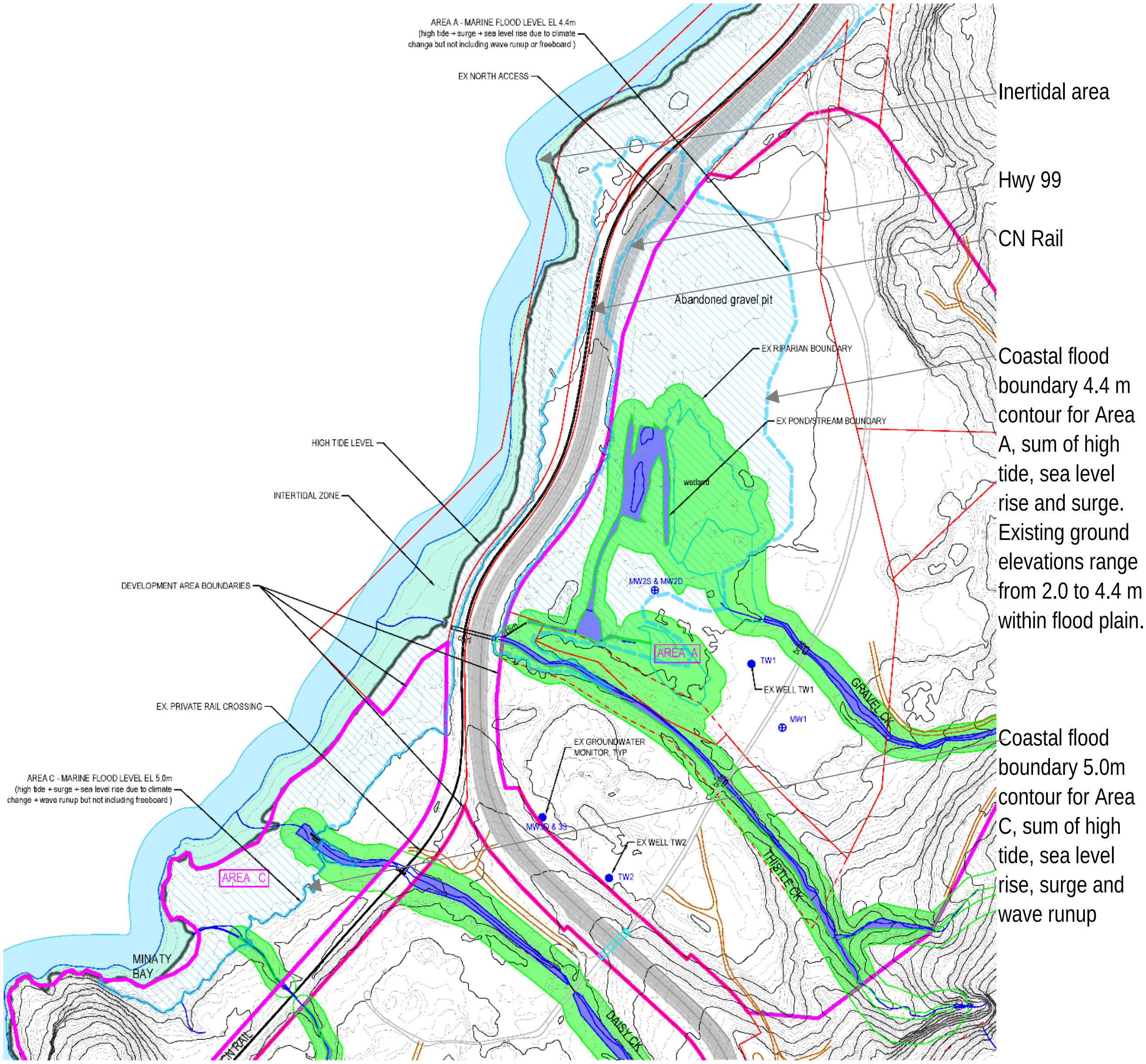
*Figure 7: Minimum development elevations for sea flood*

| Component | Criteria | Minimum elevation |
|---|---|---|
| AREA A | | |
| Structures | high tide + sea level rise + storm surge + freeboard | (4.95 m say) 5.0 m |
| Roads & lands | high tide + sea level rise + storm surge | (4.35 m say) 4.4 m |
| AREA C | | |
| Structures | high tide + sea level rise + storm surge + wave runup +freeboard | 5.6 m |
| Roads and lands | high tide + sea level rise + storm surge + wave runup | 5.0 m |

Note that these recommended construction levels might be modified by the stream flood analysis which will be completed by the next phase of the study. The minimum elevations will also be modified by land drainage requirements that will require upland areas to be higher than lowland areas to provide slope for drainage.

The following figure illustrates the extent of land affected by the sea flood elevation.

*Figure 8: Coastal flood boundary*




## Coastal Flood Mitigation Options

There are two methods of responding to the flood level while retaining the option to use the flooded land: 1) raise the land and structures, or 2) protect the land behind a sea dike. These options are discussed in the following sections. This report uses the term “development lands” to mean land in active use for buildings, roads, parking, and assembly. It does not include landscaping, recreational areas or other uses that can tolerate short term flooding without presenting a hazard.

### Filling land and raising structures

The land within the blue hatched coastal flood plain in **Development Area A** varies in elevation generally between 3.0 to 4.4 m. with a few lower areas at the wetland ponds and the Thistle Ck highway culvert. Development lands should be filled to a minimum elevation of 4.4 m. Structures should be further raised to the recommended flood construction level of 5.0 m.

The land within the blue hatched coastal flood plain in **Development Area C** varies in elevation from sea level to 5.0 m. Development lands should be filled to a minimum elevation of 5.0 m. The proposed lodge should be raised to the flood construction level of 5.6 m and protected against wave action by a low rock revetment or other coastal erosion protection feature.

Buildings and other structures can be built on raised fill pads with additional structural raising to bring the floor level to the flood construction level. Given the modest amount of raising in most of the flood area, a combination of fill and structure can mask the height.

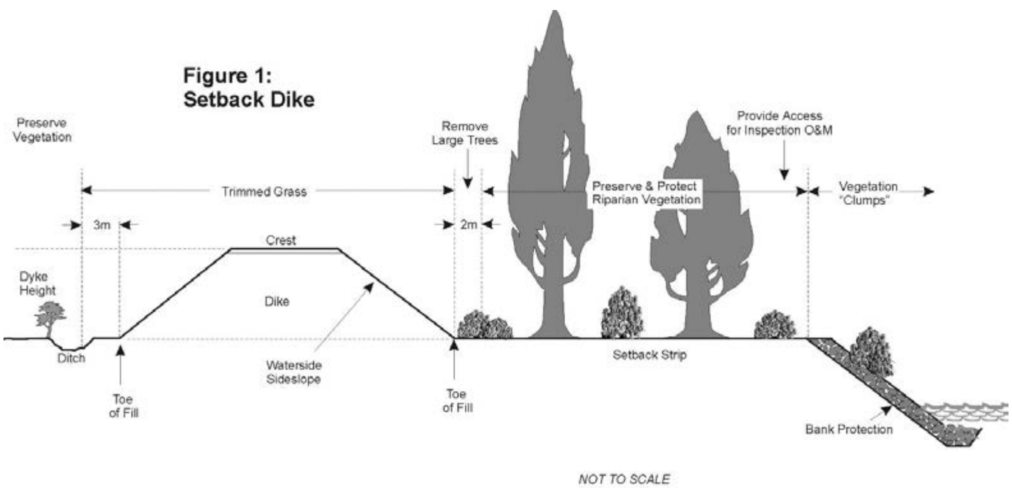
### Sea dike

A sea dike could be built to a top elevation of 5.0m along the western highway frontage of **Development Area A.** The dyke would have a maximum height of 2.0m tapering to nothing at the ends. The main entrance into the site would be raised to act as a dyke, which can be accomplished by gently ramping up the entrance road. A dyke would extend along the right bank of Thistle Creek until it meets the flood boundary elevation. Gravel Creek and the constructed wetland would drain into Thistle Creek through a flood box that would be manually closed during high coastal water levels. Future studies would confirm if the wetland has sufficient capacity to store the flow from Gravel Creek during the peak marine flood event (duration of a few hours during the peak of a tide cycle), or if a fixed or portable pump is required to pump the accumulated stream flow to discharge.

Development Area C would not use a dike but instead would use raised construction. The FCL for the improvements at Minaty Bay would be 5.60 m, including the park buildings and future tourist/commercial developments.

A standard configuration for a setback sea dyke is defined in Ref. 6 and shown in the figure below:

*Figure 9: Setback dyke configuration (from Ref.6)*



Dike design criteria

- Maximum side slope 3:1
- Crest width, 4m with crushed road base gravel running surface
- Maximum access ramp slope of 12%
- Designed to withstand the design seismic event.
- Designed to control seepage through the dike or through the permeable foundation soils.
- Provide access for maintenance. Given this is a relatively low dike, much of the maintenance can be done from the top. Provide minimum 4m wide access easements or rights-of-way along both toes of the dike.
- Provide a 20m corridor for the dike.

### Recommended sea flood protection

The owner wishes to avoid using land for a dyke and its associated mandated right of way. Therefore, a combination of land raising and building raising will be used.

## Summary

Coastal flooding can encroach on the development lands by a combination of high tide, higher sea levels due to climate change, wind surge and wave runup on the beach fronting the site. Highway 99 is slightly raised in the reach fronting the development and will protect the site from wave runup. In practice, the joint probability of a high tide occurring at the same time as a major surge and wave runup event is small and would also only occur for a few hours during high tide. This adds a large degree of conservatism to the recommended sea flood protection elevations. Also, wave runup will have a greatly reduced effect on land set-back from the shore. The following are recommended minimum elevations with respect to the sea level flood:

| Component | Criteria | Minimum elevation |
|---|---|---|
| AREA A | | |
| Structures | high tide + sea level rise + storm surge + freeboard | (4.95 m say) 5.0 m |
| Roads & lands | high tide + sea level rise + storm surge | (4.35 m say) 4.4 m |
| AREA C | | |
| Structures | high tide + sea level rise + storm surge + wave runup +freeboard | 5.6 m |
| Roads and lands | high tide + sea level rise + storm surge + wave runup | 5.0 m |

The owner wishes to avoid using land for a dyke. Therefore, a combination of land raising and building raising will be used for protection from sea flood.

## Section References


1) Village at Britannia Beach, Interim Geotechnical Assessment, Thurber Engineering Ltd., February 15, 1012
2) South Britannia Beach, Concept Flood and Foreshore Protection, File 2957.001-300, Technical Memorandum by Kerr Wood Leidal Associates Ltd., March 5, 2012
3) Engineering Servicing for South Britannia Beach, Project No. 2957.006-300, Kerr Wood Leidal Associates, November 2014
4) Britannia South Development, BC, Detailed Debris Flow Hazard Assessment and Preliminary Evaluation of Mitigation Options, Project No. 19-5356-1, Thurber Engineering Ltd., June 2016.
5) Sea Dyke Guidelines, Climate Change Adaption Guidelines for Seal Dikes and Coastal Floor Hazard Land use, BC Ministry of Environment prepared by Ausenco Sandwell, 2011-01-27.
6) Dyke Design and Construction Guide, Best Management Practices for British Columbia, Flood Management Section, Environmental Protection Difision, Ministry of Water Land and Air Protection, Province of British Columbia, (prepared by Golder Associates Ltd and Associated Engineering Ltd.), July 2003.

# GEOTECHNICAL

## Site Description

The proposed development and immediately adjacent areas include the following:

- Gravel pit floor – flat or hummocky and highly disturbed consisting of sand, sandy gravel, or gravelly sand with occasional piles of waste cobbles or stripped overburden.
- Gravel pit slopes – steep slopes surrounding the gravel pit floor terminating at natural topography, also highly disturbed and with small erodable over-steepened areas requiring remediation and consisting of sand, sandy gravel, or gravelly sand.
- Alluvial and glacio-fluvial fan – moderately to steeply sloped with remnants of the original fans left undisturbed by gravel extraction.
- Bedrock slopes – steep to very steep upland areas consisting of bedrock with colluvial veneer, glacial

The Geological Survey of British Columbia describes the surficial geology of the area as alluvial fan sediments consisting of poorly sorted sand and gravel forming the base of the mountain slopes. These sediments overly glaciomarine terrace sediments comprising stratified massive sand and gravel deposits and stratified proglacial deltaic sediments consisting dominantly of sand and gravel with minor silt and clay, locally up to 10m thick over glaciomarine silt and clay.

## Slopes

The geotechnical assessment report prepared by Thurber (2012) recommends that the slopes around the gravel pit be regraded to a maximum slope of 2H:1V (50%) for stability and to allow vegetation growth. Re-grading to 30% or less will permit use of the site for housing without extraordinary structural measures.

The rock areas are steeply sloped, often over 50% (2:1). Most of this upper area is therefore not suitable for development as the steeper slopes create difficult road access and house locations and introduce the possibility of slope instability caused by excavations.

## Geotechnical Field Investigation

A geotechnical field investigation was completed by GeoPacific Consultants Ltd. (GeoPacific) in 2015 and 2016. The documentation for the field investigation was deferred by the Owner and was subsequently assigned by GeoPacific to SFA Geotechnical Engineering (SFA) (Steve Fofonoff, P.Eng.) for completion. The SFA report is included in Volume 2.

The Geopacific investigations included the following fieldwork, which are illustrated on Figure1:

- The excavation of 34 test pits on 2015-06-29 to 30. The test pits were excavated throughout the site to help determine the overall shallow soil conditions.
- Four test holes and two cone penetration test (CPT) soundings were completed on 2015-07-16 and 17, to help identify the deeper stratigraphy and assess the liquefaction potential of the subsurface soils.
- Fifteen additional test pits were excavated on 2016-03-21 and 25.

- Three monitoring wells were installed on 2015-07-17 and five monitoring wells on 2016-05-06, to help evaluate the influence of the tides on the groundwater level below the site as well as to help determine the seasonal variability of the groundwater level.

The test pit, test hole, monitoring well and CPT locations are shown on SFA Drawing 1181-1 and reproduced on the following pages.

## Subsurface Conditions

The following soils were encountered on the surface and revealed by the test pits:

- Fill materials were encountered in most of the test sites located on disturbed ground. The fill varied from granular soils with varying amounts of silt and clay, some blasted rock and boulders, organic soils from quarry stripping and buried wood from land clearing. Fill depths varied from 0.0 to 5.2m at the test pits. The organic materials were generally found near surface but occasionally buried to depths up to 2.5m.
- Deltaic sediments consisting of compact to dense gravel and cobble with interbedded sand lenses was found in the northeastern corner of the site.
- Thick layers of dense medium to coarse sand with some gravel and trace cobbles were found to underlie much of the site’s flatter areas.
- Till-like dense silt and clay with sand, gravel and cobbles were found under the sand layer over much of the site.
- The bedrock underlying the sediments consists of granite, granodiorite and metasediments (sedimentary rock that has been crystallized by heat and pressure), as observed in the rock bluffs along the eastern edge of the site. Previous studies identified the rock as not susceptible to formation of acid runoff, but this must be confirmed by specific sampling if rock quarrying is contemplated.

The following pages include four figures that illustrate the investigations and findings.

Figure 1: Geotechnical Investigation Site Plan – locations of test pits from 2015 and 2016 site investigations

Figure 2: Surficial Soils Map – extent of surficial soils and types.

Figure 3: Geological Section – cross section through the site showing soil layers remaining after gravel extraction.

Figure 4: Fill Depths at Test Pits – The color coded test pit symbols indicate the depth of non-native fill found at surface. The fill depths suggest that the gravel pit was excavated below existing ground level and then backfilled with either native material borrowed from the site or by imported fill. The reader should refer to geotechnical test pit logs for a detailed description of fill soils encountered. The graphic presentation allows us to interpret that the fill depths are variable, ranging from 0.0 to over 5.2m (maximum depth of excavation by an excavator) and that there is no apparent pattern to the depths.

*Figure 10: Geotechnical Investigation Site Plan (from SFA Geotechnical Engineering, April 2019)*

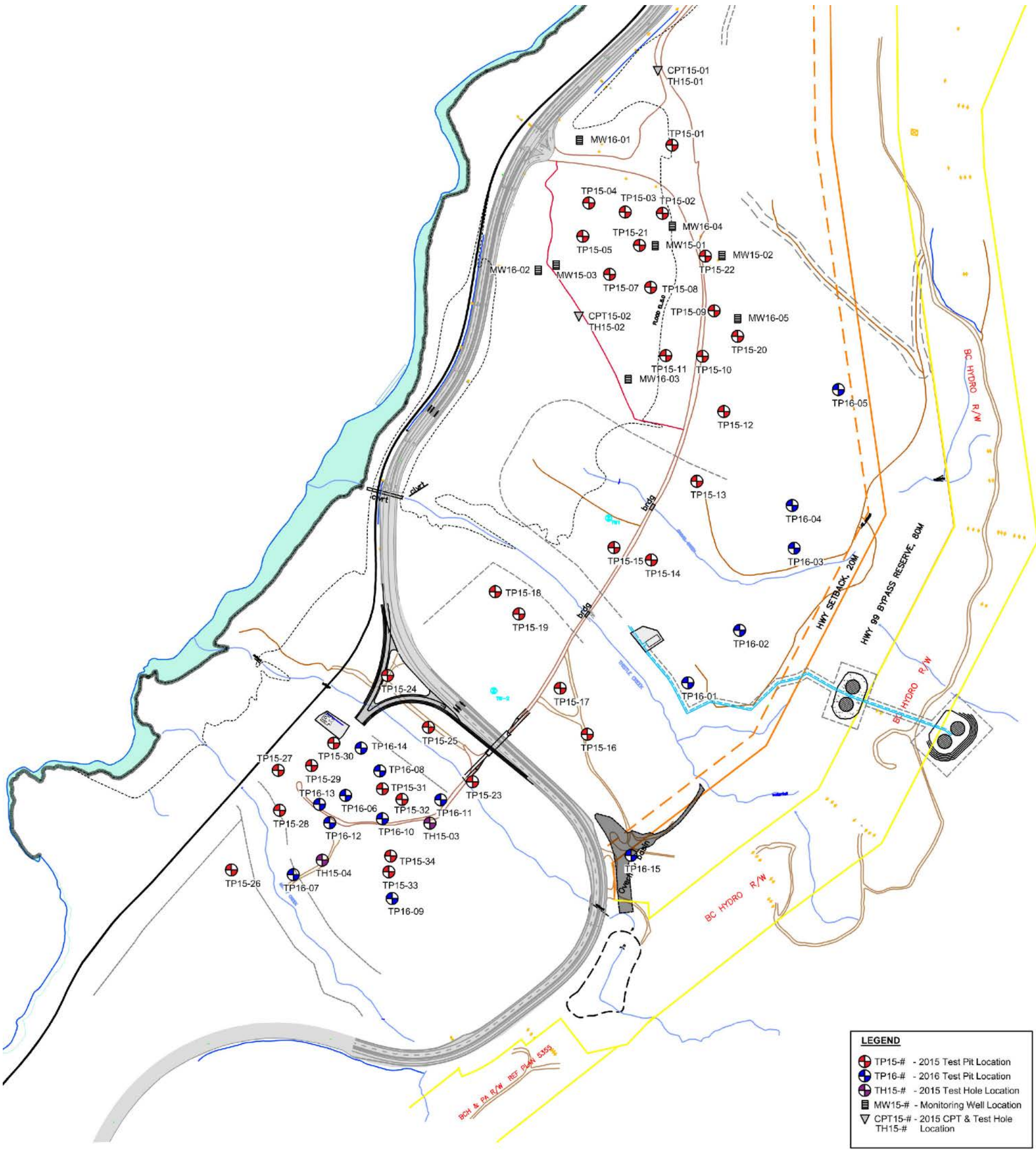



*Figure 11: Surficial soils map (from GeoPacific,2016)*

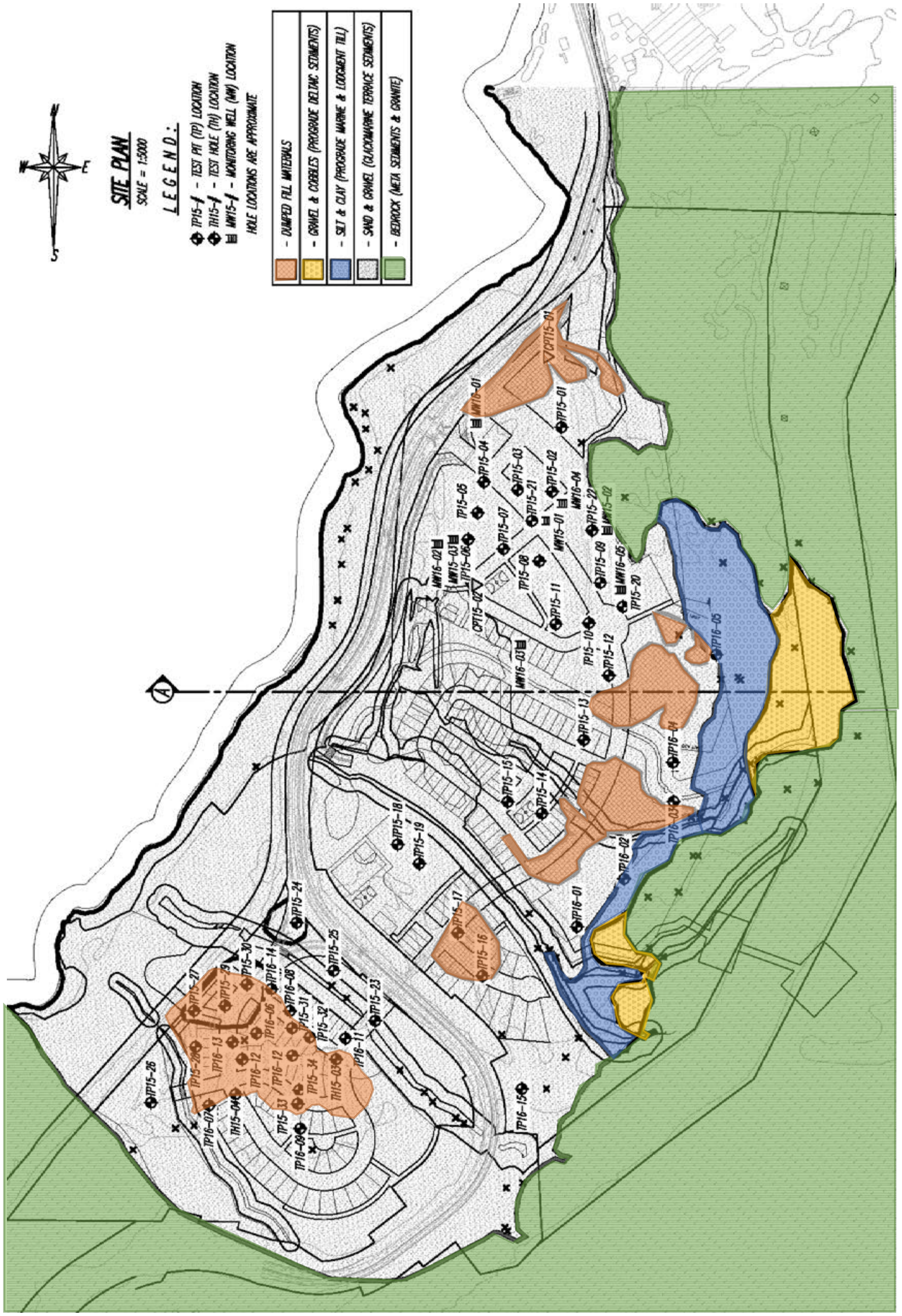

SITE PLAN
SCALE = 1:5000
LEGEND:
TP15-# - TEST PIT (TP) LOCATION
TH15-# - TEST HOLE (TH) LOCATION
MW15-# - MONITORING WELL (MW) LOCATION
HOLE LOCATIONS ARE APPROXIMATE
- DUMPED FILL MATERIALS
- GRAVEL & COBBLES (PROGRADE DELTAIC SEDIMENTS)
- SILT & CLAY (PROGRADE MARINE & LODGMENT TILL)
- SAND & GRAVEL (GLACIOMARINE TERRACE SEDIMENTS)
- BEDROCK (META SEDIMENTS & GRANITE)

*Figure 12: Geologic section (from Geopacific, 2016)*

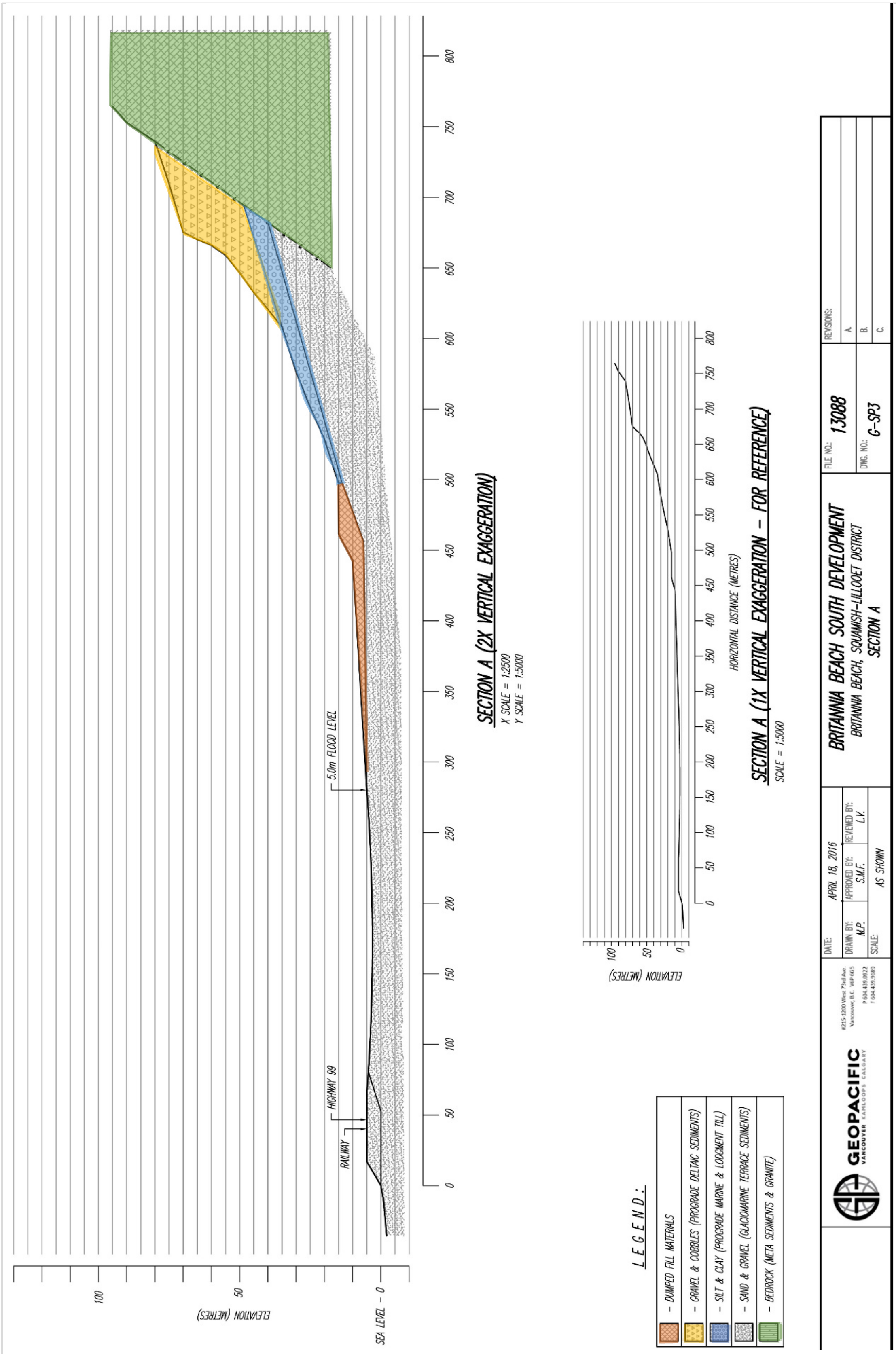
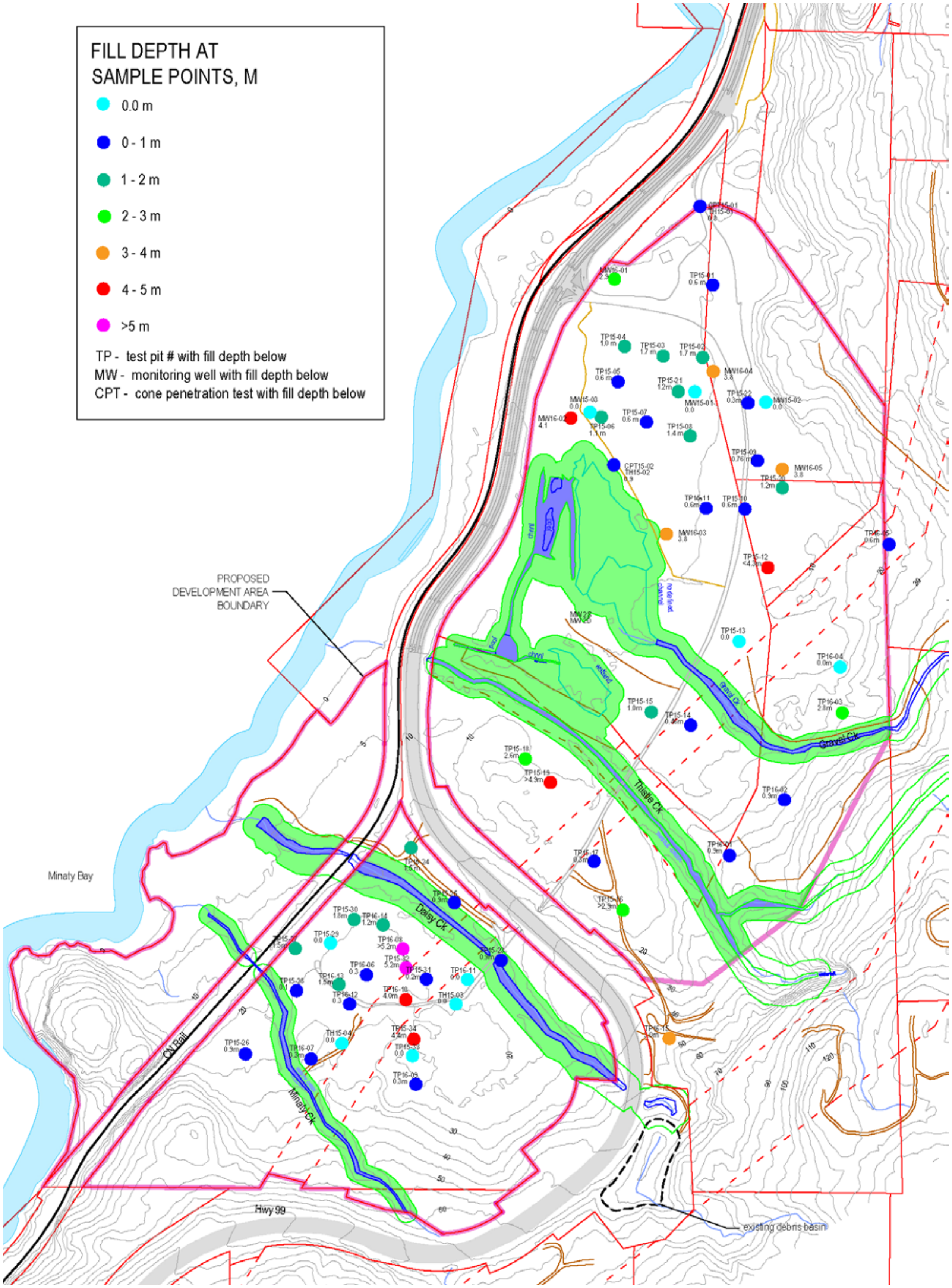


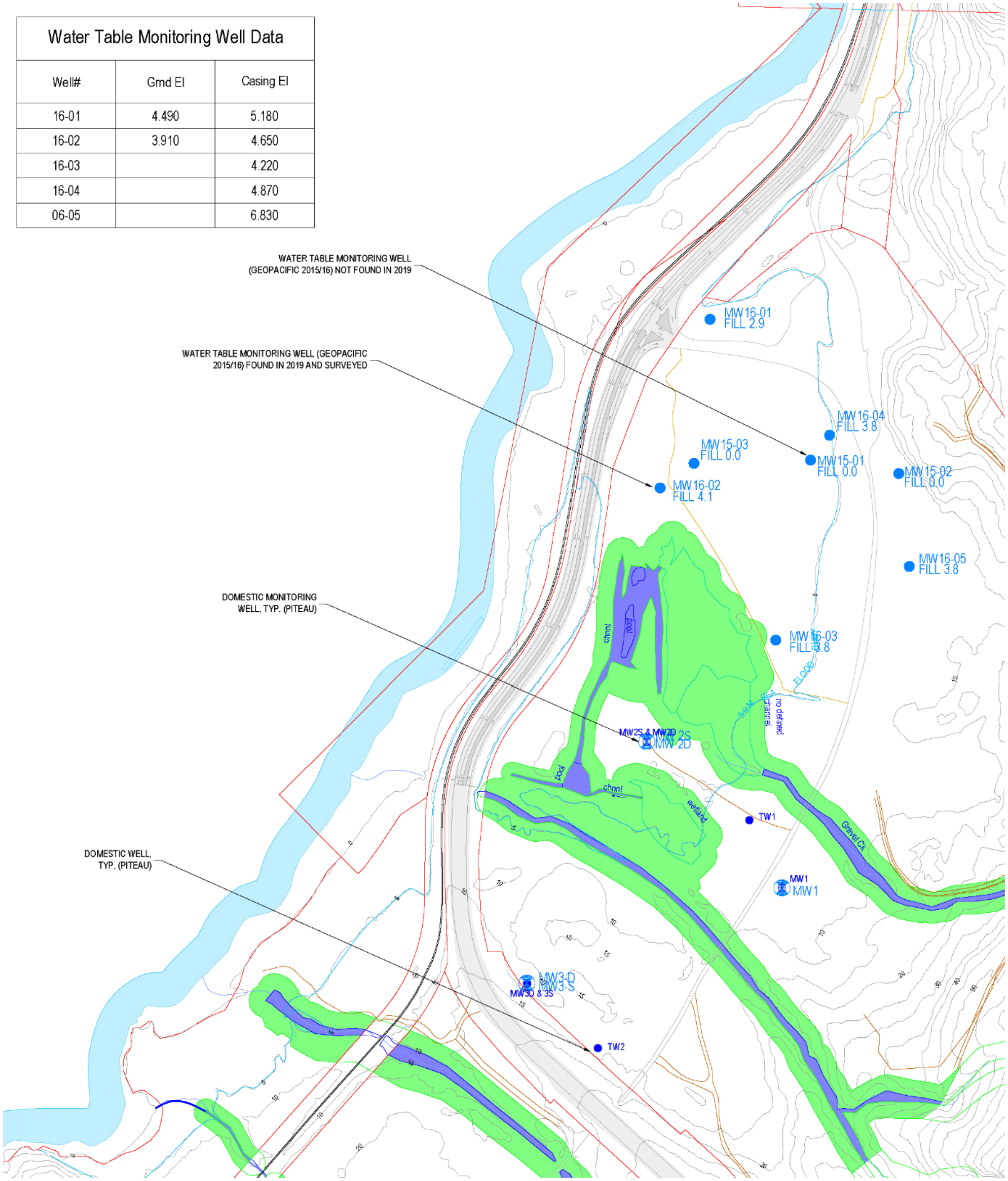
*Figure 13: Fill depths at test pits)*



## Groundwater

GeoPacific installed six groundwater (water table) monitoring wells in the northern portion of the site in 2015 and 2016. Piteau drilled two domestic water supply wells and three domestic monitoring wells in 2012. The following figure illustrates the location of these wells.

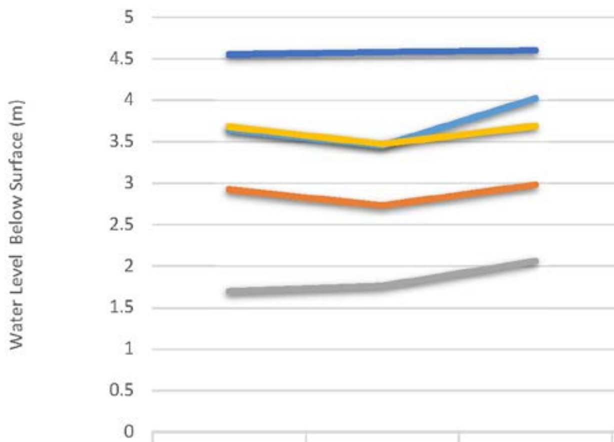
*Figure 14: Water table and domestic groundwater monitoring well locations*




| Water Table Monitoring Well Data | | |
|---|---|---|
| Well# | Grnd El | Casing El |
| 16-01 | 4.490 | 5.180 |
| 16-02 | 3.910 | 4.650 |
| 16-03 | | 4.220 |
| 16-04 | | 4.870 |
| 06-05 | | 6.830 |

The groundwater level in five of the Geopacific wells was logged on three different days in May 2016 as illustrated by the plot below. Note that these levels do not indicate the maximum elevations, but only spot observations.

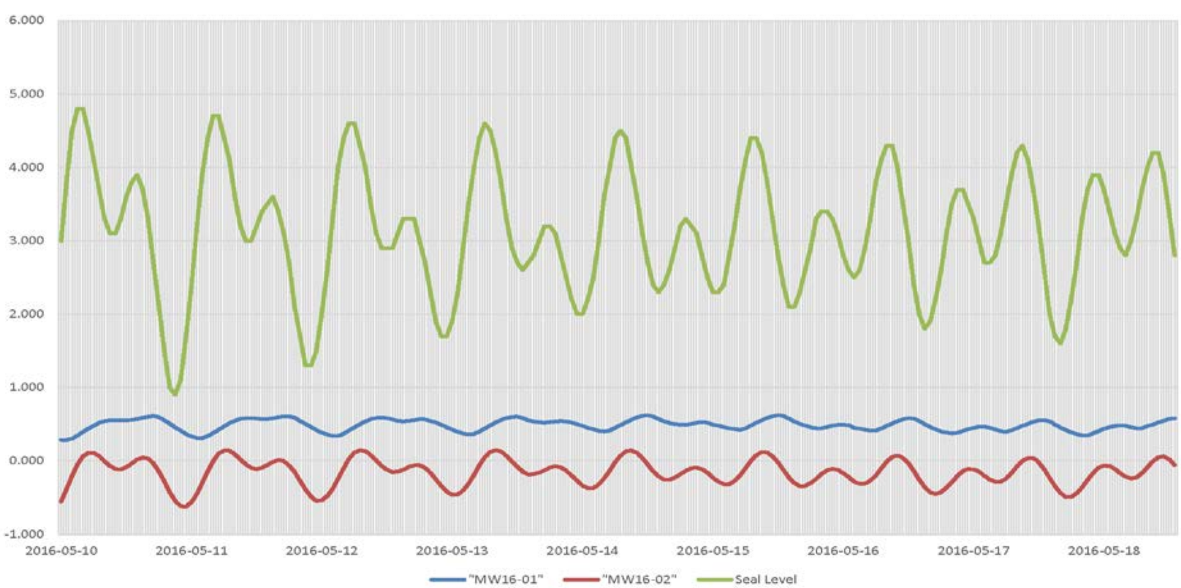
*Figure 15: Groundwater elevation spot observations (Geopacific data, SFA analysis)*




| | 6th May 2016 | 10th May 2016 | 19th May 2016 |
|---|---|---|---|
| MW16-01 | 3.64 | 3.45 | 4.02 |
| MW16-02 | 2.92 | 2.73 | 2.98 |
| MW16-03 | 1.7 | 1.76 | 2.06 |
| MW16-04 | 3.68 | 3.47 | 3.69 |
| MW16-05 | 4.55 | 4.58 | 4.6 |

Tidal influence is illustrated by the following figure. MW16-01 and 16-02 are about the same distance from the shore yet they exhibit different responses to tide.

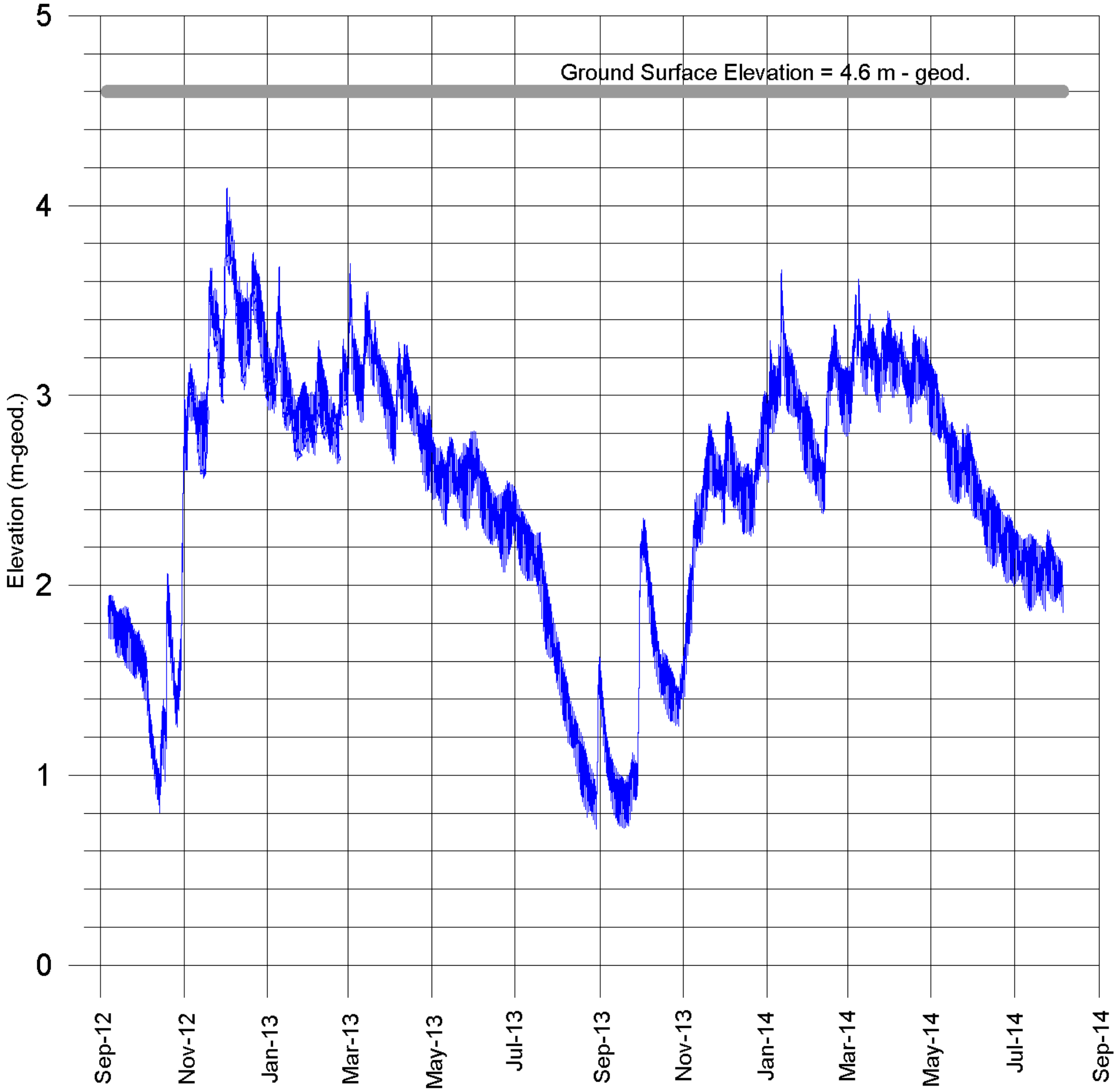
*Figure 16: Tidal influence on groundwater elevation from one-week of data logging of MW16-01 and -MW 16-02.*



Piteau Associates drilled domestic water supply wells and monitoring wells in 2012 and carried out 24 months of water level observations using a data logger that recorded the water level every 30 minutes. The following plot of water table elevation suggests the following:

- The ground elevation at the monitor is 4.6m geodetic and water table measurements are referenced to geodetic datum.
- The rapid groundwater elevation response to tides and weather events suggests a highly permeable aquifer.
- The minimum recorded water table elevation of around 0.8m occurs during late summer/early autumn.

*Figure 17: Water table elevation at Domestic Monitoring Well 2 (from Piteau, data 2013, analysis 2019)*



- The maximum groundwater elevation (MGWE) is a statistical variable that correlates with snowpack, precipitation, temperature, streamflow, tide levels, location in the aquifer, soil permeability and other factors. Estimating MGWE for design by modelling these variables is not practical.
- The maximum recorded water table elevation of around 4.0 m occurred in December 2012.
- Water table maxima occurred, as expected, during the winter months when the site experiences its maximum rainfall and streamflow in the creeks that feed the aquifer.
- Smaller peaks occur around March and April, the months that coincide with the spring freshet. Freshet is the period of maximum snowmelt and spring runoff in the mountains with the potential of rain falling on snow accelerating snow melt.
- The existing ephemeral water pools are located at the lowest elevations on the site. It is possible that the pooling is not caused by lack of infiltration into the ground, but rather by the elevation of the water table above the ground level.
- The usual approach to determining a design value for natural phenomena such as flood levels, rainfall or groundwater levels, is to conduct a statistical analysis of a long term record of the variable of interest, develop a family of curves for the variable with respect to probability of exceedance (expressed as a return period) and then select a return period and its associated value. An example is stream flooding, where a common criterion is to design for a 1 in 200 year recurrence period flood level. Given the lack of long-term data for groundwater elevations, we note that the recorded MGWE of 4.0 m is only 0.6m below ground suggesting that an extreme design event might reach the current ground elevation.
- If fill is placed on the low-lying areas to raise it above the ocean flood level, then the MGWE might rise higher than the current ground elevation and encroach into the fill.
- The design of structures in the low-lying areas must accommodate the high water table conditions. This is most reliably accomplished by placing the building above the ground surface elevation that will define the MGWE. Curtain drains, if used to locally depress the water table, must drain freely to ground or must use multiple redundant pumping systems. A system of swales or ditches can also be used throughout the site to control the peak groundwater elevation. The appropriate design response for structures will depend on the type of structure and its use, the probability of failure and the consequence of failure and will be specific to each type of structure.
- Installation of buried utilities and structures should be done during the summer months when the water table elevation is depressed. Alternatively, well point dewatering or other methods of controlling groundwater must be used. Simple trench pumping might not be suitable due to the potential for high inflows because of the permeable soils.
- Installation of permanent long-term groundwater monitors is recommended. These can provide additional data related to natural groundwater fluctuations and can also monitor aquifer response to long term domestic water pumping after the site is occupied. The monitors are not expensive and can be deployed with modest effort. The Owner of the site can maintain and routinely download and compile the data for use by their consultants.

## Further observations

- Test drilling and cone penetration tests have confirmed that the site is not subject to seismic soil liquefaction.

- Bedrock at the knoll on the extreme south end of the site is granodiorite which does not generate acid runoff when exposed to water and air.
- The steep upland areas consist of glaciomarine terrace sediments that will require regrading to a more stable slope followed by revegetation.
- Most of the site soils are suitable for bulk fill if handled and compacted under optimum moisture conditions.
- Consider using onsite silt lining the wetlands to inhibit water loss into the underlying sand and gravel.
- Due to the disturbed nature of the site, the recommendations in the referenced geotechnical investigation reports can be used only as a general guide, and it is essential that site-specific investigations and design be carried out for all earthworks, structures and facilities.
- Refer to the SFA report for general recommendations related to excavations, slopes, foundations, foundation drainage, roads, utility trenches and re-use of materials.

## Site Investigation for Wavegarden

SFA Geotechnical Engineering completed additional site investigations for the proposed Wavegarden structure in March 2020, consisting of drilling five solid-stem auger test holes supplemented with dynamic cone penetration test (DCPT) soundings. The test holes were advanced to a depth of 9.0m below grade. The location of the test holes is illustrated in the following figure provided by SFA (Ref.4).

*Figure 18: Test hole locations for Wavegarden geotechnical investigation*


The soil profile observed by this investigation is consistent with the observations in previous investigations and is described by SFA 2020 as compact to very dense sand and gravel over native sand and gravel deposits. The site is overlain by 0.5 to 1.4m of granular fill, generally consisting of cobbly sand and gravel that is inferred to be reworked native material. The new test pits did not encounter any woody debris that was encountered in TP15-05, 06, 07 and 11 during the 2015 investigation.

SFA installed two ground water monitoring wells. The groundwater table was measured at approximately 3.4 to 3.9m below ground level during the investigation and is expected to be tidally influenced and to fluctuate seasonally and in response to precipitation. SFA installed groundwater monitoring data loggers in the two new wells and outfitted two of the water supply monitoring wells with loggers to allow for continuous monitoring of groundwater to aid in the design of the Wavegarden structure.

The SFA report concluded as follows:

1. The corrosion potential, soluble sulphate concentration, liquefaction potential (seismic) and expansion potential of the soils are low.
2. Replace the overlying disturbed soil with well compacted engineered fill ( maximum 300 mm loose lifts, within 2% of optimum moisture content and compacted to 95% of ASTMD1557 “Modified Proctor” density) to limit differential settlement. Most of the native material might be useable as engineered fill. Site stripping and replacement should extend a minimum of 1.5m or equal to the depth of excavation beyond the footing, whichever is greater.
3. The peak ground acceleration at this location is 0.29g for the 1:2475 design ground motion event. This corresponds to a probability of occurance of 2% in every 50 years.
4. Temporary excavations should have a slope no steeper than 1.5H:1V.
5. Dewater excavations during construction to depress the water table surface at least 0.6m below the underside of the foundation.
6. Conventional spread footings can be used for structures at serviceability limit state bearing pressure of up to 125 kPa and factored ultimate limit state of 250kPa supported on native soils or engineered fill.
7. Frost protection depth is 0.45 m.
8. Earth pressures for foundation or retaining wall design are: static Pa = 5.4*H (where Pa is lateral earth pressure in kPa due to static loading and H is wall height in m) and seismic Pe=2.7*H (where Pe is earth induced earth pressure in kPa using inverted triangular distribution and H is wall height in m).
9. The Wavegarden design should incorporate an underslab drainage layer, using dewatering pumps to depress the groundwater level 0.6m below the underside of the pool floor when the pool is empty of water.

## Summary

The Geological Survey of British Columbia describes the surficial geology of the area as alluvial fan sediments consisting of poorly sorted sand and gravel forming the base of the mountain slopes. These sediments overly glaciomarine terrace sediments comprising stratified massive sand and gravel deposits and stratified proglacial deltaic sediments consisting dominantly of sand and gravel with minor silt and clay, locally up to 10m thick over glaciomarine silt and clay.

Site-specific geotechnical investigations confirmed the general classification for the site and concluded that the site was suitable for the intended purpose. Native soils consist of the original gravels and sands, fill consisting of reworked gravels and sands and other materials, and overburden materials remaining from the gravel mining operations.

Although there is no danger of slope instability, it is nevertheless recommended that slopes steeper than 2H:1V be regraded and vegetated to reduce erosion and ravelling and also to reduce fall hazard.

Technical observations include the following:

1. The corrosion potential, soluble sulphate concentration, liquefaction potential (seismic) and expansion potential of the soils are low.
2. Replace the overlying disturbed soil with well compacted engineered fill ( maximum 300 mm loose lifts, within 2% of optimum moisture content and compacted to 95% of ASTMD1557 “Modified Proctor” density) to limit differential settlement. Most of the native material might be useable as engineered fill. Site stripping and replacement should extend a minimum of 1.5m or equal to the depth of excavation beyond the footing, whichever is greater.
3. The peak ground acceleration at this location is 0.29g for the 1:2475 design ground motion event. This corresponds to a probability of occurance of 2% in every 50 years.
4. Temporary excavations should have a slope no steeper than 1.5H:1V.
5. Dewater excavations during construction to depress the water table surface at least 0.6m below the underside of the foundation.
6. Conventional spread footings can be used for structures at serviceability limit state bearing pressure of up to 125 kPa and factored ultimate limit state of 250kPa supported on native soils or engineered fill.
7. Frost protection depth is 0.45 m.
8. Earth pressures for foundation or retaining wall design are: static Pa = 5.4*H (where Pa is lateral earth pressure in kPa due to static loading and H is wall height in m) and seismic Pe=2.7*H (where Pe is earth induced earth pressure in kPa using inverted triangular distribution and H is wall height in m).
9. The Wavegarden design should incorporate an underslab drainage layer, using dewatering pumps to depress the groundwater level 0.6m below the underside of the pool floor when the pool is empty of water.

The following are next steps:

1. Continue monitoring ground water elevations to assist in design of building basements, parking structures and the Wavegarden pool.
2. Conduct site specific investigations and recommendations for all structures and facilities.

## Section References


1) Village at Britannia Beach, Interim Geotechnical Assessment, Thurber Engineering Ltd., February 15, 2012
2) Preliminary Geotechnical Recommendations and Summary Report, Proposed Comprehensive Development, South Britannia Beach, BC, File 1181, SFA Geotechnical Engineering, April 15, 2019.
3) Groundwater hydrology reports by Piteau Associates dated November 2011, February 2012, November 2012, March 2013, January 2014 and March 2016 and monitoring well chart provided by Piteau April 2019.
4) Draft Geotechnical Recommendations Report, Proposed Wave Garden Structure, Britannia Beach South Development, Britannia Beach, BC by SFA Geotechnical Engineering, April 28, 2020.

# CONTAMINATION

## Background

Environmental matters pertaining to contaminated sites in British Columbia fall under the jurisdiction of the Ministry of Environment (MOE), under the *Environmental Management Act* (EMA). The primary regulation under the EMA relating to the assessment and remediation of contaminated sites is the Contaminated Sites Regulation (CSR). The CSR sets out legal procedures for screening sites, determining if a site is contaminated, assessing liability, initiating remediation processes, and setting standards for site remediation and soil relocation. This is a complex process overseen by the MOE and the Society of Contaminated Sites Approved Professionals of BC (CSAP Society).

As the proposed future use of the site is a combination of residential, parkland and commercial, the appropriate soil standards from the Contaminated Site Regulation (CSR) are the most conservative (lowest) of Residential Land (RL), Urban Park (PL), and Commercial Land (CL) standards.

## Studies

Taicheng Development Corporation (Taicheng), now rebranded as Tiger Bay Development Corporation (Tiger Bay), retained Piteau Associates Engineering Ltd. (Piteau) to complete a Stage 1 and Stage 2 Preliminary Site Investigations (PSI). These were initiated in 2014 and completed in 2020 with publication of the referenced report.

The Stage 1 study involves a review of historical maps and aerial photographs, land title records, government databases, previous consultant reports, on-site interviews and site inspections to identify Areas of Potential Environmental Concern (APECs). The Stage 1 study does NOT include any sampling.

The Stage 2 study includes investigation of soil and groundwater conditions within the APECs to determine if contamination is present.

## Objective

The objective of Stage 1 of these studies is to identify potential environmental liabilities at the Site that may have resulted from previous land uses or construction and to identify present conditions or practices that may represent an environmental liability. The work includes research into past use of the Site and adjacent properties, to evaluate possible historical sources of contamination. If research indicates an Area of Potential Environmental Concern (APEC) then the objective of Stage 2 is to investigate soil and groundwater within the APEC to determine if concentrations of potential contaminants of concern exceed applicable standards from the Contaminated Site Regulatin (CSR).

## Areas of Potential Environmental Concern

The Stage 1 PSI identified eight APECs within the proposed development site that are summarized in the following table. Locations are shown on the following figure.

*Table 8: Areas of potential environmental concern*

| APEC No. | Description | Risk | Media | Potential Contaminants of Concern (PCOCs) |
|---|---|---|---|---|
| 1 | Existing and former soil stockpiles at north end of site | moderate | Soil, groundwater | Metals |
| 2 | Historic fuel storage at former helipad | low | Soil, groundwater, vapour | LEPH, VPH, BTEX, PAH, lead |
| 3 | Former location of stockpiles of 1997 creek washout debris | moderate | Soil, groundwater | Metals |
| 4 | Debris from W Vancouver construction site | low | Soil, groundwater | Metals |
| 5 | Miscellaneous refuse at trailer | low | Soil, groundwater, vapour | LEPH, VPH, BTEX, PAH, HEPH, metals |
| 6 | Steel ASTs, creosoted timbers | low | Soil, groundwater, vapour | LEPH, VPH, BTEX, PAH, HEPH, lead |
| 7 | Miscellaneous refuse | low | Soil, groundwater | LEPH, VPH, BTEX, PAH, HEPH, metals |
| 8 | Impact from neighboring lands along the northeast site boundary | low | Soil, groundwater | metals |

APEC = Area of Potential Environmental Concern
PCOC = Potential Contaminants of Concern
LEPH=Light extractable petroleum hydrocarbons
HEPH=Heavy extractable petroleum hydrocarbons;
VPH = volatile petroleum hydrocarbons;
BTEX = benzene, toluene, ethylbenzene, and xylenes;
PAH = polycyclic aromatic hydrocarbons

## Soil Testing

The **soil standard** applicable to the site is the lowest of Low Density Residential ($RL_{LD}$) and Commercial Land (CL) standards from Schedule 3.1 of the Contaminated Site Regulation.

Soil samples were analyzed for the following:

- Polycyclic Aromatic Hydrocarbons (PAHs) – 4 samples
- Total metals **-** 31 samples including 3 duplicates
- Light and heavy extractable petroleum hydrocarbons (LEPH / HEPH) – 11 samples including 1 duplicate.
- Benzene, ethylbenzene, toluene, xylenes (BTEX) and volatile petroleum hydrocarbons (VPH) – 5 samples.

The soil sample tests are summarized in the following figure. Test details are included in Piteau 2020. Soil analysis results indicate concentrations of PCOCs are below soil standards appropriate for the anticipated future use. Based on these analytic results, it is concluded that the site is uncontaminated for its intended use with respect to soil.

## Groundwater Testing

The **groundwater standards** applicable to the site include Drinking Water (DW) and Marine Aquatic Life ($AW_m$) standards from Schedule 3.2 of the Contaminated Site Regulation.

Groundwater samples from test wells MW15-01 and MW15-02 were tested form dissolved metals. The results of the test are included in Piteau 2020 and summarized in the following figure. Testing of the samples from the groundwater monitoring wells indicate concentration of groundwater PCOCs below the standards for protection of marine aquatic life and drinking water with are applicable to the site. Based on these analytic results, it is concluded that the site is uncontaminated for its intended use with respect to groundwater.

*Figure 19: Preliminary Site Investigation - lot location plan (from Piteau 2020)*

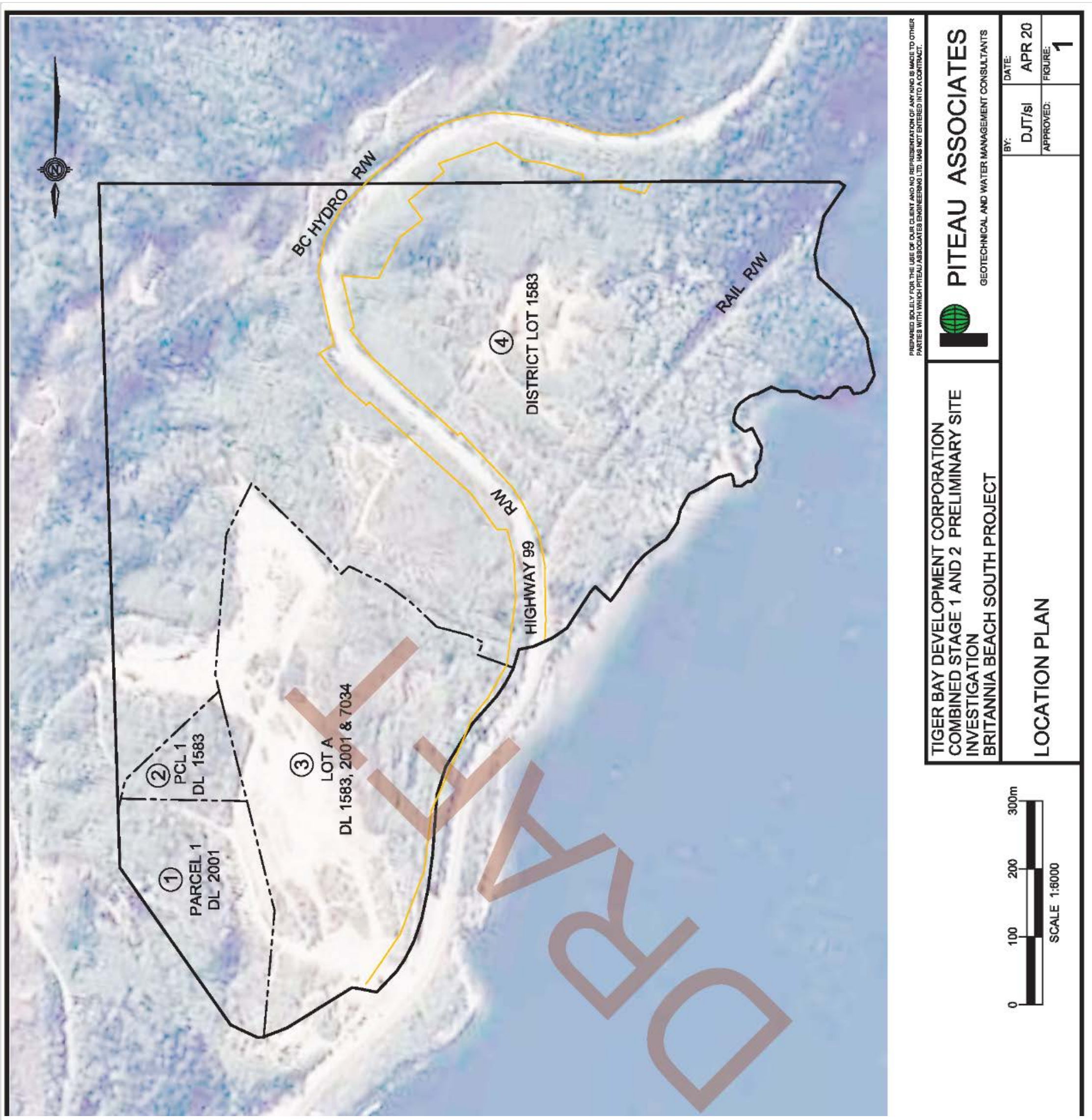


*Figure 20: Preliminary Site Investigation - test pit and well locations (from Piteau 2020)*

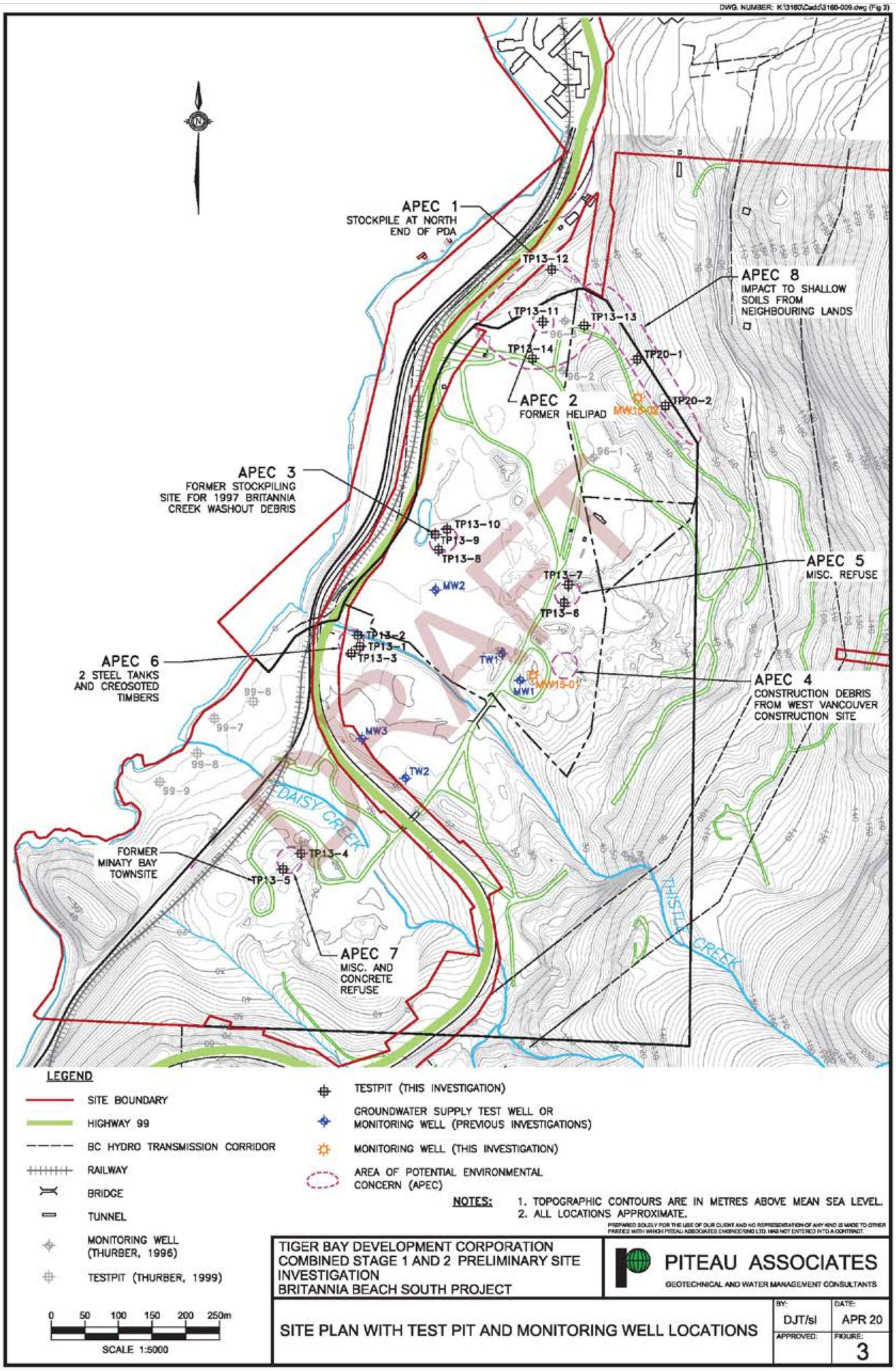


*Figure 21: Preliminary Site Investigation – results for soils (from Piteau 2020)*

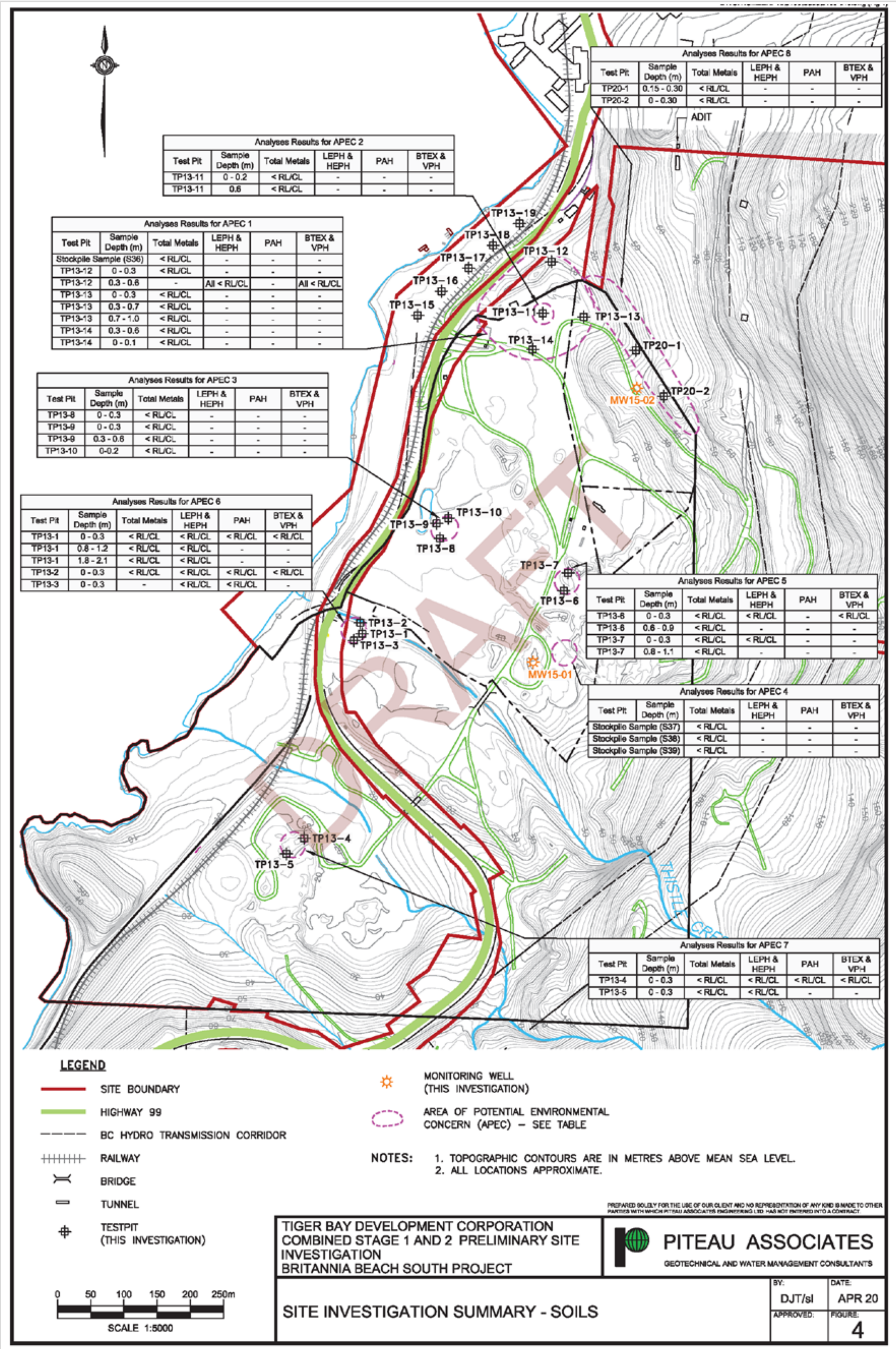
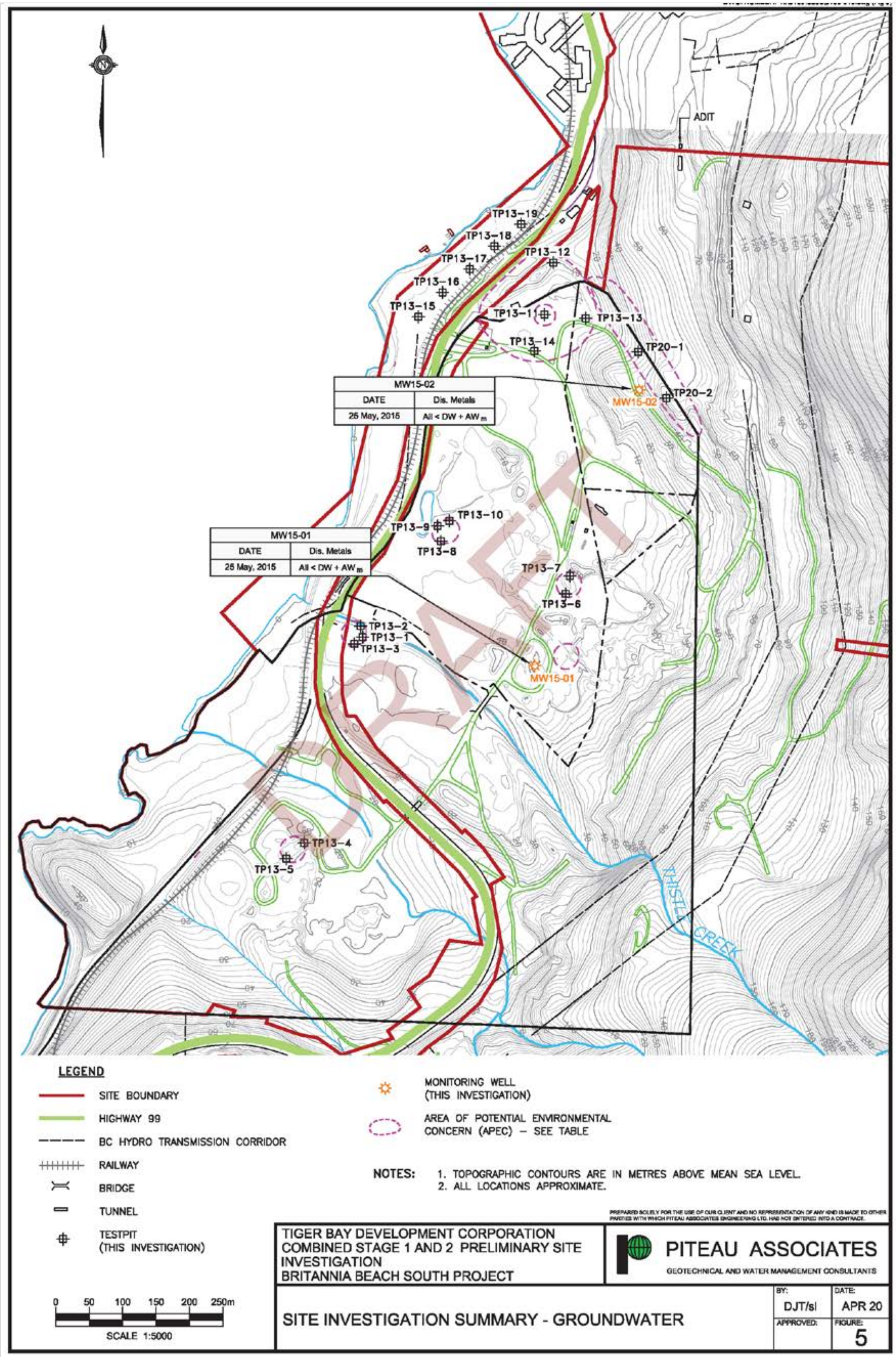


*Figure 22: Preliminary Site Investigation – results for groundwater (from Piteau 2020)*



## Summary

Environmental matters pertaining to contaminated sites in British Columbia fall under the jurisdiction of the Ministry of Environment (MOE), under the *Environmental Management Act* (EMA). The primary regulation under the EMA relating to the assessment and remediation of contaminated sites is the Contaminated Sites Regulation (CSR). The CSR sets out legal procedures for screening sites, determining if a site is contaminated, assessing liability, initiating remediation processes, and setting standards for site remediation and soil relocation. The site screening proceeds through two stages.

The Stage 1 study involves a review of historical maps and aerial photographs, land title records, government databases, previous consultant reports, on-site interviews and site inspections to identify Areas of Potential Environmental Concern (APECs). The Stage 1 study does NOT include any sampling.

The Stage 2 study includes investigation of soil and groundwater conditions within the APECs to determine if contamination is present.

Site investigations and soil analysis results indicate concentrations of potential contaminants of concern are below soil standards appropriate for the anticipated future use. Based on these analytic results, it is concluded that the site is uncontaminated for its intended use with respect to soil.

No additional work is required regarding contamination.

## Section References


1. Combined Stage 1 and Stage 2 Preliminary Site Investigation for Britannia Beach South Project near Britannia Beach BC, Piteau Associates Engineering Ltd., April 2020

# DEVELOPMENT PLAN

The development plan incorporates a mix of tourist commercial and medium to high-density residential together with associated community amenities including a neighbourhood commercial centre, parking, a transit centre, parks, a destination view restaurant, a naturalistic regional park in the Minaty Bay area, trails, rights-of-way and utility areas for roads and infrastructure. The drawing *Site Plan, Final* illustrates the proposed community layout, land uses, features, and utilities. The proposed utilities are discussed in later sections.

## Major Land Uses

The following describes the major land uses.

### Commercial

Located in the north area and functioning as the core and "main street" of the community, the commercial village will include the following:

- Surf park with associated infrastructure and commercial support.
- Neighbourhood commercial area to support the daily needs of local residents and visitors.
- Destination view restaurant atop the cliffs on the north-east boundary of the village.
- Parking and transit facilities.

### Residential

Medium to high-density residential areas totalling 1050 units and located north of the highway and in the main bowl of the old gravel pit including:

- Townhouses.
- Stacked townhouses.
- 3-6 storey apartments.
- Sports field.
- A small field house associated with the sports field. The field house contains a small amount of community amenity space and might also house a small daycare.

### Accommodation

Resort developments located in all three Parcels including:

- 50-unit surf hotel in Parcel A associated with the Wavegarden surf park.
- 30-unit resort hotel and 80-units of wilderness cabins and glamping sites accessed by narrow service roads, located in Parcel B.
- 30-unit waterfront lodge located in Parcel C.

### Park

A regional park that occupies the picturesque bay and steep rock point at the south end of the site. The plan also includes a community sports field with parking and a community building.

### Environmental and Natural

Environmentally sensitive riparian areas surrounding streams and ponds/wetlands and natural or rehabilitated areas set aside as green space and for recreation or as buffer to other uses.

### Utility

Land used for utilities (water supply and monitoring wells, water treatment, reservoir, sewage lift station, pipeline easements, stormwater management ponds and drainage ways), transit hub, parking and road rights-of-way.

### Institutional

- Fieldhouse/community building associated with the sports field.
- Public works yard and building site

## Design Features

The following design features are shown on *Dwg 4 – Engineering Concept, Final* and discussed below. Additional details for some of the features are provided later in this report or directly on the drawing.

**Path and utility R/W to Britannia North** – a 5 to 6m wide utility corridor with path connects South Britannia and North Britannia. This corridor extends from the north end of the site to Copper Drive. The corridor is routed behind the Galileo coffee house and along the hillside within Tiger Bay property, through the MoTI chain-up area and then behind the concrete barrier on Hwy 99 to the mining museum property. The corridor is then routed along the eastern border of the highway R/W to Copper Drive. The corridor will contain a 3 m wide paved path for pedestrian and bicycle access between the communities. It will also be the route for the proposed sewer force main to the existing wastewater treatment plant in Britannia North. The corridor might also provide emergency vehicle access between North and South Britannia in the event of highway blockage.

**Underground parking structure** – 307 stall parking structure located at the North Access, to service the recreational and commercial areas. The structure will also provide parking for the destination restaurant located on top of the rock bluff. Longer-term parking will be purposely pricey to discourage the use of the lot as a park and ride. The intention is that transit users either walk or cycle to the transit center or get dropped off. On-street parking spaces close at the transit centre will be dedicated for car-share parking with additional car-share parking provided in the underground parking structure.

**Transit center** – an extensive transit centre is located next to the Surf Hotel commercial area. It includes parking for share cars, bus and shuttle laybys, bicycle parking, transit shelters and a drop-off area. This also provides convenient access to the path leading to the cliff-top café.

**North Access** – upgraded existing highway intersection used for full movement entrance and exit for the first phase of development and rebuilt as a restricted right-in and right-out intersection for the second phase or when required by actual traffic count. Refer to the *Transportation* chapter for a full discussion of the intersection.

**Britannia Boulevard and Multi-Use-Path** – Britannia Boulevard is the primary road corridor through the community and will be built as a treed boulevard with a 3.0 m Multi-Use-Path (MUP) on the east side used by pedestrians and slow cyclists. The MUP will be separated from the edge of the road by boulevard to improve comfort for pedestrians and therefore encourage walking rather than driving. The posted maximum speed of the Boulevard will be 40 km/h to improve safety for shared bicycle use on the roadway. The main road design will incorporate frictional elements to naturally reduce driving speed thus enhancing pedestrian and bicycle use and safety. The key frictional element is the use of slightly narrower than normal vehicle and parking lanes (to Euro standard rather than N.American standard). Refer to the transportation section.

**Flood contour** – the dashed blue line on the drawing indicates the marine flood level. In Area A, this is an elevation of 4.4m, which is the sum of high tide, sea-level rise due to climate change and surge. In area C the marine flood elevation is 5.0 m, which is the sum of high tide, sea-level rise, surge and wave runup. The flood construction levels are 0.6m higher than the flood levels. Flood protection will consist of land filling and raising of buildings so that the underside of the floor structural system (or floor slab) is no lower than the flood construction level. Roads will be raised to the flood level, which would continue to provide access in all conditions but without freeboard. Development land will be raised to the flood level elevation. The main road (Britannia Boulevard) will be built to an elevation greater than 5 m to provide sufficient elevation for drainage.

**Sewage lift station** – A sewage lift station will pump all sewage, through a new sewage forcemain, to the wastewater treatment plant located on the north side of Britannia Creek. The lift station will consist of a 3m diameter fibreglass wet well, submersible pumps with variable frequency drive control to attenuate flows into the treatment plant, electrical supply and control kiosk, standby generator kiosk, water supply backflow preventer kiosk and sewage flow meter kiosk.

**Detention pond** – Stormwater runoff from the Wavegarden development parcel that cannot be infiltrated into the ground will be directed into a detention pond located on the margin of the reconstructed and expanded wetland. It will provide attenuation of peak flows and primary settlement of solids and also a second dichlorination barrier for Wavegarden pool water discharge. The Wavegarden will include its own chemical dechlorination facility. A detention pond is shown only for the Wavegarden to accommodate the larger extent of paved areas in this neighbourhood. The developers of the other parcels will be required to include drainage attenuation into their facility designs. The concept drawing indicates potential flow paths and locations for parcel detention facilities that discharge to Gravel Ck, Thistle Ck or the wetland pond.

**Gravel Creek Channelization** – Formalize a route for Gravel Creek to supply water for a constructed wetland and provide neighbourhood definition.

**Constructed wetlands, ponds and streams** – Construct aquatic and riparian habitat to replace similar areas used for development. The new wetland will provide a higher quality environment than the ephemeral and very poor quality existing wetland, which consists of the lowest elevation area of the old gravel pit. Gravel and Thistle Creeks, together with the wetland, provide the drainage outlets for each of the development parcels.

**Streamside easement** – Provide 5m wide streamside easements through the development parcels to contain training berms or dykes where required. Include covenants requiring parcel developers to provide maintenance access easements to the streamside easements.

**Water supply wells and monitoring wells** – The existing test well TW2 will be used as a production water supply well. Decommission test well TW1 and drill two new wells to use as additional production wells. The total pumping capacity of the wells will be limited to 75 L/s to remain below the threshold that triggers a provincial environmental review. Similarly, retain the monitoring wells or decommission and re-drill them at suitable locations.

**Path** – Construct paths and trails through the wetlands and riparian areas for exercise, nature viewing and shortcuts to the coffee shop.

**Sports field** – Use the land parcel to the east of the underpass tunnel for a community sports field, community building and parking. This site will also be used as an overflow basin for the Daisy Ck debris basin.

**South Access** – Construct a new right-in and right-out intersection with acceleration and deceleration lanes. The intention is to defer construction until Phase 2 or when traffic counts indicate that it is required. Refer to the *Transportation* section of this report. Note that the circular road leading to the south access has a 60m radius, the maximum that would fit the site, which is less than the 80m radius required by MoTI standards for a 50 km/hr speed. This is considered sufficient for the proposed 40 km/hr road speed limit.

**CN rail crossings to Parcel C** – An overhead public pedestrian bridge will provide public pedestrian and golf cart access to the Minaty Bay waterfront. The existing private at-grade CN Rail crossing will be upgraded to conform to current CN Rail requirements, and it will provide service access to the waterfront lands and guest drop-off access to the waterfront lodge. The types and timing of crossings are subject to further negotiation and discussions with the SLRD, the community, CN Rail and MoTI. Refer to the CN Rail options in this report and *Dwg.2 – Engineering Concept, Final.* Public statutory rights of way provide access to both crossings.

**Surf Hotel, Minaty Lodge, Minaty Resort, cabins and glamping sites** – 50-unit surf hotel, 30-unit lodge, 30-unit resort and 80-units of cabins/glamping sites. The Surf Hotel is located next to the Wavegarden and will be serviced from the municipal infrastructure. The Minaty Lodge and Resort will have full infrastructure servicing, fire protection and road access. The cabins and glamping sites will be accessed by service roads only without user vehicle access. Infrastructure for the cabins and glamping sites will consist of underground power, wireless communications, small diameter water distribution (no hydrant based fire protection) and small diameter septic tank effluent or low-pressure sewers pumping into the sewer force main serving the Minaty sewage lift station.

**Slope regrading** – Regrade steep slopes in excess of 2H:1V to a more erosion-resistant and stable 2:1 slope with revegetation.

**Highway underpass** – Carry out structural evaluation of the existing MoTI corrugated metal culvert underpass that provides access across Highway 99 and replace or repair as required. The underpass consists of a 5.95m wide by 5.43m wide (Hatch Engineering) multiplate steel culvert. A single lane of traffic would be routed down the middle of the underpass, to maximize available height, with narrow pedestrian sidewalks on either side. Bicycles would share the road with cars while passing through the underpass. Both the height and width are constrained, and a dimensional survey and detailed design are required to confirm if they are sufficient for the anticipated configuration. The transportation study has confirmed that a single signalized vehicle lane with a pedestrian sidewalk has the capacity for local traffic and to convey traffic between the two right-in and right-out intersections. The study confirmed that a two-lane underpass is not required. MoTI has stated a requirement that Tiger Bay conforms to the MoTI design criteria that requires a two-lane underpass notwithstanding traffic loading. The final configuration will be determined by negotiation. Refer to the discussion in the *Transportation* section of this report.

**Upgrade debris basin outlet channel and highway culvert at Daisy Ck** – A local high-intensity storm event on January 28, 2016, caused a clear water overflow of the debris basin discharge channel and highway culvert onto the highway and hence into the development property on both sides of the highway. The channel and culvert are effectively protected against erosion but have poor hydraulic characteristics that reduce hydraulic capacity. MoTI will be requested to re-assess the capacity of the debris basin channel that was built in 2007 and construct improvements, if necessary, to maintain the clear water flows within the channel of Daisy Creek.

**Daisy Creek debris basin** – The drawings and figures in this report indicate the approximate outline of the existing MoTI debris basin. The basin capacity is sufficient to capture the sediment from the 1:2500-year debris flood event. Refer to the discussion in the *Flood Protection* section of this report. The debris flow hazard is under study as of the date of this report.

**Daisy Ck. block avulsion points** – block potential avulsion points on Daisy Creek upstream of the debris basin as described in Thurber report.

**Daisy Ck. clear water overflow basin, channel & berm** – the Daisy Creek debris basin, while sized sufficiently to capture sediment, might be overtopped by large magnitude clear water overflows that can flow down the highway into adjacent lands. Construct a training berm downstream of the debris basin and extend the existing Jersey barrier to the bottom of the hill to keep overflow on Highway 99 and away from the site. The sports field area will act as a secondary debris basin to retain debris and attenuate clear water overflows into Thistle Ck., should ongoing studies indicate this is necessary.

**Minor debris basins** – Construct minor debris basins on Gravel and Thistle Creeks in the upland areas as described in the flood mitigation chapter of this report.

**Water reservoir** – Provide twin bolted steel ground-level water reservoirs located at a bottom water level of 110m and top water level of 120m located east of the BC Hydro R/W accessed from the existing BC Hydro access road. Upgrade the BC Hydro access road to provide reliable all-weather access.

**Water main easements** – Provide a 5m wide easement, between the water treatment plant and the reservoirs, that contains the water supply and distribution mains. BC Hydro has confirmed that an underground crossing of the right-of-way is acceptable subject to their approval of the design.

**Reservoir service road** – Use the BC Hydro powerline service road for reservoir access. BC Hydro has confirmed that joint use is acceptable subject to detailed agreements and potential road upgrading for the more frequent access requirements of the reservoir. The service road connects to a paved public road in Britannia Beach North.

**Water treatment plant** – Provide a water filtration and disinfection plant. The building size is assumed to be 250m2 in a 1,000m2 lot for illustration purposes.

**Highway bypass reserve** – 80m wide right-of-way reserve set aside for a possible future highway bypass built by MoTI to alleviate traffic congestion at the Copper Drive intersection.

**Bypass setback** – 20m buffer between proposed development areas and the highway bypass.

**Destination restaurant** – A dramatically situated destination restaurant located on the rock bluff above the Village neighbourhood. Service access would be provided by a private service road. Public access will include a paved pathway and a feature funicular or external elevator with a bridge.

**Soundview Park** – View park with trails and picnic area located on the bluff above the Village neighbourhood and accessible by service road and trails.

**Park trail** – switchback trail connecting the utility corridor with the top of Soundview Park.

**Climbing Cliff** – recreational climbing cliffs associated with Soundview Park .

## Proposed Development Land Uses and Phasing

The proposed South Britannia development includes residential units, accommodation and commercial space summarized on the following table phased over approximately 25 years.

*Table 9: Land uses and phasing (from Tiger Bay Development Corp.)*

| Land Use | Facility | units | Phase 1 2019-25 | Phase 2 2026-30 | Phase 3 2031-35 | Phase 4 2036-45 | Total |
|---|---|---|---|---|---|---|---|
| Housing | Townhouses & Apartments | housing units | | 202 | 259 | 589 | 1050 |
| Commercial | Recreation (Wavegarden) | m2 floor area | 2500 | 370 | | | 2870 |
| Food & beverage | Brew pub & Restaurant | m2 floor area | 400 | | 300 | | 700 |
| Municipal | Office & Works Yard (1) | m2 land area | 500 | | | 1500 | 1500 |
| Accommodation | hotel, cabins, glamping | keys | 20 | 70 | 70 | 30 | 190 |
| Recreational | various | m2 land area | 25000 surf park, 9700 skate park | 1300 park & open space | 45000 park & open dueinf space | 1300 park & open space | 25000 active + 47600 passive |

(1) the works yard will be used for a construction office, staging yard, and work yard for Ph. 1 and will then be used as the public works yard for Phase 2 and beyond to support municipal utility operations.

The extent of Phase 1 is determined by the maximum traffic that can be accommodated by only the North Access operating as a stop sign-controlled full movement intersection with small improvements to the existing configuration. Phase 2 is initiated by the construction of the South Access, improved highway underpass, connecting boulevard and Nouth Access, thus facilitating the remainder of the development.

The separation into phases after Phase 1 is uncertain and is presented as a working assumption to permit a time-based transportation analysis. The actual order of development and timing will be dictated by market demand and economics, and some land uses might vary from the assumptions noted in the table. As such, it might be necessary to revisit the impact assessment in the future.

## Summary

Major land uses include the following:

- Commercial
- Residential
- Accommodation

- Park
- Environmental and Natural
- Utility
- Institutional

*Site Plan, Final* illustrates the configuration of the land uses, servicing, land grading concept, environmental mitigation and compensation, mobility and other features of the fully built-out site.

# TRANSPORTATION

## Existing conditions

Highway 99 is the major north-south corridor connecting Vancouver to the interior of the province through West Vancouver, Lions Bay, Furry Creek, Britannia, Squamish, Whistler, Pemberton and terminates at Highway 97 near Cache Creek. The recently upgraded Highway 99, a legacy of the 2010 Olympics, is a lifeline for all communities along the Sea to Sky Corridor. The highway consists of a combination of one and two lanes in each direction. Posted speeds range from 60km/h to 100km/h, with the lower speed limit designated in urban areas such as Lions Bay, Squamish, Britannia Beach and near signalized intersections. The highway passes through the Britannia community and the development site, as shown in the following figure.

Copper Drive is the main access road providing a Highway connection to the existing North Britannia community and Mine Museum. It is a 2-lane road that connects to Highway 99 as a T-intersection with traffic signal control, including a pedestrian crosswalk. Right turn channelized lanes are in place for the northbound and westbound approaches.

Access to the South Britannia site is provided by the existing North Access that allows all turns, has a southbound left turn-in lane and a short section of northbound right turn-in lane and a short northbound merging lane, all without signal control.

Two sections of 2-lane highway are located at the Copper Drive “pinch point” and at the Murrin Park “pinch point”. These pinch points cause traffic to back up, sometimes for kilometres, at the peak travel times on the highway that generally corresponds to the skier commutes between Vancouver and Whistler occurring northbound on Friday PM and southbound on Sunday PM.

The Copper Drive pinch point is caused by the highway being reduced to 2-lanes between the CN Rail to the west and a steep rock cliff, a historic mine conveyor and the tourist entrance portal to the mine to the east.  Refer to the photos after the site plan. The Copper Drive intersection capacity is also constrained by the 2-lane bridge located immediately north of the intersection.

The Murrin Park pinch point is caused by a section of highway constrained to two lanes by a lake to the west and cliffs and the BC Hydro transmission R/W to the east. Refer to the photos after the site plan.

Conversations with a Whistler resident (the author’s brother) confirmed that the Murrin Park pinch point delay is typically 10 to 20 minutes, is almost always the first and worst backup and that residents travelling the highway know this and time-shift to avoid the delay and aggravation. Delays at Copper Drive, both north and southbound, were noted to be much shorter, especially southbound presumably because the Murrin Park pinch point throttled traffic volumes reaching the Copper Drive intersection.

In time, a bypass route for Highway 99 might be constructed by MoTI along the hillside the east of South Britannia. This new section of highway would provide for higher speed movement of through traffic along the Sea to Sky Corridor. The old highway route through the lower lands at Britannia Beach would become an urban collector for the community with slower-moving vehicle traffic mixed with pedestrians and cyclists and a more urban streetscape. The timing for this expensive construction is uncertain and MoTI indicated it might be in the order of 15 to 30 years. Because of this uncertainty, it is necessary to design site access to suit existing conditions.

*Figure 23: Highway 99 through Britannia*

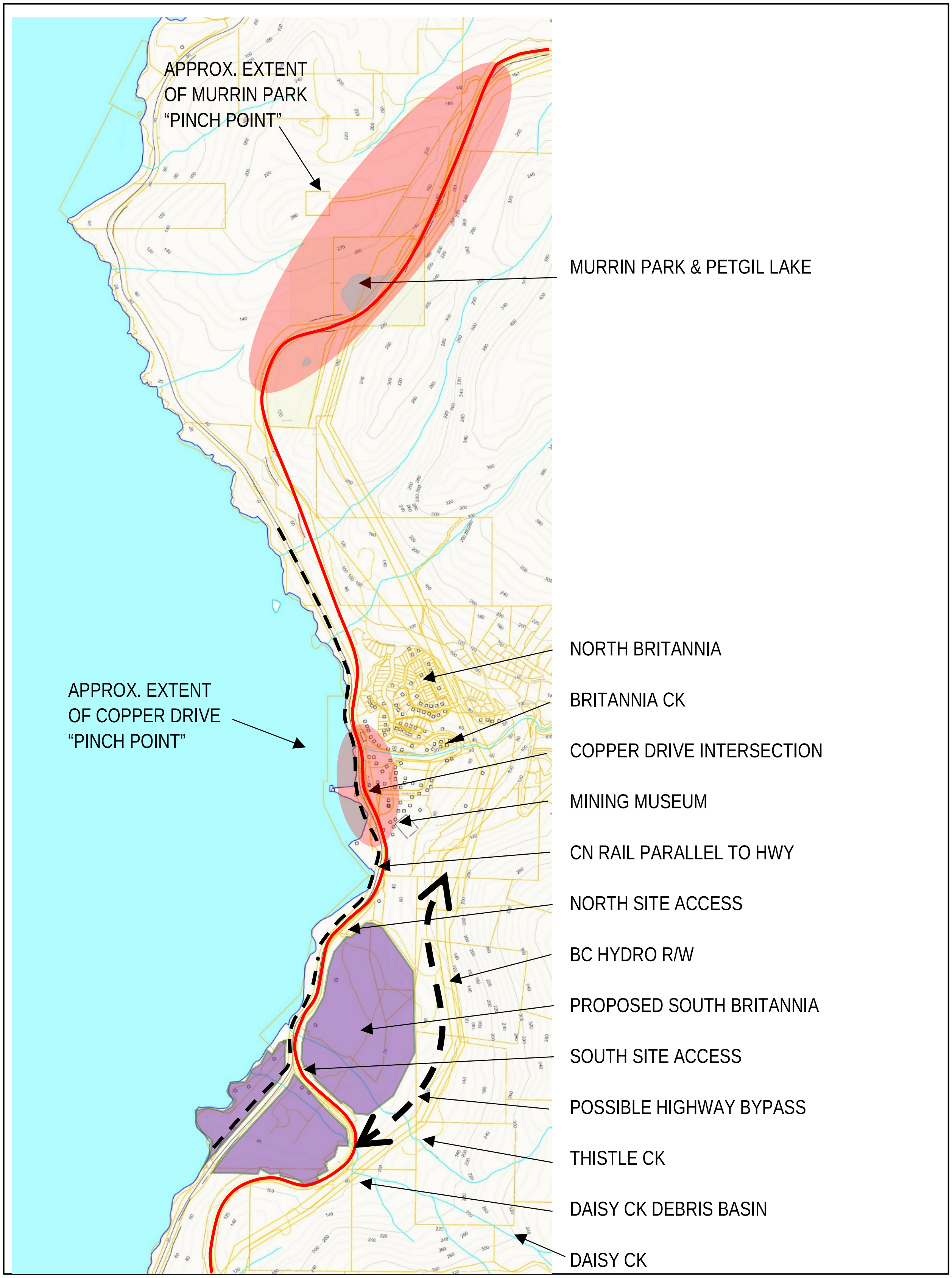


*Figure 24: Copper Drive pinch point and Google Streetview image looking from conveyor to the south*

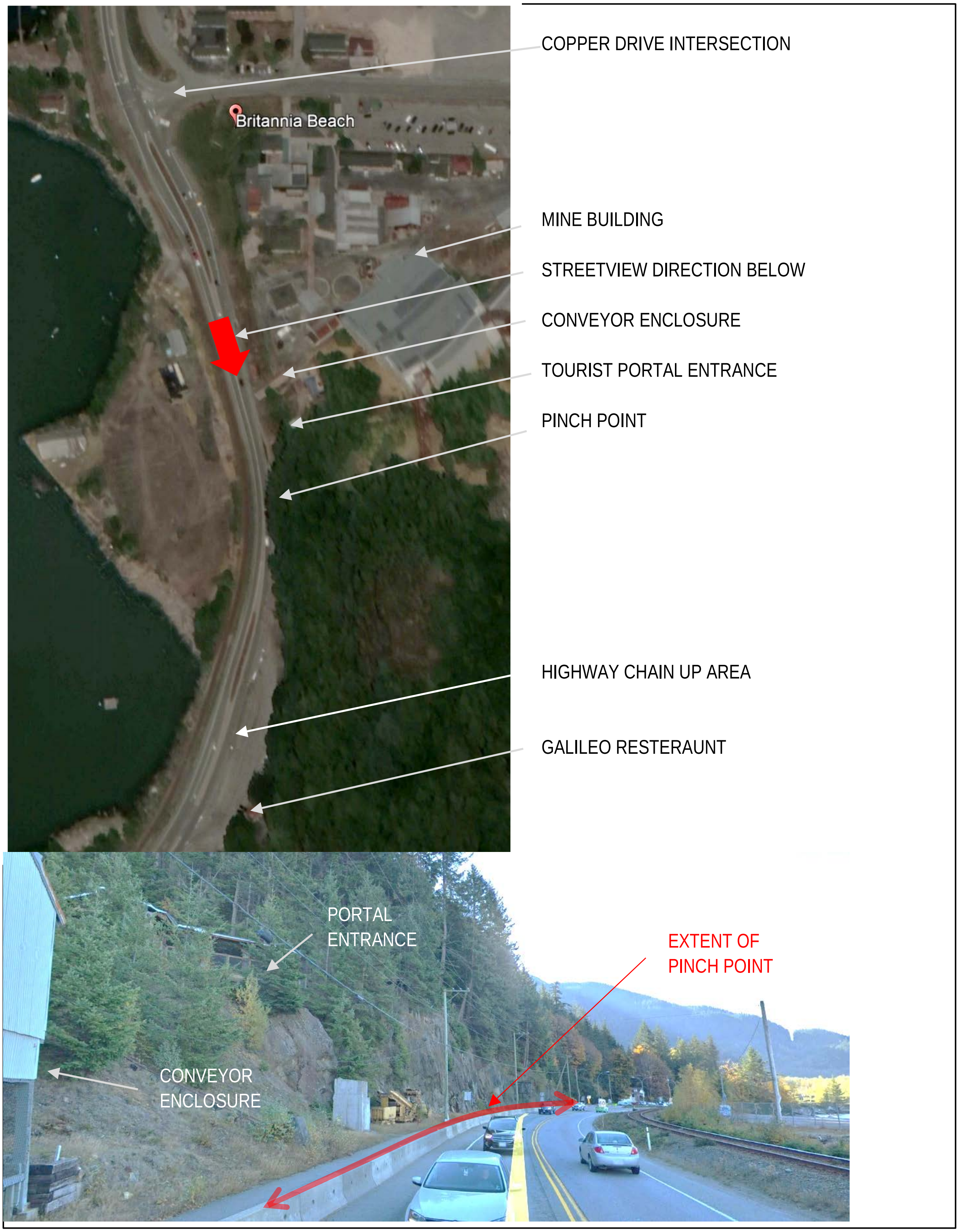
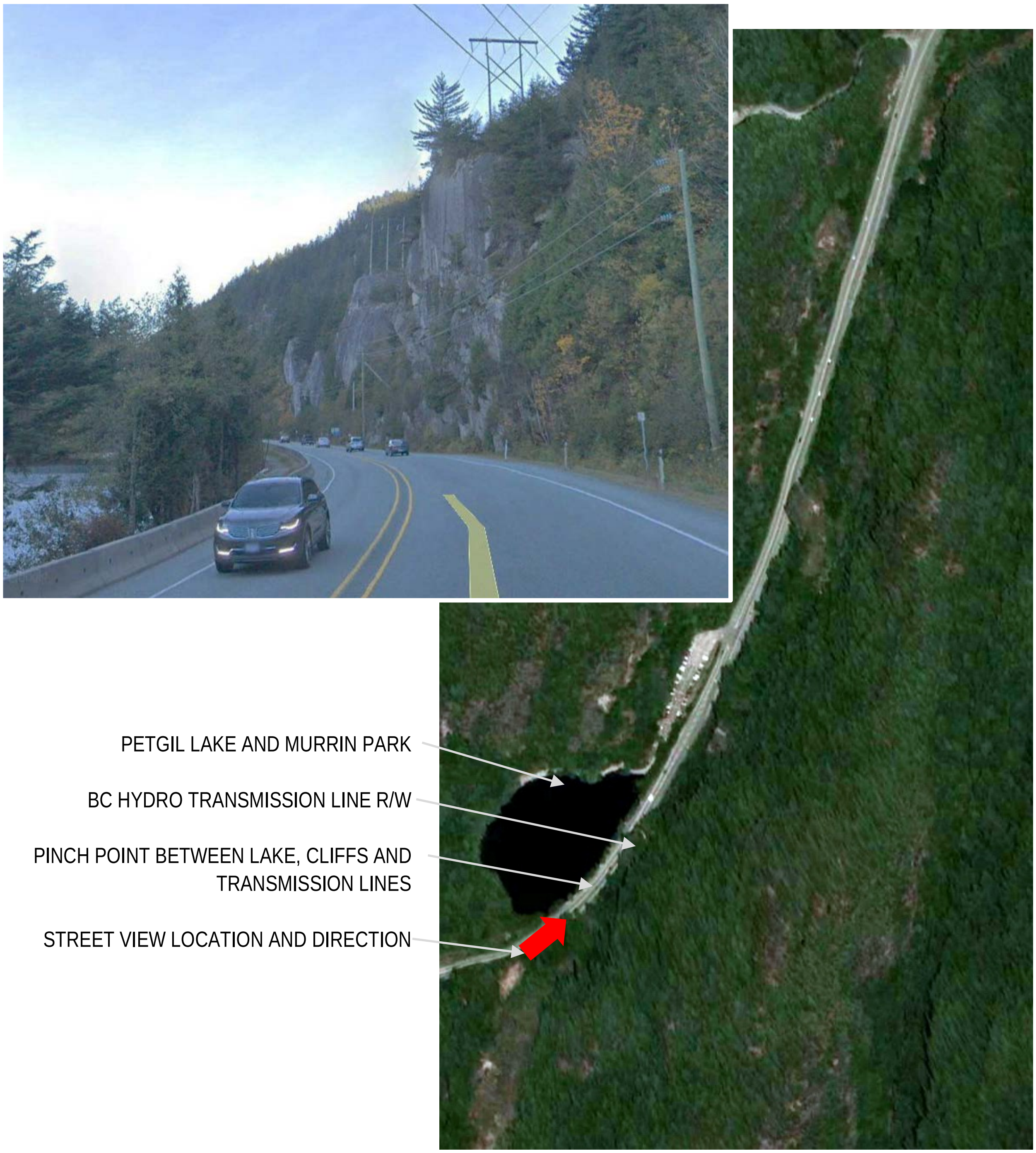


*Figure 25: Murrin Park pinch point and Google Streetview looking north*



### Existing transit service

Translink is the entity responsible for the regional transportation network in Greater Vancouver terminating at Lions Bay, which is 20 km south of Britannia Beach. BC Transit, the corporation responsible for services outside of Greater Vancouver, provides public transit in Squamish, Whistler and Pemberton. There are no public transit services connecting Britannia to Vancouver or Squamish and beyond.

Private companies offer transportation services along the Sea to Sky Corridor to Greater Vancouver and the Vancouver Airport. Some of them stop upon request at Copper Drive.

## Capacity Analysis Parameters

A capacity analysis generates volume-to-capacity ratios (v/c), a predicted "delay-based" Level of Service (LOS) indicator and a queueing length Q in meters for each traffic movement at the analyzed intersection.

A v/c ratio of up to 0.85 is generally considered to be acceptable for an intersection and up to 0.90 for individual lanes or lane groups. A v/c ratio of 1.0 or greater indicates that the traffic operation is over-capacity.

Shorter queueing length Q is better, and longer queueing length indicates a lower service level provided by the intersection.

The LOS indicator ranges from "A" with a delay of 10 seconds or less and indicating minimal or no delay through to "F" with a delay of 50 seconds (un-signalized intersection) or 80 seconds (signalized intersection) indicating generally unacceptable delay. Note that the LOS is a delay in seconds. Therefore it is possible to have a long delay, though a short queue length and a low v/c.

Capacity is a quantitative measure, whereas LOS is a qualitative measure. Capacity is defined by considering the traffic, geometry and control conditions and is best obtained from field observation. LOS assigns quality levels of traffic based on performance measures like speed, density, etc.

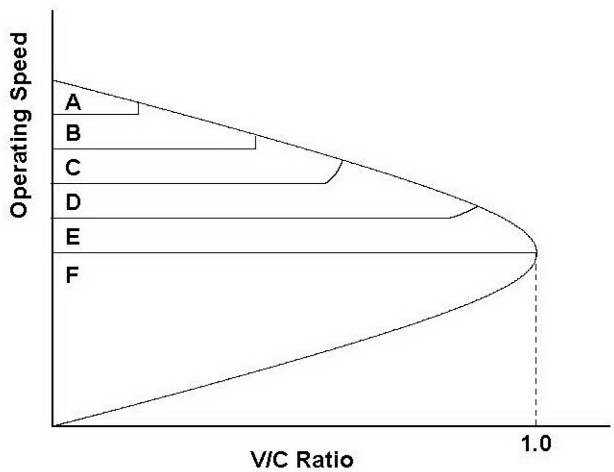
The following is a description of LOS from the Highway Capacity Manual of the Transportation Research Board in the United States:

> A: free flow. Traffic flows at or above the posted speed limit, and motorists have complete mobility between lanes. The average spacing between vehicles is about 550 ft(167 m) or 27 car lengths. Motorists have a high level of physical and psychological comfort. The effects of incidents or point breakdowns are easily absorbed. LOS A generally occurs late at night in urban areas and frequently in rural areas.
> B: reasonably free flow. LOS A speeds are maintained, maneuverability within the traffic stream is slightly restricted. The lowest average vehicle spacing is about 330 ft(100 m) or 16 car lengths. Motorists still have a high level of physical and psychological comfort.
> C: stable flow, at or near free flow. The ability to maneuver through lanes is noticeably restricted, and lane changes require more driver awareness. Minimum vehicle spacing is about 220 ft(67 m) or 11 car lengths. Most experienced drivers are comfortable, roads remain safely below but efficiently close to capacity, and posted speed is maintained. Minor incidents may still have no effect, but localized service will have noticeable effects, and traffic delays will form behind the incident. This is the target LOS for some urban and most rural highways.
> D: approaching unstable flow. Speeds slightly decrease as traffic volume slightly increases. Freedom to maneuver within the traffic stream is much more limited, and driver comfort levels decrease. Vehicles are spaced about 160 ft(50m) or eight car lengths. Minor incidents are expected to create delays. Examples are a busy shopping corridor in the middle of a weekday, or a functional urban highway during commuting hours. It is a common goal for urban

streets during peak hours, as attaining LOS C would require prohibitive cost and societal impact in bypass roads and lane additions.
E: unstable flow, operating at capacity. Flow becomes irregular, and speed varies rapidly because there are virtually no usable gaps to maneuver in the traffic stream, and speeds rarely reach the posted limit. Vehicle spacing is about six car lengths, but speeds are still at or above 50 mi/h(80 km/h). Any disruption to traffic flow, such as merging ramp traffic or lane changes, will create a shock wave affecting traffic upstream. Any incident will create serious delays. Drivers' level of comfort become poor.[1] This is a common standard in larger urban areas, where some roadway congestion is inevitable.
F: forced or breakdown flow. Every vehicle moves in lockstep with the vehicle in front of it, with frequent slowing required. Travel time cannot be predicted, with generally more demand than capacity. A road in a constant traffic jam is at this LOS, because LOS is an average or typical service rather than a constant state. For example, a highway might be at LOS D for the AM peak hour, but have traffic consistent with LOS C some days, LOS E or F others, and come to a halt once every few weeks.

The following graphic gleaned from the Internet (therefore it must be true) attempts to illustrate the qualitative aspects of LOS

*Figure 26: Level of Service chart*




In summary, satisfactory intersection performance would have:

- v/c less than 0.85-0.90,
- Q that is not too long, though this is not defined
- LOS of D or better.

## Transportation Impact Assessment

### Scope of analysis

Bunt & Associates (Bunt) were engaged by Tiger Bay Development Corporation to prepare a Transportation Assessment Report for the proposed Britannia Beach South development in Britannia Beach, BC. The report provides a summary of the proposed access strategy, traffic operations impact results and design recommendations to support the Britannia Beach development. The scope of the assessment includes:

- Collection & review of available relevant information along the Highway 99 corridor;
- Collection & review of traffic counts in the defined study area;
- An assessment of existing traffic demand and operational conditions as well as existing provision for alternative modes of travel;
- An assessment of future background traffic demand and operational conditions, without the site development area;
- Estimation of future site traffic volumes during key periods and operational conditions of adjacent intersections;
- Development of a phased access strategy to connect to Highway 99;
- Determination of improvements, if any, required to support the additional traffic generated by the proposed development; and,
- A review of the site plan including vehicle access and circulation, high-level parking review, and
- provision for potential alternative modes of travel.

The proposed study area for the operational analysis consists of approximately 2.5 km of Highway 99, extending up to the Copper Drive intersection to the north and the edge of the proposed development to the south.

### Traffic counts

Bunt used the following highway traffic counts to establish base loads and calibrate their model:

- Data from MoTI permanent count stations located north of Horseshoe Bay and at Cheekeye north of Squamish.
- Traffic counts performed by Bunt at the Copper Drive/Highway 99 intersection on Friday, April 12, 07:00 to 09:00 and 15:00 to 18:00 and on Sunday, April 14, 11:00 to 16:00.

The traffic counts revealed the following:

- The two highest traffic volume periods for Highway 99 near the site are Friday afternoon to early evening northbound, and Sunday afternoon for southbound.
- Summer total traffic volumes are greater than winter total traffic volumes.
- Peak hourly volumes tend to be higher in winter than in summer.
- The highest peak hour volumes occur during the winter holiday season (typically New Year Jan 1 to Jan 2), spring break (last two weeks of March) and summer vacation (July to August).
- Other than the noted holiday peaks, traffic volumes on Highway 99 are reasonably consistent, and Bunt assumed represented by the April 12 and 14 traffic counts.

*Table 10: Observed traffic volumes on Highway 99 at Copper Drive (from Bunt Associates)*

| Direction | Existing (Vehicles per hour) | | |
|---|---|---|---|
| | Weekday AM | Weekday PM | Sunday |
| Northbound | 500 | 1200 | 600 |
| Southbound | 600 | 750 | 1200 |

### Background Growth

MoTI requires that the background traffic volume is calculated using a growth rate of 2.3% per year (compounded) for Highway 99 imposed on the 2019 traffic volumes noted above with no highway traffic capacity constraints.

The 2.3% annual growth rate includes residential development in the corridor and, therefore, presumably includes the 1050 units for Britannia South. MoTI methodology for traffic studies superimposes traffic from a proposed project on the background, in this case, effectively double-counting the traffic from the proposed development. This methodology might be acceptable for a small development on a major transportation corridor but might become inappropriately conservative as the development size increases in relation to the capacity of the corridor. This issue has not been investigated, therefore making Bunt's analysis conservative.

### Existing Conditions Analysis for Copper Drive intersection

Level of Service at the Copper Drive intersection, when optimized at a 90-second cycle length and using 2019 traffic counts, range from LOS "A" to an unacceptable "D" for Weekday AM and PM peak hours. The traffic volume-to-capacity (v/c) ratios are generally acceptable except for southbound through on Sunday and northbound through for weekday afternoon, especially Friday.

*Table 11: Copper Drive intersection, existing vehicle operations*

| Movement | Weekday AM | | | Weekday PM | | | Sunday | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOS | v/c | Q, m | LOS | v/c | Q, m | LOS | v/c | Q, m |
| *overall* | *A* | *0.51* | *na* | *A* | *0.83* | *na* | *A* | *0.82* | *na* |
| WBL | C | 0.16 | 6 | D | 0.13 | 6 | C | 0.26 | 10 |
| WBR | C | 0.02 | 6 | D | 0.03 | 9 | C | 0.02 | 8 |
| NBT | A | 0.45 | 55 | B | 0.87 | 276 | A | 0.46 | 60 |
| NBR | A | 0.01 | 2 | A | 0.02 | 2 | A | 0.01 | 2 |
| SBL | A | 0.02 | 1 | B | 0.17 | 2 | A | 0.06 | 2 |
| SBT | A | 0.49 | 42 | A | 0.50 | 53 | A | 0.79 | 157 |

WB= westbound, NB=northbound, SB=southbound, L=left, T=through, R=right

Overall intersection operations (first row in the table) are acceptable during the weekday AM and PM and Sunday peak hours, each having a LOS of "A". The overall v/c ratio does not exceed 0.83.

Queuing is not a direct measure of service as some intersection queues can move quickly. However, it is clear the combination of w/c=0.87 and Q=276m for weekday PM northbound-through is a concern, as is the 157m Sunday southbound queuing length. It is noted that the highway performs acceptably during all other conditions and that upgrading would relieve congestion that occurs for only a few hours per week and as such might be difficult to justify.

Bunt conducted a sensitivity analysis of the existing vehicle operations by changing the proportion of north and southbound traffic. The results did not materially change from the analysis noted above.

The addition of one more southbound and one more northbound traffic lane on Highway 99 through the Copper Drive intersection would significantly improve traffic flow during the noted peaks. Unfortunately, potential road and R/W widths through this section (referred to as the “Copper Drive pinch point) are constrained by the CN Rail on the ocean side and rock cliffs and the entrance to the Mining Museum’s mine portal tour entrance on the land side. Widening the R/W to the west (seaward) is likely impractical because of opposition by CN Rail, and because the rail bed is already installed on ballast rock perched on the potentially unstable steep underwater alluvial fan of Britannia Creek. This leaves expansion to the east, into the cliff, as the only practical expansion option. There are two immediately recognized constraints to eastward expansion. The first is the rock cliff that would require blasting. The second is the location of the staging area for the tourist portal for the Mine Museum that is located near the highway. Three possible conjectured solutions to the portal location are:

- Access the mine tour using a different access point or route;
- Partially cantilever a reconfigured staging area over the expanded highway rock face; or
- Locate a reconfigured staging area on the east side of a pedestrian overpass located at that area and used to both support the mine’s staging area and provide a pedestrian crossing. This might be a structurally cheaper solution than a cantilevered platform.

Two alternatives to the expensive upgrading of the Britannia pinch point are noted below:

1) Allow the congestion to persist, which will result in drivers time-shifting to spread the peak load. The critical times are Friday PM and Sunday PM when drivers are travelling to and returning from skiing at Whistler. Given that this is a recreationally driven peak, it might be reasonable to rely on time-shifting, thus transferring the onus of response to the travellers who are the cause of the peak loading.
2) Aggressively encourage transit solutions that would remove weekend drivers from the road to reduce peak loading and environmental impacts of driving. For example, the driving cost for a passenger vehicle used to travel for skiing is around 240km x $0.50/km vehicle cost plus $15/d parking = $135 return. Epic Rides operates a convenient app-booked bus service for $35 return which is substantially cheaper than driving, but for some people might be more agreeable as it avoids the need to drive in the dark and mutter their way through the Murrin Park pinch point in both directions. Driving cost equals bus cost at a party size of 4 persons. Of course, the bus is the only option for skiers without access to a car and might be the preferred option for travellers who wish to reduce their environmental footprint.

The Bunt analysis <u>assumes that MoTI builds the additional south and northbound lanes by 2025. The traffic analysis for South Britannia is based on this improved highway configuration, as these are required to alleviate existing delays that will be exacerbated by background growth.</u>

## Proposed Access Design

Two access points will be developed in a phased manner to match the transportation requirements of South Britannia. Refer to *Dwg.2 - Engineering Concept, Final* for the location of the referenced North and South Access and to the previous section for the phasing plan.

**North Access** – For Phase 1, do minor upgrading of the existing at-grade North Access intersection to provide access as a full turning movement intersection. At the start of Phase 2, "downgrade" the North Access to provide right-in and right-out access only and carry out further improvements to the intersection so that it conforms to current geometric standards.

**South Access** – At the start of Phase 2, build a new at-grade intersection with only right-in and right-out access.

The following table summarizes the phased site access strategy. The analysis that leads to this strategy is detailed in the Bunt report. Figures on the following pages illustrate the configuration of the recommended improvements while maintaining acceptable Level of Service. Specific dates are used rather than the phase date ranges and correspond with the dates in Bunt Table 6.13.

*Table 12: Access improvements by date*

| Date | North Access (by developer) | South Access (by developer) | Hwy 99 Britannia Ck to North Access including Copper Drive Intersection (by MoTI) |
|---|---|---|---|
| 2025 | Complete minor upgrading of the existing North Access intersection including: (1) longer northbound right-in deceleration lane with larger radius entrance; (2) longer northbound right-out acceleration lane with larger radius; (3) Stop-controlled left turn lane westbound out of site heading southbound on Hwy99 | n/a | Improvements to mitigate background growth, including: (1) Signal optimization at Copper Drive to 90-second cycle length. (2) Add a second Hwy99 southbound lane between Copper Drive and the North Access through the pinch point. (3) Add a length of northbound Hwy99 lane between the start of the pinch point past Copper Drive and extending to the Britannia Ck bridge. (4) Add a second northbound Hwy99 lane through the North Access intersection. |
| 2028 | Convert full movement North Access to right-in and right-out only with second northbound through lane and larger radius entrances and islands. | Build new South Access with: (1) southbound deceleration lane with right-in only access ramp; (2) southbound right-out ramp with acceleration lane, | na |

Should the Highway Bypass be provided before or within the noted phases, the suggested improvements to the North Access will not be required and the South Access will be substantially simplified.

*Figure 27: Existing (2019) laning (from Bunt)*

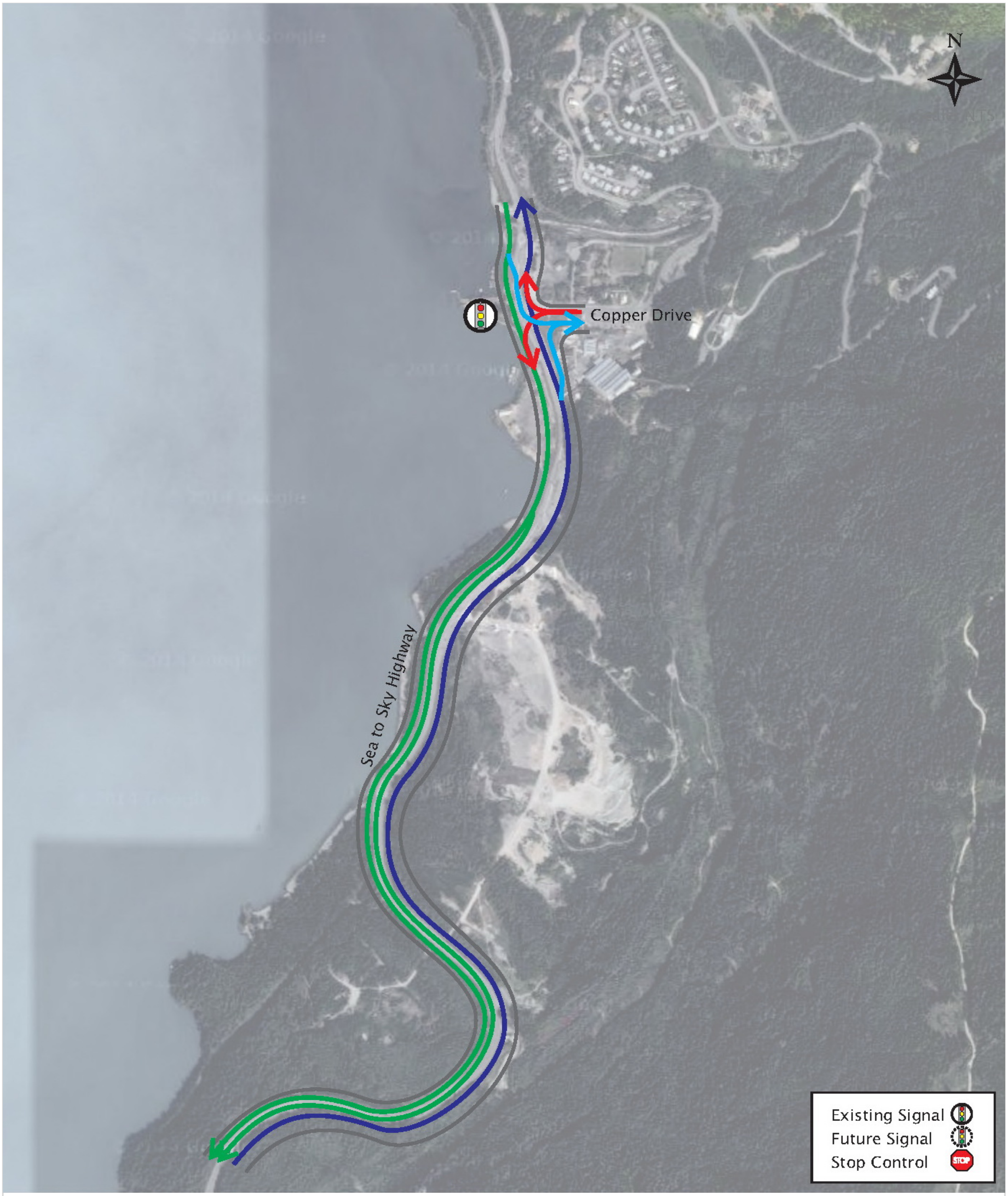





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*Figure 28: (2025) required laning improvements at Copper Drive and Access A to suit existing conditions and to service the Phase 1 development (from Bunt)*

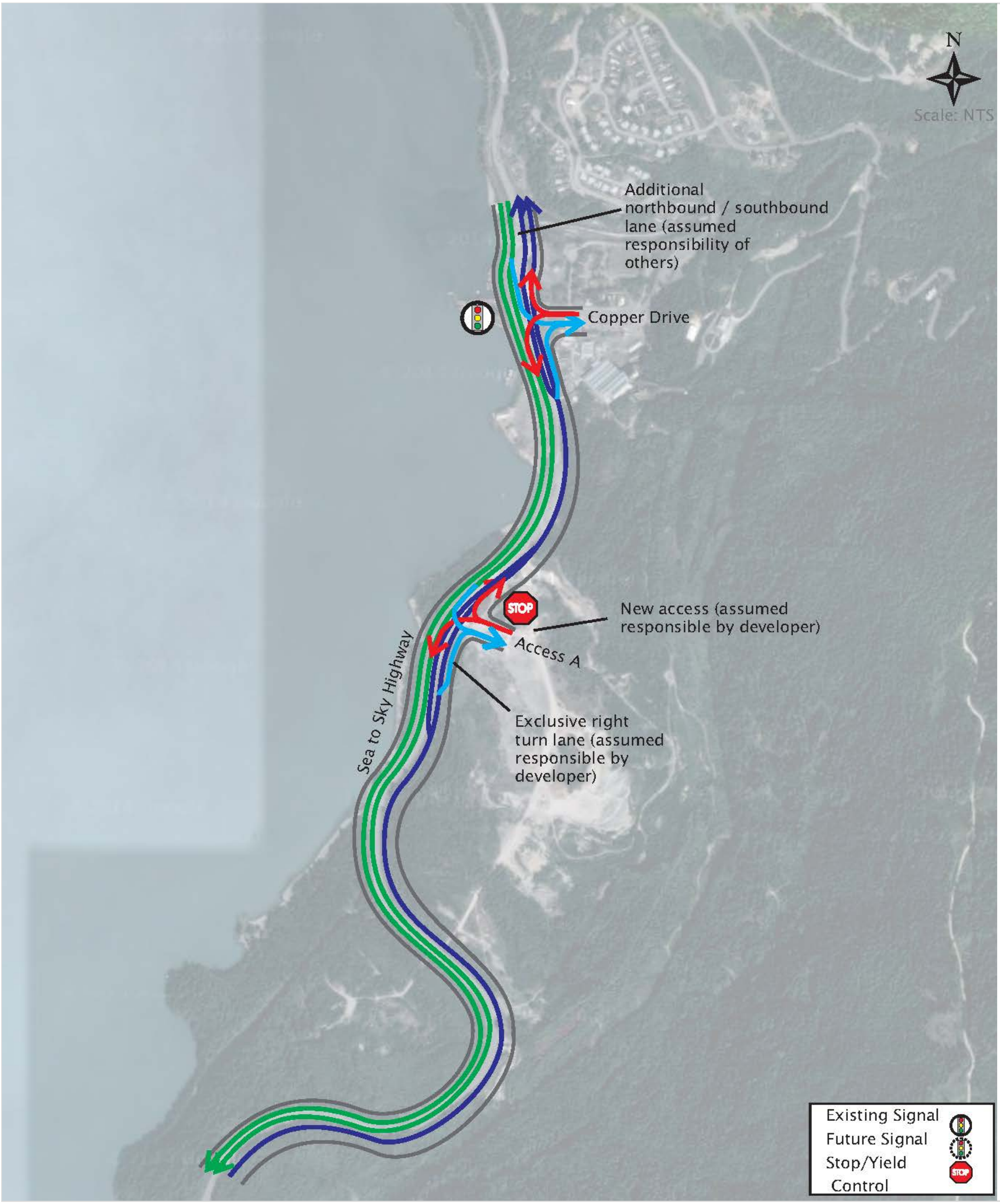
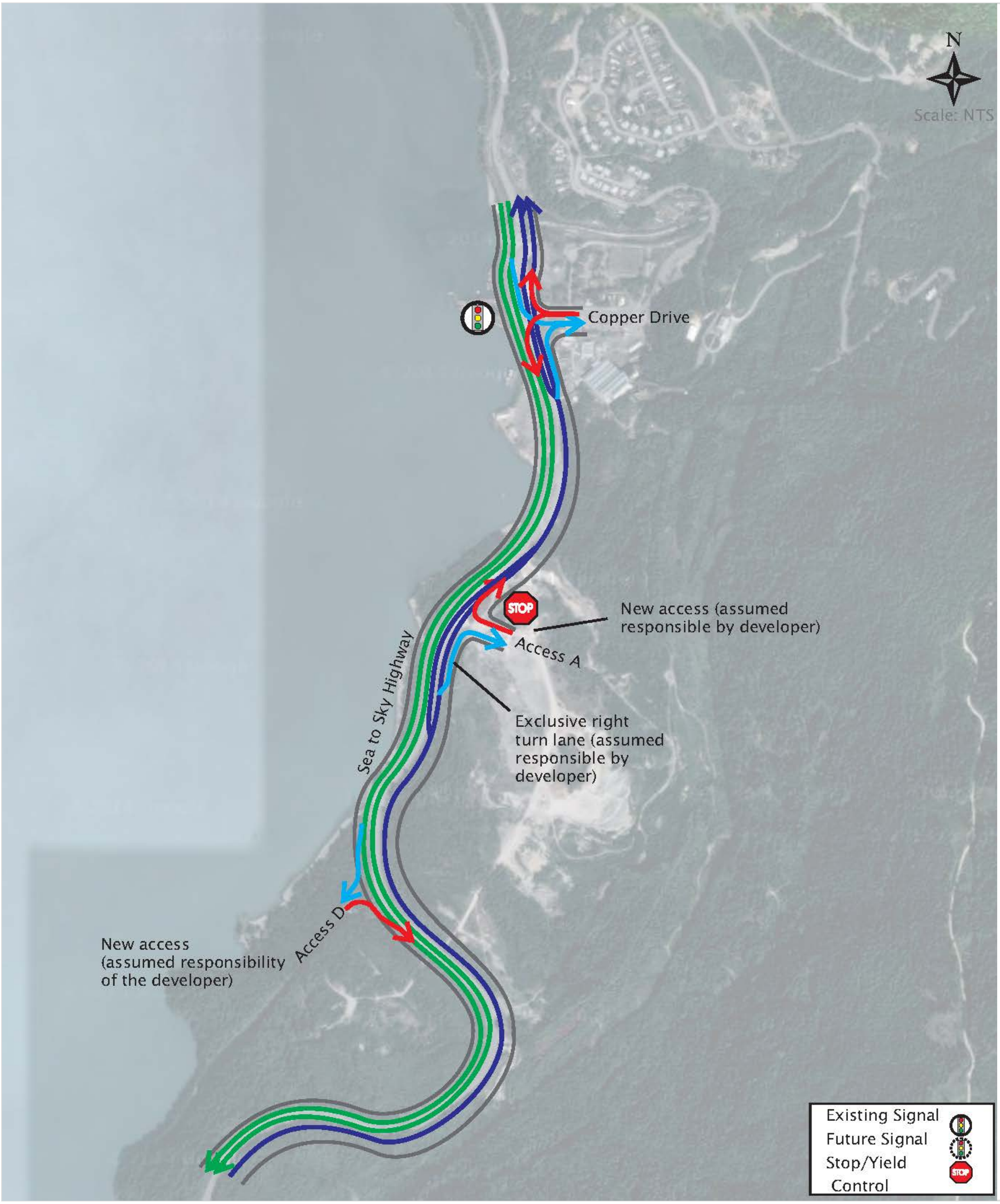


*Figure 29: 2028 intersection improvements (from Bunt)*



## Proposed On-Site Road Design

A single main traffic collector road (Britannia Blvd.) connects the existing highway intersection (North Access) and the Minaty highway intersection (South Access) while providing access to the residential, commercial, institutional and park areas via secondary roads, lanes and paths. All local roads will be designed to permit slow speed access by emergency, utility and snow clearing vehicles.

### Collector road

Britannia Blvd. consists of two 3.0 m vehicle travel lanes, bike lanes, multi-use pathway, and parking bays alternating with rain gardens and trees all set in a 22m wide right-of-way. The roadway surface will be drained to rain gardens at the low points of the road. Fast cyclists will use the vehicle lane that is enhanced by a 1.4m  bike "sharrow" next to the vehicle lane. Slow cyclists can use the 3.0 m wide multi-use sidewalk. The geometric design speed will be 50 km/hr to conform with MoTI requirements but will be posted for 40 km/hr to improve comfort and safety for pedestrians and cyclists. Frictional elements such as the slightly narrow travel lanes, parking, treed boulevards both sides, pedestrian crossing bump-outs at intersections and mid-blocks, will be included to attenuate travel speeds naturally. Other speed attenuating elements might also be added during design.

The collector cross-section will consist of the following widths:

*Table 13: Collector road cross-section*

| Element | Width, m | |
|---|---|---|
| WEST | | |
| Utility setback / boulevard | 1.0 | |
| Boulevard (to gutter) | 1.8 | |
| Alternating parking and rain garden (to gutter) | 2.3 | |
| Bicycle sharrow | 1.4 | |
| Vehicle | 3.0 | |
| Subtotal ROW to CL | | 9.5 |
| EAST | | |
| Utility setback | 1.0 | |
| Multi-use sidewalk | 3.0 | |
| Boulevard (to gutter) | 1.8 | |
| Alternating parking and rain garden (to gutter) | 2.3 | |
| Bicycle sharrow | 1.4 | |
| Vehicle | 3.0 | |
| Subtotal ROW to CL | | 12.5 |
| Total ROW | | 22.0 |

These cross-sectional elements are preliminary and subject to review by the approval agencies.

### Residential local roads

The local roads that provide access to the development parcels will be designed and built by developers to suit their proposed parcel design. These can be designated as public roads, or as private roads or driveways.

Public local roads should conform to the MoTI local road standard with modifications to reduce traffic speed by using frictional elements. Public local roads should consist of two 3.0m travelled lanes, 2.3 m parking/rain garden lanes, 1.9m boulevards, 1.8m sidewalks and 1m utility space set in a 20.0 m right-of-way. The design and posted speed will be 30 km/hr. This specification is flexible. Cyclists and pedestrians will share the road with local traffic. The local roads will be drained using a combination of curb and gutter, as well as sections of road-side rain gardens and grassed verges replacing one side of parking. Flat curbs or curb cuts will be used at rain gardens to permit drainage to the rain-garden. The local roads will use more aggressive frictional elements such as irregular parking, angled parking (by consolidating both parking lane allowances into one side and weaving the travelled lanes), rain gardens, pedestrian bump-outs, neighbourhood entrances, shoulder use changes (alternating rain-gardens with parking) and other landscape features to naturally attenuate speed and signal a change of use from vehicle to pedestrian and bike. If successful, the secondary streets will be littered by shinny goals, basketball hoops, children and parents with strollers.

*Table 14: Local road cross-section*

| Element | Width, m | Totals |
|---|---|---|
| Utility setback / boulevard | 1.0 | |
| Sidewalk | 1.8 | |
| Boulevard | 1.9 | |
| Parking/rain garden | 2.3 | |
| Vehicle | 3.0 | |
| Subtotal ROW to CL | | 10.0 |
| Utility setback / boulevard | 1.0 | |
| Sidewalk | 1.8 | |
| Boulevard | 1.9 | |
| Parking/raingarden | 2.3 | |
| Vehicle | 3.0 | |
| Subtotal ROW to CL | | 10.0 |
| Total ROW | | 20.0 |

### Highway underpass

An existing single-lane highway underpass culvert connects Area A with Areas B&C and provides a travel path to the South Access. The underpass consists of a large corrugated metal pipe that was built in the 1950s during the original highway construction. The steel culvert pipe is corroded and might be near the end of its life. Tiger Bay will be approaching MoTI to replace or repair the culvert (perhaps with concrete slip lining) so that it is structurally suitable to support the highway for the long term and so that it satisfies MoTI’s responsibility to provide access to lands otherwise cut off by the highway.

The underpass will be further upgraded in Phase 2 to provide a single-lane alternating signalized vehicle passage with narrow raised pedestrian sidewalks both sides. The tunnel and entrance will be upgraded with enhanced lighting and the entrances will be landscaped to improve the aesthetics and comfort, especially for pedestrians.

MoTI standards require two-lane access to all lands as a condition of subdivision approval. Transportation studies by Bunt have demonstrated that signalized single-lane access is sufficient for the anticipated traffic. Further discussions will reveal if the expensive and disruptive construction of the second lane underpass can be avoided.

### Parking

The SLRD Zoning Bylaw No. 20 outlines the following off-street parking requirements:

*Table 15: Parking bylaw requirements (from Bunt)*

| Land Use | Size | Bylaw Requirements | |
|---|---|---|---|
| | | Rate | Spaces |
| Multi-family Residential (townhouse and apartment) | 1050 units | 1.25/unit plus 1 visitor space per 5 units. | 1313 + 210 = 1523 |
| Commercial and office | 2870 m2 gross floor area | 3 per 100 m2 of gross floor area | 87 |
| Food & beverage | 700 m2 gross floor area | 6 per 100 m2 of gross floor area | 42 |
| Hotel | 190 rooms or equivalent | 1 per room | 190 |
| Municipal office & works yard | | allowance(1) | 20 |
| Surf park, pump track, climbing cliff | | estimated | 200 |
| TOTAL | | | 2062 spaces |

(1) municipal spaces have not yet been defined.

All land uses will provide their own off-street parking requirements.

### Bicycle

Roads will be posted for reduced vehicle speeds to mitigate risk and discomfort for pedestrian and bicycle users. Bicycles will share the roads with vehicles and, besides, will be permitted to use the hard-surfaced, off-roadway “paths”. This will give users the choice of using easier and quicker roadway routes, or the more “scenic” routes, that together will, it is hoped, encourage bicycle use.

### Pedestrian

There are four classes of pedestrian routes that will provide efficient connections through the site, as well as recreational opportunities.

**Sidewalk** – Along Britannia Blvd.,  3.0 m wide multi-use path on one side, hard-surfaced with drainage control. Along local roads, 1.8m both sides or modified by landscape architectural design.

**Roadway** – local roads will be designed to reduce vehicle speeds and encourage roadside pedestrian use.

**Paths** – major off-road walking/bike routes, hard-surfaced (asphalt or packed fine gravel), shared with bicycles, generally flat or low grades, connecting the various community areas, 2 m wide surface with 0.5 m wide gravel shoulders, raised a minimum of 200 mm above the natural ground surface and crowned, with drainage control to protect the integrity of path structure.

**Trails** – minor off-road walking routes, located more remotely, can be steep, soft (native soil) surfaced, 1 to 2m wide to suit terrain and vegetation cover, minor or no drainage control.

In all cases, the design approach is to provide easily used, convenient, safe and inviting pedestrian routes that encourage walking.

## Transit

There is currently no public transit service to Britannia Beach, and a two-tiered approach is being contemplated. The site would be initially serviced by private operators and later supplemented by public transit.

Initially, transit will be provided by private "for-profit" operators such as the Squamish Connector, providing service to Vancouver and Squamish using the on-site transit centre. The transit center will include shelters, bike racks and a drop-off layby. Additional lay-bys can be included on both sides of Britannia Boulevard adjacent to the transit loop if required. Northbound transit vehicles will enter the site using the North Access and proceed to the transit centre and then exit the site and continue northward using the North Access. Southbound transit vehicles will enter the site using the South Access, proceed to the transit centre through the underpass and then continue their southward journey by again using the underpass and the South Access. The alternative to this inconvenient route is to provide a radio-controlled, south-bound, left-in turning lane at the North Access for busses only.

Public or express transit will likely wish to avoid the delay of entering the site to access the transit loop. Transit currently stops on the highway at Copper Drive where passengers can use the signalized intersection for crossing the highway and then walk or bike to their destinations in North Britannia, or to South Britannia using the connector path and then walk/bike to their destination or be picked up at the transit centre.

The possibility of establishing an express bus layby at the highway chain-up area associated with the Galileo Coffee Shop will be explored in future phases and will require the support of MoTI. This location would provide a direct pedestrian/bike connection to both communities (North and South) using the connecting path and utility corridor.

All bus shelters should include lighting, radiant heating, webcam security, real-time schedule update and free local/emergency phone. These safety and comfort features should enhance transit use. The webcam could be accessed by the public to allow security monitoring of their children.

School buses will use the same routes described for local transit and will traverse Britannia Blvd. to pick up students near their homes. A bus continuing to Furry Creek would exit the South Access southbound. A bus travelling to Squamish would exit the North Access northbound.

## Ride Share

Rideshare includes both passenger pick-up by private drivers as well as organized car and van-pooling. Individual rideshares can be coordinated using existing online apps or by private communications.

Organized pooling can be provided by existing organizations or by a local organization that owns the vehicle(s) and coordinates schedules, bookings, insurance and vehicle maintenance. Tiger Bay will coordinate and facilitate a trial rideshare program after substantial completion of Phase 2 servicing construction, with the details and cash contributions to be determined after further research.

## Car Share

*Car share* is a model of vehicle rental where people rent vehicles for short periods of time, often by the hour. They are attractive to customers who make only occasional use of a vehicle or might have only one family vehicle and occasionally need a second, as well as others who would like occasional access to a vehicle of a different type than they use day-to-day. The organization renting the cars may be a commercial business or the users may be organized as a company, non-profit society, public agency, cooperative or other *ad hoc* grouping.

Although every Care Share Organization (CSO) is different, carsharing has characteristics that are the same within every CSO:

- Car Share is defined by its environmental and social purpose, rather than business and financial objectives.
- Car Share is designed for local users in support of community transit and environmental goals. Its mission, vision and values lead to actions aimed at decreasing personal car ownership, reducing vehicle distance travelled, improving urban land use and development, providing affordable access to vehicles for all constituencies, as well as motivating residents to walk, cycle and take buses and trains, and decreasing dependence on fossil fuels while reducing the emission of greenhouse gases.
- Car Share is a membership-based service available to all qualified drivers in a community. No separate written agreement is required each time a member reserves and uses a vehicle. All CSOs offer members access to a dispersed network of shared vehicles 24-hours, 7-days a week at unattended self-service locations.
- Car Share is primarily designed for shorter time & distance trips as an extension of the transportation network, providing a public service designed to enhance mobility options. Longer trips may be available. CSOs help members save money over the cost of individual car ownership by encouraging members to drive less often, plan trips more, use other modes of transportation more, and share fuel-efficient vehicles when a car is needed.

Car Share organizations operating in Vancouver include ZipCar, Modo, Evo and Car2Go. A representative from Modo indicated that the South Britannia community does not fit their service model, suggesting issues related to the low number of potential users and that the isolated location of the community deterred the usual pick-up and drop-off scenario that makes the system work well. Modo offered the use of their booking technology for a fee to an organization that owned and maintained their own or Modo branded vehicles.

Car Share would not work well in Britannia in the usual mode of short-term use with pick-up and drop-off at different locations. The primary use might be to access shopping or services in Squamish, West/North Vancouver and Vancouver and then return the car to Britannia. This might be workable for people who do not wish to own a vehicle and can consolidate their usage, or to those who want to supplement a single-family vehicle or have access to a van or small truck for utility use.

Notwithstanding the substantial impediments noted above, Tiger Bay believes that Car Share might be a useful supplementary service, and Tiger Bay will conduct further research into viability and operating models after Substantial Completion of the Phase 2 construction.

## Summary

Four development phases are defined for the purpose of the traffic analysis. These phases are defined in the previous chapter *Development Plan*. The traffic loading and impacts were analyzed for each phase to understand the potential impacts to traffic flow along Highway 99. The proposed access strategy was evaluated based on a phased approach to meet access requirements at each development phase and impacts along the highway

A background traffic growth rate of 2.3% is used in the analysis as mandated by the Ministry of Transportation and Infrastructure (MoTI).

The traffic analysis evaluation scenarios included the typical winter Friday AM, Friday PM and Sunday afternoon peak hours, which represent the peak hour traffic volume conditions along the Sea to Sky corridor.

Immediate upgrading of Hwy 99 is required, between the Britannia Ck bridge and the existing North Access, to provide an acceptable level of service for current and background traffic growth during the peak traffic periods. The North Access will be upgraded in Phase 1 for improved full turning access and then converted in Phase 2 for right-in and right-out only access. The South Access will be built in Phase 2 for right-in and right-out access.

The proposed improvements include the following:

**Hwy 99 between Britannia Ck and North Access (2019-2025 by MoTI)**

Improvements are driven primarily by background growth, as evidenced by the need for immediate improvements to alleviate existing problems. All improvements should be completed by 2025.

- Copper Drive signal optimization to 90-second cycle length.
- Add a second Hwy99 southbound lane between Copper Drive and the North Access through the pinch point.
- Add a length of northbound Hwy99 lane between the pinch point south of Copper Drive and extending to the Britannia Ck bridge.
- Add a second northbound Hwy99 lane through the North Access intersection.

**North Access (by Tiger Bay)**

- Phase 1 (2019-2025) - continues to operate as a full movement intersection, extend the northbound deceleration lane to enter the site northbound, extend the acceleration lane to exit the site northbound.
- Phase 2 (2026-2028) - convert the intersection from all movement to right-in and right-out only by removing or repurposing the southbound left-turn lane turning into the site. Note that this might be repurposed as a radio signal controlled bus turning lane.

**South Access (by Tiger Bay)**

- Phase 2 (2026-2028)- construct new South Access, including a right-in deceleration lane and right-out acceleration lane complete with a bike lane.

The development plan allocates an 80m wide reserve for a future highway bypass located on the hillside above the new community and located immediately adjacent to the BC Hydro right-of-way and in an area that was originally planned to contain over 100 single-family lots. The proposed development areas are separated from the bypass corridor by an additional 20m wide buffer. The bypass will provide for higher speed movement of through traffic along the Sea to Sky Corridor. After construction of the bypass, the old highway route through the lower lands at Britannia Beach would become an urban collector route for the community with slower-moving vehicle traffic mixed with pedestrians and cyclists with an urban streetscape. The timing for this expensive construction is uncertain, and MoTI indicated it might be in the order of 15 to 30 years or beyond and is not being actively pursued. Access intersection improvements will be simplified if the bypass is implemented while the project is under development.

In order to support and encourage sustainable transportation modes, the site plan includes the provision of a pedestrian and bicycle path to North Britannia, and pedestrian trail systems and greenways throughout the community.

Based on the SLRD Zoning Bylaw, the proposed site will require 2,062 off-street parking spaces where the actual number will be refined during detailed design. Parking will be provided by the developer of each parcel for the use of that parcel.

Transit, car-sharing and ride-sharing programs are currently being solidified based on on-going discussion with multiple organizations.

Next steps include:

1. Complete review of the Transportation Impact Assessment (Bunt 2019) with MoTI and incorporate changes into the development plan.
2. Confirm that MoTI will accept a reduced speed standard for the proposed main road and a reduced curve radius for the approach to the South Access.
3. Carry out discussions with MoTI regarding configuration and usability of the existing culvert underpass, followed by structural and geometric assessments.
4. Carry out a pre-design of the North Access and South Access to define their geometry and update the development plan to accommodate any changes. This will also define the space available between the South Access off-ramp and the at-grade CN Rail crossing.

## Section References


1) *South Britannia Master Plan, Transportation Impact Analysis, Draft Update 4*, Bunt & Associates, Transportation Planners and Engineers, Project No 4983.03, June 26, 2019

# CN RAIL

## CN Rail Requirements

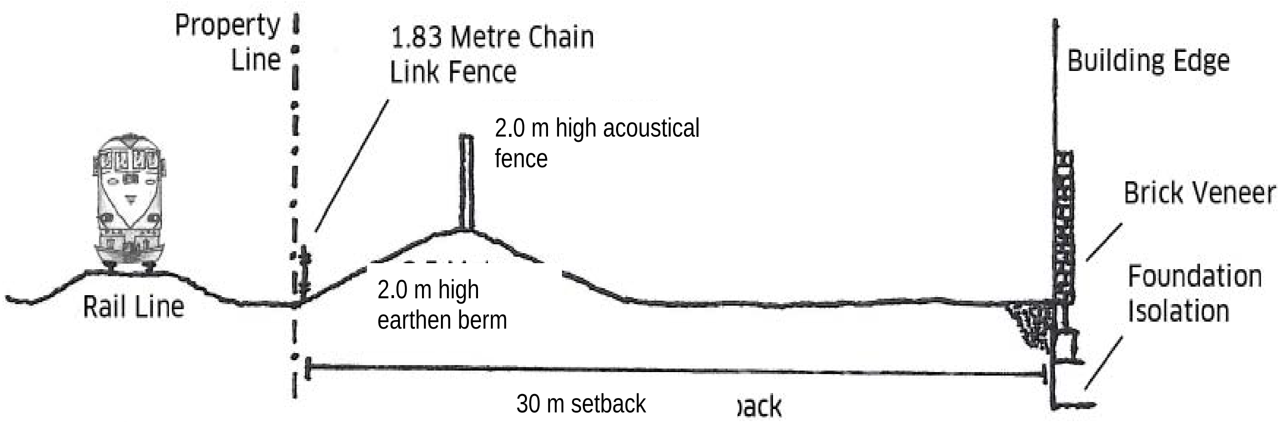
The location of residential land close to railway operations poses challenges for municipalities, developers and railways. The Federation of Canadian Municipalities (FCM) and the Railway Association of Canada (RAC) developed the updated *Guidelines for New Development in Proximity to Railway Operations* (Guidelines) in May 2013. The Guidelines are intended to document general planning policies when developing on lands in proximity to railway facilities, as well as to establish a process for making site-specific recommendations and decisions to reduce land-use incompatibilities for developments in proximity to railway operations.

Areas B and C of the proposed development abut the CN Rail line, which is a "Principal Branch Line," hosting a maximum of 5 trains per day at a speed of 25 mph. The southern portion of the rail alignment is set many meters below the surrounding land in an excavated trench. The final 300 m of rail through the north end of the neighbourhood, is at the same grade or higher than the surrounding land.

The west side of the rail line is bordered by the proposed Minaty Bay Community Park and by the proposed 30-room waterfront lodge. The Park borders an area of entrenched railway right-of-way, and the lodge site borders an area of level or raised railway right-of-way.

The following graphic is a simplified summary of the requirements that apply to developments bordering a Principal Branch Line and includes the following:

*Figure 30: Standard mitigation for new residential developments in proximity to a Main Line railway (Principal Branch Line uses 15 m setback) from Section Reference 1.*




- 1.83m (6 foot) high chain-link fence along the entire length of the bordering property line.
- 2.0m high berm with a maximum 2.5:1 side slopes to protect adjacent property from train derailment. A ditch or swale can be used in place of a berm. A berm is not required if the railway is entrenched by a depth equal to or exceeding the required berm height. The requirement for the berm will apply only to the Minaty Bay Lodge when that property is developed.

- 2.0 m high fence & sound barrier on top of the berm (for a total of 4.0 m height). The sound barrier is not required if the railway is entrenched a depth equal to or exceeding the required fence height (4m). The barrier will therefore only be required next to the Lodge site.
- A 15 m residential building/structure setback from the railway right-of-way for a Principal Branch Line
- A noise impact study is required when the rail line is within 150 m of development.

CN Rail advised by memo (undated c April 2013) of the following requirements that CN expects developers to abide by the guidelines for a development abutting a principal branch line. These guidelines are intended to be consistent with the RAC-FCM guidelines noted above.

1) The safety setback of habitable buildings from the railway rights-of-way shall be a minimum of 15 metres in conjunction with a safety berm. The safety berm shall be adjoining and parallel to the railway rights-of-way with returns at the ends, 2.0 metres above grade at the property line, with side slopes no steeper than 2.5 to 1.
2) The Owner shall engage a consultant to undertake an analysis of noise. At a minimum, a noise attenuation barrier shall be adjoining and parallel to the railway rights-of-way, having returns at the ends, and a minimum total height of 4.0 metres above top-of-rail. The acoustic fence shall be constructed without openings and shall be composed of a durable material weighing not less than 20 kg/m2 of surface area.
3) Ground-borne vibration transmission to be evaluated in a report through site testing to determine if dwellings within 75 metres of the railway rights-of-way will be impacted by vibration conditions in excess of 0.14 mm/sec RMS between 4 Hz and 200 Hz. The monitoring system should be capable of measuring frequencies between 4 Hz and 200 Hz, ±3 dB with an RMS averaging time constant of 1 second. If in excess, isolation measures will be required to ensure living areas do not exceed 0.14 mm/sec RMS on and above the first floor of the dwelling.
4) The Owner shall install and maintain a chain-link fence of minimum 1.83-metre height along the mutual property line
5) The following clause should be inserted in all development agreements, offers to purchase, and Agreements of Purchase and Sale or Lease of each dwelling unit within 300m of the railway right-of-way: “Warning: Canadian National Railway Company or its assigns or successors in interest has or have a right-of-way within 300 metres from the land the subject hereof. There may be alterations to or expansions of the railway facilities on such rights-of-way in the future including the possibility that the railway or its assigns or successors as aforesaid may expand its operations, which expansion may affect the living environment of the residents in the vicinity, notwithstanding the inclusion of any noise and vibration attenuating measures in the design of the development and individual dwelling(s). CNR will not be responsible for any complaints or claims arising from the use of such facilities and/or operations on, over or under the aforesaid rights-of-way.”
6) Any proposed alterations to the existing drainage pattern affecting railway property must receive prior concurrence from the Railway and be substantiated by a drainage report to the satisfaction of the Railway.
7) The Owner shall through restrictive covenants to be registered on title and all agreements of purchase and sale or lease provide notice to the public that the safety berm, fencing and vibration

isolation measures implemented are not to be tampered with or altered and further that the Owner shall have sole responsibility for and shall maintain these measures to the satisfaction of CN.

8) The Owner shall enter into an Agreement stipulating how CN's concerns will be resolved and will pay CN's reasonable costs in preparing and negotiating the agreement. 4 I. The Owner shall be required to grant CN an environmental easement for operational noise and vibration emissions, registered against the subject property in favour of CN.

## Crossing Requirements

The development will require one or more CN Rail crossings to access the proposed community park and lodge site in the Minaty Bay area west of the rail line.

The private crossing that currently provides access, is located on the north side of Daisy Creek, where the railway crosses the creek. It is an informal access that served the miners community for decades but is now non-conforming even as a private crossing.

*Photo 1: Existing non-conforming CN Rail crossing*


### Private crossing requirements

Section Reference 2 outlines the requirements for continued use as a private level crossing. Compliance is required by year-2021 and includes the following:

- The crossing upgrades must be paid for and maintained by Tiger Bay.
- Provide rubber flange-way surrounding the tracks.
- Provide 36” diameter minimum culverts under the approach road on both sides of the track.
- Approach roads shall be at the same elevation as the track (0% grade) for a distance of 25 ft. from the centerline of the track with slopes beyond to not exceed 5% (for an unspecified distance).
- Provide sight-line clearing in accordance with the regulations (estimated around 180 m to be confirmed).
- Provide standard crossing signs.
- Use is restricted to principals and employees of Tiger Bay.

### Public crossing requirements

The following process and improvements are required to change use from a private to public crossing:

- Complete a formal “Grade Crossing Safety Assessment” carried out by a registered professional.
- Provide sight-lines required by frequency of use and train speed.

*Photo 2: Railway crossing warning systems and barriers*


- A warning system (lights and bell) is required for a level crossing when the “cross-product” (daily crossings x daily trains) is greater than 1000. Therefore, for the current maximum of 5 trains per day, warning lights will be required for greater than 200 crossings per day.
- A warning system plus gates will be required for a level crossing when the cross-product exceeds an unspecified number.
- The clear span of an elevated crossing must be the full width of the railway right-of-way and provide a minimum 23-foot overhead clearance.
- Use gates or maze barriers to slow and direct public pedestrian access for an at-grade pedestrian crossing.
- A public road crossing must be owned and maintained by the recognized road authority. The MoTI will be the road authority until the community is incorporated, after which it reverts to the local government.

- A public pedestrian-only crossing can be sponsored by the regional district in the absence of a municipality.
- In the case of split jurisdiction, two separate crossings on two legal parcels must be provided to delineate responsibility. These properties can be contiguous.

## Rail crossing options

Construction of the South Access during Phase 2 will block the existing informal access road to the private railway crossing site. There are two options for a permanent rail crossing:

- a private or public at-grade railway crossing located about 20m north of the existing crossing with a new service access road located between the rail and the South Access off-ramp, and/or
- a public elevated crossing located 130m south of the existing private crossing where the railway is entrenched, and a bridge can launch off the high banks on both sides.

The proposed crossing must serve multiple uses including:

- lodge service access,
- lodge guest access,
- park service access,
- public park user access,
- emergency response access and
- fire protection access.

Refer to the drawing *Site Plan, Final* for reference to the proposed crossing options.

### At-grade crossing option

This option consists of using the existing at-grade crossing accessed by a new service road located between the railway and the South Access off-ramp. This service road can continue to be private, used only by Tiger Bay to access their waterfront lodge and to provide park services to SLRD under contract. Alternatively, it can become a public access in a statutory right-of-way to provide unrestricted access to the waterfront lodge and regional park. A public access will likely require automatic gates and pedestrian control as outlined above. The upgraded at-grade public crossing requires CN Rail approval and the agreement of MoTI to be the road authority responsible for the public road crossing. We note that the space available for the access road to the at-grade crossing is constrained by the South Access off-ramp. A preliminary layout of this road has confirmed that safe vehicle access is possible but it is not possible to conform with MoTI geometric road standards due to the sharp 90-degree bend required at the crossing that does not conform to MoTI road radius standards. This suggests that a public crossing at this location is only possible with the relaxation of MoTI road standards for the service road if this road is public.

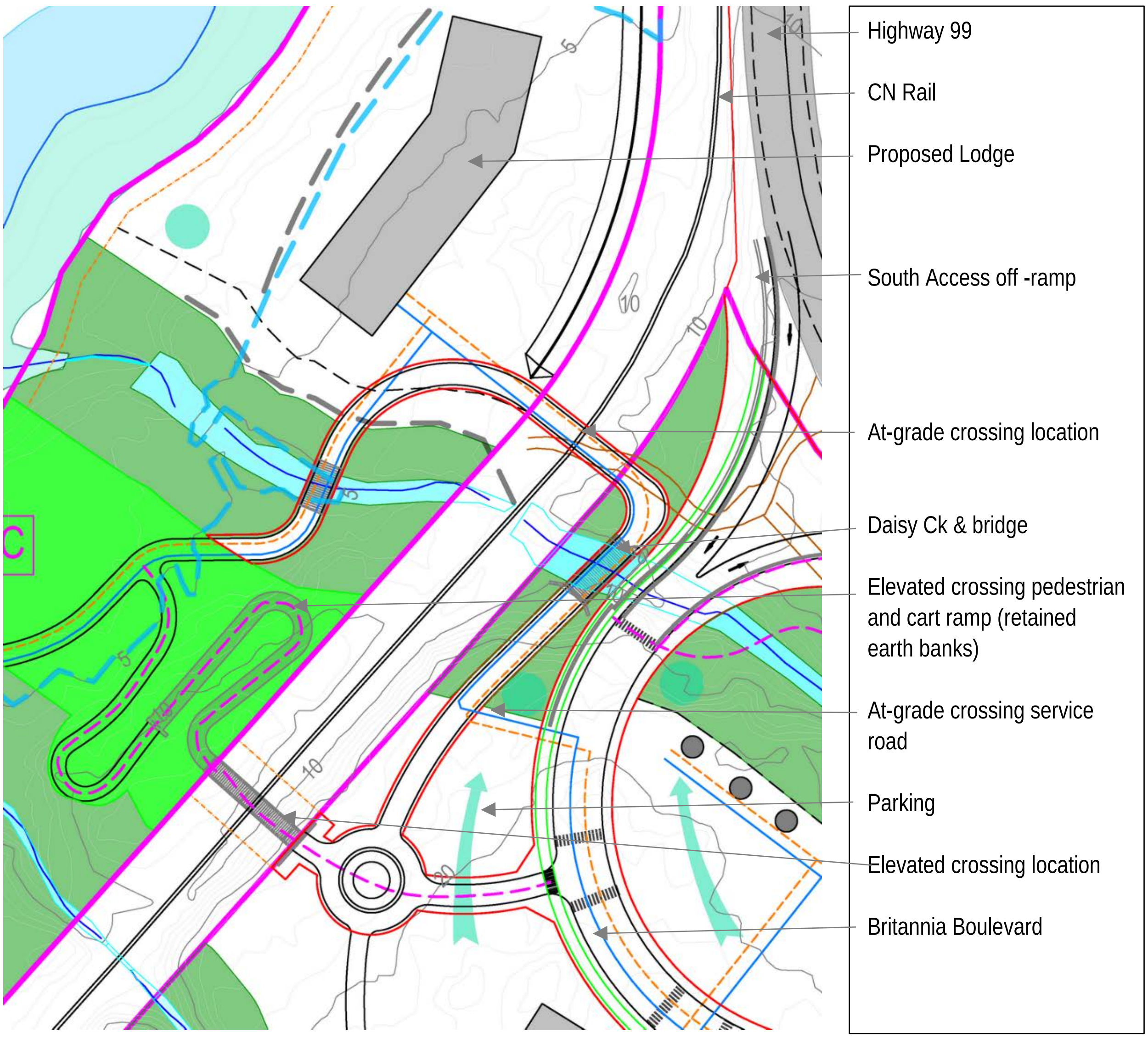
### Elevated crossing option

This option uses an elevated public railway crossing located 130 m south of the existing private crossing. The railway is entrenched at this location, and a bridge can launch off the high banks on both sides. The bridge is easily accessible from the east. However, the land falls away steeply to the west of the crossing, and a long, gradually sloping elevated ramp is required to meet the ground elevation at the park. A bridge must provide 7m clearance between the rail and the bottom of the bridge. The bridge deck would be at an elevation of 18m. The ramps must be at a maximum slope of 8% to allow wheelchair access.

A vehicular bridge at this location must conform to MoTI standards, which would require an intrusive ramp on the west side that would dominate and disfigure the regional park.

Alternatively, the bridge could be used for pedestrians and golf carts only. This would allow use of a less intrusive access ramp on the west side, as illustrated in the following figure.

*Figure 31: CN Rail crossing options*




The elevated public crossing is not required if a <u>public</u> at-grade crossing is selected and approved. The elevated public crossing is required only if a <u>public</u> at-grade crossing is rejected. In this case, CN Rail would need to allow emergency vehicle access across the private at-grade crossing that would be retained in use by Tiger Bay (the private crossing permit from CN Rail restricts use to the owner and its employees).

Further discussion between Tiger Bay, CN Rail, MoTI and SLRD are required to develop a mutually acceptable solution.

The plan illustrates statutory rights of way to contain the service roads and an air easement to contain the elevated pedestrian bridge over the CN Rail right of way.

## Crossing Phasing

### Immediate

Immediately carry out the following improvements to improve safety and reduce liability:

- Move the crossing to the north of the existing crossing by around 20m to facilitate the future construction of the private access road bridge over Daisy Creek. The extra distance is required to allow the bridge to be raised to provide sufficient clearance over the creek and then drop again to the rail elevation.
- Install fencing along the railway right-of-way bordering the Tiger Bay property.
- Improve sight-lines at the existing crossing, particularly to the north.
- Improve the approach road by providing an orthogonal crossing at track elevation for a 25 ft. (8m) length either side of the tracks with 5% grade transition to existing road grades.
- Install crossing warning signs (cross-bucks) and stop signs at optimum locations on the approach road.
- Install a locking chain link pedestrian gate, in addition to a locking vehicle gate, to exclude public access from the crossing.

### 2021

Upgrade the private crossing to comply with the 2021 requirements for a private crossing. The key conditions are that the crossing is private, the Minaty Bay park property remains in Tiger Bay ownership, and the new South Access highway intersection is not required as this would block access to the existing approach road. Improvements include:

- Move the private crossing approximately 20m to the north of the existing crossing, as described above. The exact amount will be determined by the geometric design of the future service road and the bridge over Daisy Creek.
- Improve the road approach geometry and provide gravel road base on the approach road for 8m either side of track centerline to improve the safety and function of the approach. Locate the improved crossing to conform with the ultimate configuration.
- Upgrade line-of-sight clearing if required to comply with the regulations.
- Install rubber flangeways surrounding the tracks.
- Install 36” culverts under approach roads with connecting ditches.

### Phase 2 (2026-30)

Construct either a public at-grade crossing or a combination private at-grade vehicle crossing with a public pedestrian/cart elevated crossing. The selected option will depend on the outcome of reviews and negotiations between the stakeholders.

## Summary

Areas B and C of the proposed development abut the CN Rail line, which is a "Principal Branch Line" hosting a maximum of 5 trains per day at a speed of 25 mph. The southern portion of the rail alignment is set many meters below the surrounding land in an excavated trench. The final 300 m of rail through the north end of the neighbourhood, is at the same grade or higher than the surrounding land.

The existing private crossing is located on the north side of Daisy Creek, where the railway crosses the creek. It is an informal access that served the miners community for decades, and it must be substantially upgraded to conform to current requirements for a private crossing. A private crossing can be used only by the landowner and its employees. Further upgrading is required to convert the private to a public crossing, and approval for this change is not assured.

Construction of the South Access during Phase 2 will block the existing informal access road to the private railway crossing. There are two options for a permanent rail crossing:

- an at-grade railway crossing located about 20m north of the existing crossing, and/or
- an elevated crossing located 130m south of the existing private crossing where the railway is entrenched, and a bridge can launch off the high vertical rock banks on both sides.

The at-grade option can be used for a public crossing if the proposed non-conforming approach road geometry is approved my MoTI. If this is not approved, then the at-grade crossing can only be used as a private crossing.

The elevated crossing option is suitable for public pedestrian/cart access because it uses a compact ramp structure on the west side drop from the bridge elevation to the shore elevation. The elevated crossing is unlikely to be suitable for a public vehicle crossing because of the large west side ramp required. Therefore, only a public pedestrian/cart bridge is recommended.

The preferred rail crossing option and configuration will be determined through future discussions between CN Rail, SLRD, Tiger Bay and MoTI.

Next steps include the following:

1. Tiger Bay must upgrade their private crossing to comply with their existing private crossing permit.
2. Tiger Bay should review the crossing options with SLRD, CN Rail and MoTI to determine an acceptable configuration and phasing.
3. Complete a preliminary geometric design of the at-grade crossing to confirm its feasibility.
4. Carry out consultations with stakeholders to confirm the preferred rail crossing configuration.

## Section References


1) Guidelines for New Development in Proximity to Railway Operations by the Railway Association of Canada and Federation of Canadian Municipalities, May 2013
2) Private Crossing Agreement at Mile 30.40 Squamish Subdivision, near Minaty, BC, by CN Rail Business Development and Real Estate, December 11, 2014 (considered by CN Rail to be confidential)
3) Proposed Development of Britannia Beach, BC, memo from Raymond Beshro, CN Rail to Tiger Bay Development Corporation undated c April 2013.

4) Telephone conference between Gary Hanson, CN Rail Operations and Paul Turje, P.Eng., April 4, 2016.

# WATER SERVICING

## Water Source

Kerr Wood Leidal Associates (KWL) examined the following water supply options in past studies: surface water (local creeks and Britannia Creek), freshwater from wells and brackish water from over-pumped wells with reverse-osmosis treatment. Freshwater from wells is the selected option. In 2014, Piteau Associates Engineering Ltd. (Piteau) completed an investigation of groundwater supply potential for the South Britannia project that involved the construction of two production water wells and an extended aquifer pumping test during the dry summer period. The production water wells are identified as TW1 and TW2. These wells draw from a local aquifer situated between the base of the steep mountain slope to the east and Howe Sound to the west. The aquifer dimensions are approximately 850m parallel to the shore and 320m wide (perpendicular to shore).

Thistle and Daisy creeks drain from the steep mountain slopes and flow across the aquifer before discharging into the ocean. Water Infiltration from the creeks into the ground is the primary source of recharge to the aquifer. Flows in the creeks are highly variable, and dry season flows are small and provide minimal recharge to the aquifer. Lowering aquifer water levels below sea level for prolonged intervals may lead to saltwater intrusion and aquifer contamination. It is important to avoid lowering the aquifer level excessively by over-pumping the aquifer. This is especially important during the drier summer and autumn when freshwater recharge is lowest. Because the creeks are perched, water withdrawn by the wells has no environmental impact on the creeks because the water flows from the creeks to the aquifer rather than vice versa.

Based on the results of an extended aquifer pumping test conducted between July and October 2013, Piteau (2014) concluded that TW1 and TW2 are able to sustain individual flows of 26.7 and 19.9 L/s respectively over the dry period. The combined flow of the wells is about 46.6 L/s (rounded to 47 L/s). This flow can be pumped from the aquifer over a 100-day drought period, without causing saltwater intrusion from Howe Sound. It is important to note that this is an aquifer limitation and not a well or well pump limitation. The aquifer and wells are able to provide a higher flow rate during the wet periods. Refer to the following figure for the locations of the Test and Monitoring Wells.

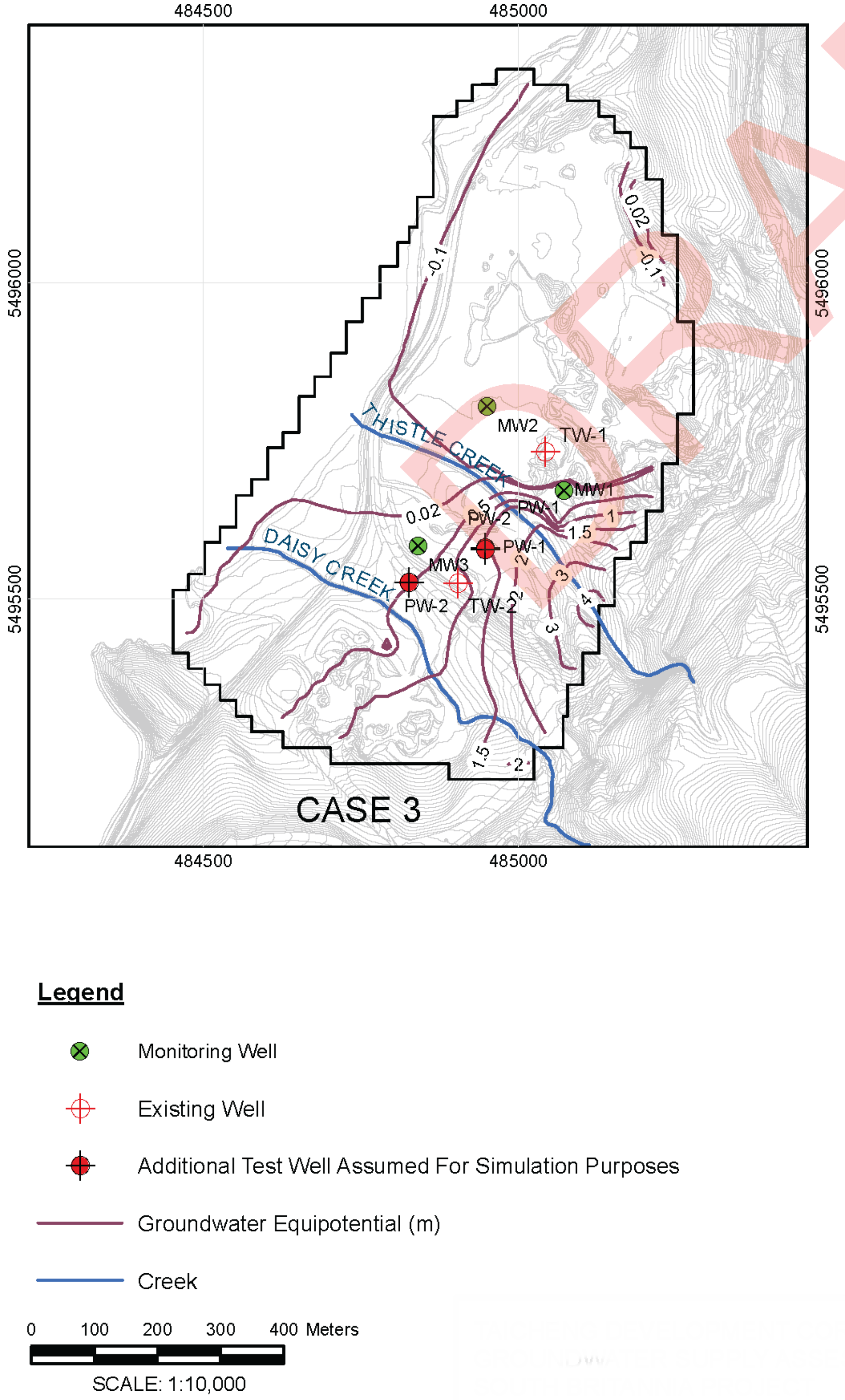
Subsequent to Piteau's 2014 report, Tiger Bay Development Corp requested Piteau to quantify the potential maximum amount of groundwater that can be withdrawn from the aquifer during an extended dry period, assuming extra wells were drilled. The proposed work plan included:

- Analysis of existing information and groundwater flow simulations
- Construction of additional wells and conducting aquifer pumping tests
- Continuous water level monitoring
- Water quality analyses
- Data analyses and further groundwater flow simulations to predict safe aquifer yield
- Reporting

The groundwater flow simulations revealed that a maximum combined sustainable aquifer yield of 56L/s to 72L/s might be feasible, assuming the use of the Test Wells plus two additional Proposed Wells, during a 100-day drought period. Given the potential for recharge variability, Piteau recommended an adaptive approach that would optimize groundwater withdrawals by continuous monitoring at the already installed monitoring wells to prevent over-pumping, possibly leading to saltwater intrusion.

The following figure illustrates the locations of the Test Wells (TW1 and TW2), the Monitoring Wells (MW1, MW2, MW3) and the simulated additional Proposed Wells (PW1 and PW2).

*Figure 32: Groundwater wells and modelling (from Piteau 2016)*



In summary, the aquifer yield during a 100-day drought period is:

- Proven by testing (two wells): 47 L/s or 4061 m3/d
- Low estimate of potential yield (four wells): 56 L/s or 4838 m3/d
- High estimate of potential (four wells): 72 L/s or 6221 m3/d

For planning purposes, we will use the proven maximum summer aquifer yield of 47 L/s while acknowledging the possibility of higher safe yields proven by operational experience. Note that this proven maximum yield is the maximum continuous aquifer withdrawal to avoid saltwater intrusion during a 100-day drought period. The short term pumping capacity of the wells and the long term capacity of the aquifer during the rainy months is much higher but has not been determined as the short term draught period is the critical design condition for domestic water supply.

The total aquifer withdrawal should be limited to 75L/s to avoid triggering an expensive and lengthy environmental assessment process, which is a provincial requirement if this amount is exceeded. This suggests that the maximum pumping capacity of each well should be 75 L/s divided by the number of wells or:

- Two wells: 37.5 L/s
- Three wells: 25.0 L/s
- Four wells: 18.8 L/s

The existing Test and Monitoring Wells are located to optimize their performance. However, these locations will not necessarily suit the development layout. If necessary, existing wells that are in conflict with the layout can be filled and sealed and replaced by new wells drilled nearby in a preferred location. Wells should be located in a minimum 10 x 10m easement or lot with a minimum 5m wide access right-of-way to allow service vehicle access for installing and servicing the pumps. The discharge water pipe and underground electrical and communication cables will be located within the access route.

## Water quality

The groundwater is of the calcium-carbonate type, slightly acidic and very low in dissolved minerals and metals. Concentrations of all chemical parameters tested were less than the Guidelines for Canadian Drinking Water Quality (GCDWQ) and there were no detectable concentrations of hydrocarbons or herbicides associated with potential sources of contamination. Refer to the referenced hydrogeological reports for detailed water chemistry.

Groundwater at risk of containing pathogens (GARP) is defined as a groundwater supply that is likely to be contaminated by any source of pathogens (anthropogenic or natural), or disease-causing organisms. In accordance with Section 5(2) of the B.C. Drinking Water Protection Regulation, a water supply requires disinfection if it poses a significant threat to public health. Pathogens include various types of bacteria, viruses, and protozoa (e.g., Giardia and Cryptosporidium) that commonly originate from human and agricultural waste and surface water. Sources of pathogens in surface water include animal excrement and decomposing terrestrial and aquatic organisms. Groundwater that is under the direct influence of surface water (GWUDI) is groundwater that is hydraulically connected to surface water and should be considered GARP unless hydrogeological evidence indicates that filtration by the aquifer matrix is sufficient to remove all pathogens. With reference to the most recent guidance document on the subject (Ministry of Health, 2013), groundwater from TW1 and TW2 is likely to be considered GARP and, as such, requires treatment by two-stage disinfection and filtration unless it can be demonstrated that filtration is not needed. Given that the seasonal high water table is within a meter of the ground surface, it is highly unlikely that filtration will be exempt.

The primary risks to the quality of groundwater pumped from TW1 and TW2 are the intrusion of saltwater from Howe Sound and pathogens from surface water. Risks associated with the historical activities at the former Britannia Mine, or gravel extraction at the Site, are judged to be low based on the absence of any known impacts to aquifer water quality. The aquifer is unconfined and vulnerable to contamination from surface sources. There are no other industrial or agricultural activities nearby that could lead to groundwater contamination. However, spillage of hazardous materials such as hydrocarbon fuels and chemicals transported via Highway 99 or CN Rail onto the ground above the aquifer, and/or into Thistle or Daisy creeks, is a hazard. The duty to clean up after a spill occurring on the highway or railway rests with the owner and/or transporter of the spilled product, it would be prudent to develop spill response and contingency plans to ensure that protection of groundwater resources and drinking water are properly taken into account in the event of a spill in the vicinity of the aquifer.

## Domestic Water Demand

### Residential

Normal SLRD criteria require a water supply of 1500 L/person/day (maximum day demand). Squamish criteria are 600 L/p/d for average day demand and 1000 L/p/d for maximum day demand, which has been accepted by SLRD as the criteria for this proposal. KWL asserts in previous studies that the water demand can be realistically reduced to 450 L/p/d (maximum day demand) using current best management practices. We agree that this value is readily achievable using only moderate water conservation practices coupled with care to avoid pipeline leakage.

Similarly, current SLRD development criteria define residential occupancy rates as: single-family residential and duplex = 4 persons per unit; and multi-family = 3 occupants per unit. As above, SLRD accepted a reduced residential occupancy criterion of 2.6 persons/unit (townhouse, apartment) for calculation of residential water demands.

In summary, the residential water demand criteria are:

- An occupancy rate of 2.6 persons/unit applied to 1050 residential units (all of which are either townhouse or apartment).
- Average Day Residential Demand = 600 L/p/d = 0.60 m3/p/d
- Maximum Day Residential Demand = 1000 L/p/d = 1.0 m3/p/d

The residential demand for 1050 units is calculated as:

Average Day Demand (ADD) = 1050 u * 2.6 p/u * 0.6 m3/p/d = **1638 m3/d**

Maximum Day Demand (MDD) = 1050 p * 2.6 p/u * 1.0 m3/p/d = **2730 m3/d**

### Industrial, Commercial and Institutional Water Demand (ICI)

The potable ICI demand is calculated in the following table.

*Table 16: Potable ICI water demand criteria and flows*

| Use | Facility size | ADD Criteria | ADD, m3/d | MDD, m3/d (2) |
|---|---|---|---|---|
| Commercial | (2,600 m2 to) 3,600 m2 GFA<br>1.3 ha land area | <br>0.7 L/s/ha (1) | <br>78.0 | <br>117.0 |
| Childcare centre (assumed ultimate) | (697 m2 GFA)<br>24 toddlers, 50 preschoolers,<br>6 staff<br>0.1 ha irrigation (3) | -<br>75 L/child/d<br>50 L/staff/d<br>2 mm/d | -<br>5.6<br>0.3<br>2.0 | -<br>8.4<br>0.5<br>2.0 |
| Accommodation rooms | 110 units<br>0.25 ha irrigation area | 2p/unit*600 L/p/d<br>2 mm/d | 132.0<br>5.0 | 198.0<br>5.0 |
| Accommodation cabins & glamping | 80 units<br>no irrigation | 2p/unit *400 L/p/d | 64.0 | 96.0 |
| Municipal office allowance | (465 m2 GFA) or assume 5 staff/d<br>50 visitors/d<br>0.1 ha irrigation | 50Lstaff/d<br>10L/visitor/d<br>2 mm/d | 0.25<br>0.50<br>2.0 | 0.4<br>0.8<br>2.0 |
| School allowance | 176 student<br>11 staff<br>0.5 ha irrigated area | 30 L/student/d<br>50 l/staff/<br>2 mm/dd | 5.3<br>0.6<br>10.0 | 8.0<br>0.9<br>10.0 |
| Wavegarden domestic demand | 1400 guest/d<br>50 staff/d<br>water treatment housekeeping<br>0.5 ha irrigation | 25 L/g/d<br>50 L/s/d<br>200 L/d<br>2 mm/d | 35.0<br>2.5<br>0.2<br>10.0 | 52.5<br>3.8<br>0.3<br>10.0 |
| Water treatment plant backwash | allow 1% assuming that backwash water is settled and reused | 1% | 3.6 | 5.2 |
| TOTAL | | | 356.6 | 521.2 |

GFA= gross floor area,
(1) using ADD = 0.7 L/s/ha and MDD = 1.0 L/s/ha common municipal criteria.
(2) MDD peaking factor = 1.5
(3) irrigation demand = 2 mm/d for coastal regions, using drought tolerant landscaping, ADD = MDD

### Total Domestic Water Demand

The domestic potable water demands are summarized below:

*Figure 33: Total domestic potable water demand*

| Type | ADD | MDD |
|---|---|---|
| Residential | 1638 | 2730 |
| Industrial, commercial, institutional | 357 | 521 |
| Total domestic demand | 1995 m3/d<br>23.1 L/s | 3251 m3/d<br>37.6 L/s |

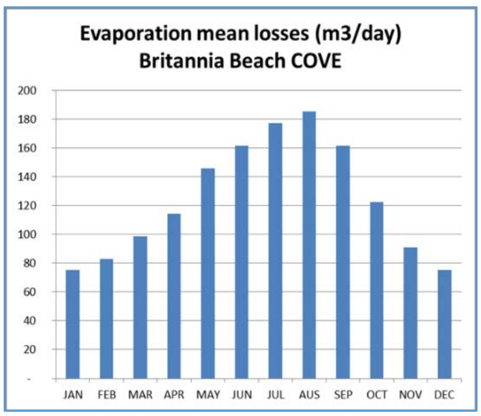
ADD = average day demand, MDD = maximum day demand

## Wavegarden Operations Water Demand

The Wavegarden operations water uses, that do not require potable water, include the following:

- Annual pool filling after draining and maintenance. This will normally take place in early spring while the aquifer is being recharged by snowmelt and spring rains. The pool volume is 26,000 m3 plus evaporation loss allowance during the filling period. The pool water is lightly disinfected only and not filtered.
- The water in the pool is continuously filtered and disinfected. Backwash of the filters is estimated by Wavegarden to be 1 m3/d.
- Add an additional 1 m3/d for miscellaneous water loss.
- Irrigation of the Wavegarden site is NOT included as an operations water use but is included in the earlier potable water calculation because of difficulty in avoiding people drinking from a hose.
- Wavegarden calculated the daily evaporation losses as summarized in the following figure. The maximum evaporation rate is around 185 m3/d during August.

*Figure 34: Mean daily evaporation losses by month during wave making that increases evaporation (from Wavegarden technical memo)*




Operations water consumption during the summer (August) is, therefore, **187 m3/d** (sum of evaporation, backwash and miscellaneous).

Assuming routine maintenance filling takes place in March, the evaporation loss during filling will be 98 m3/d according to the chart above (that includes extra evaporation during wave-making). To be conservative, assume no rainfall during the filling period and assume conservative evaporation from the chart.

## Aquifer Capacity

The critical water supply condition is the sustained aquifer yield over the summer drought period. The aquifer capacity was discussed at the beginning of this chapter. The following table compares summer total water demands (not including Wavegarden filling) with the tested 2-well aquifer capacity and the simulated 4-well aquifer capacity.

*Table 17: Water demand and aquifer capacity summary*

| Description | ADD | MDD |
|---|---|---|
| Total community potable water demand | 1995 m3/d<br>23.1 L/s | 3251 m3/d<br>37.6 L/s |
| Total Wavegarden potable water demand | 187 m3/d<br>2.2 L/s | 187 m3/d<br>2.2 L/s |
| TOTAL | 25.3 L/s | 39.8 L/s |
| Tested 2-well long-term water supply | 47 L/s | 47 L/s |
| Percentage used | 54% | 85% |
| Estimated 4-well long-term water supply | 56 to 72 L/s | 56 to 72 L/s |
| Percentage used | 46% to 35% | 71% to 55% |

ADD = Average (annual) Day Demand, MDD = Maximum (annual) Day Demand

In conclusion, the 2-well aquifer capacity is sufficient to satisfy the estimated maximum day demand for a continuous 100-day summer drought period with (100% - 85% =) 15% standby capacity. The average demand during the summer drought period will be between the ADD and the MDD, so the reserve capacity is likely 25% or greater. The use of water conservation can substantially increase the reserve capacity.

The 4-well simulated aquifer capacity is sufficient to satisfy the estimated maximum day demand for a continuous 100-day summer period with 29% to 45% standby capacity where the realistic amount is greater. The use of water conservation can substantially increase the reserve capacity.

## Water Well Configuration

Wells must be placed in locations that suit the development layout, or alternatively, the layout must accommodate the existing well locations. In the event of irreconcilable conflict, existing well(s) might have to be decommissioned and new wells drilled at a suitable location(s). Wells should be located in small dedicated lots with an access right-of-way for servicing and for pipelines and electrical and control conduits.

The wells will be outfitted with pitless units and electrical kiosks containing the power supply and control panels. The wells will be controlled by water level signals from the domestic reservoir and a small Wavegarden buffer tank. The wells will be protected by the usual low water level shut down controls. Potable water supply during a power outage will be maintained by the emergency supply capacity of the reservoir, therefore, no standby power generation is included at the wells.

The new production wells, and the existing or new monitoring wells, will contain permanent water level monitoring transducers with data logging telemetry to the Public Works Office. This will allow real-time monitoring of the aquifer water level to safeguard against saltwater intrusion and overpumping and will also facilitate a continuous record of seasonal aquifer performance.

Use the domestic wells to supply both potable water and Wavegarden non-potable pool filling. This will require a total of three or four well to increase available water supply during spring freshet to the 75 L/s environmental review threshold. These wells should be drilled at the PW#1 and PW#2 locations noted on the figure in the Water Supply section of this chapter. Connect the wells using a common raw-water main.

Extend the raw-water main to the Wavegarden to fill a small ground-level untreated water buffer tank (say minimum 50 m3 capacity). During pool filling, the water will drain continuously from the raw-water tank to the pool. During normal operations, raw water will be taken from the tank as required for operations and replenishing evaporation. Level controls in the raw-water tank will turn on well pump(s) as required to replenish the tank.

The common raw-water main will also extend to the water treatment plant, passing through a flow control valve that will limit the water flow rate to the treatment capacity. The well pumps will be turned on by level controls in the potable water reservoirs located at 110m elevation east of the BC Hydro R/W. The raw water will pass through the treatment plant (see later discussion) and to the potable water reservoirs through a dedicated supply main that provides chlorine contact time. The potable water in the reservoirs supplies the domestic water needs through distribution pipes.

The well pumps will be operated through Variable Frequency Drives (VFD's) that vary the AC power frequency thus controlling the flow rate delivered by the pumps to limit their flow rate to the seasonal capacity of the aquifer. The total flow capacity of the well pumps will be a maximum of 75 L/s to avoid exceeding the environmental assessment threshold.

The well capacities should be large enough that the system can provide ADD with the largest well pump out of commission. The rated summer capacity of TW1 is 26.7 L/s and TW2 is 19.9 L/s. The Average Day Domestic Demand is 37.6 L/s which is more than the capacity of TW2. Therefore, it will be necessary to drill at least one additional well to satisfy this standby rule. In this case the combined capacity of the two smaller wells must be larger than the ADD of 37.6 L/s.

The treatment plant will have a capacity equal to the maximum day domestic demand of 37.6 L/s, which is 50% of the total well pump capacity. This can normally be supplied by two wells where the total flow is reduced by the VFD to the required flow.

The well pumping capacity available for Wavegarden filling is 75 L/s minus the domestic demand. Assuming Wavegarden filling takes place in March, when the aquifer is fully recharged and the wells can be operated for an extended time at full capacity of 75 L/s, then the Wavegarden filling rate is 75 L/s minus the domestic demand or (75-37.6 =) 37.4 L/s. The filling time is the time to fill the pool plus the time required to compensate for evaporation or:

$t = v/ (q-e) = 26000/(3231.4 - 98) = 8.29$ days

where:

$t$ = filling time in days
$v$ = pool volume = 26000 m3
$e$ = daily evaporation in March = 98 m3/d
$q$ = available filling rate = 37.4 L/s = 3231.4 m3/d

The filling time will be more or less dependent on domestic demand. This filling time is adequate, given that the pool is expected to be out of commission for one to two months for maintenance.

## Domestic Water Treatment

The BC Drinking Water Treatment Objectives (2012) and Vancouver Coastal Health authority considers a GARP water source to require the same level of treatment as surface water. This includes filtration and disinfection, unless water quality data demonstrate compliance with a four-part filtration exclusion criterion in which case it might be possible to replace the filtration requirement with dual barrier ultra-violet light plus chlorine disinfection. The existing water quality data appears to support a filtration exemption but this potential exclusion will not be exercised and filtration will be provided.

In summary, the wells will pump raw water to a treatment plant that provides pH adjustment, UV disinfection and chlorination with filtration.

## Reservoir Location and Pressure Zones

The highest service elevation in South Britannia is along the steep slope in Area B at a ground elevation of 60m. The lowest service is at ground elevation 5m. The reservoir should be located at a ground level between 90m and 110m to provide pressure for fire protection and to avoid excessively high pressures in the low elevation piping. An appropriate reservoir location at 110m elevation is shown on the water servicing figure. This location will permit the system to operate as one pressure zone.

## Water Storage

The required total reservoir capacity is the sum of A+B+C where:

A = fire storage = 150 L/s for 2 hours or 1080m3
B = equalization storage of 25% of MDD = 0.25 * 3546m3 = 812m3
C = emergency storage of 25% of A + B = 473m3
Total = 2365m3

The reservoir will be located east of the BC Hydro right of way, as illustrated on *Site Plan, Final*. It will consist of two equal-sized, above ground, non-insulated bolted steel tanks with structural roofs. Both tanks will normally be in service. Valves will allow either tank to be isolated for maintenance while leaving the other tank in service.

The reservoirs will be filled by an independent supply main to provide for chlorine contact time prior to the water reaching the reservoir. The inlet piping will include manifolds that use duck-billed check valves to create water jets that mix the water to maintain a chlorine residual and avoid stagnation zones. The water treatment plant will include a cross-connection between the fill and distribution pipes with a recirculation pump, automatic chlorine residual analyzer and re-chlorination equipment. This chlorine residual monitoring will determine if re-chlorination is required at the reservoir, especially during the early stages of development, when low water demands can result in long reservoir residence times that can lead to chlorine residual decay.

## Distribution

Domestic demand and fire protection will flow to the community from the reservoir through a large diameter main that will feed the distribution piping. Water distribution piping will be sized for the estimated built-out population and a fire protection flow of 150 L/s. The engineering concept drawing illustrates the proposed layout of the distribution system.

Domestic demand and 150 L/s fire protection flows will be provided to the two proposed lodges located south of the highway.

Domestic demands to the cabins and glamping sites will be provided by a small diameter water mains installed in the service roads. These sites will not be serviced by fire hydrants but instead will be protected by residential sprinkler systems and the tanker capacity of the Britannia fire department.

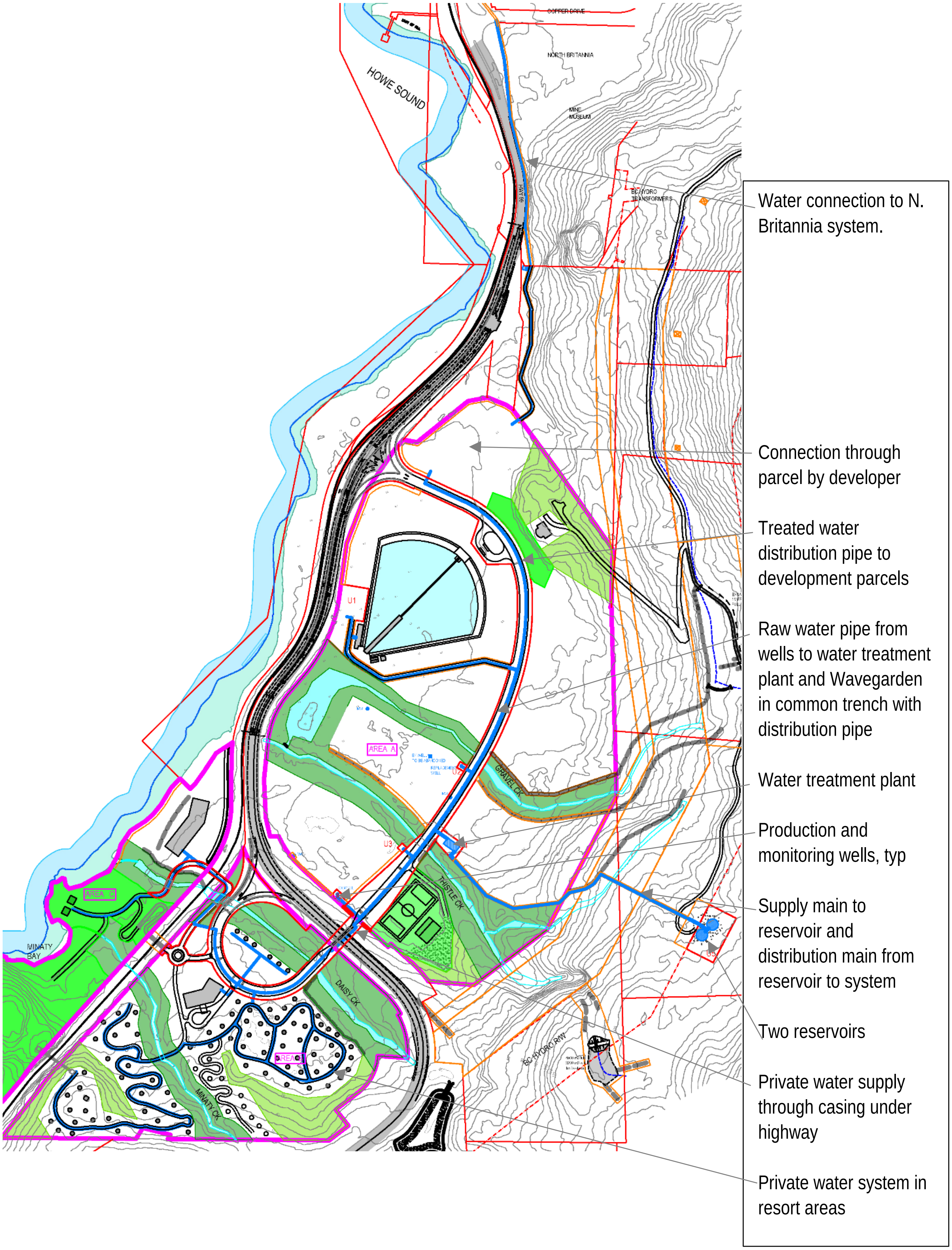
The water system serving Areas B and C will be private with a demarcation at the tunnel crossing. The private water system will use conventional rigid PVC piping to provide domestic and fire flows to the lodge and resort buildings. The cabins and glamping sites will be serviced by small diameter, flexible, high-density polyethylene pipe to permit more economical routing along the twisty service road. The flexible pipe will also be snaked within its trench to provide flexibility against settlement in the patches of poor soils in Area B.

The residence time and resulting chlorine residual in the water mains should be modelled during system design. This is likely to be a problem for the extremities of the small diameter distribution mains that supply the cabins in Area B. This can be corrected by:

- Frequently flushing the distribution mains through blow-offs at the extremities of the system. This requires diligence by the operator and will waste a large amount of water during the summer drought period.
- Installing a small diameter recirculation pipe in common trench with the distribution main. Use a small buffer tank, recirculation pump, chlorine residual analyser and hypochlorite supply pump to boost the chlorine concentration to the required value and continuously recirculate the water through the susceptible water mains.

The selection of method will be made during design.

*Figure 35: Water system layout*



## Summary

Domestic and Wavegarden water supply will be provided by three or four wells developed in the local aquifer that is recharged by infiltration from Gravel and Thistle Creeks and by runoff from the adjacent slopes. Based on the results of an extended aquifer pumping test conducted between July and October 2013, Piteau (2014) concluded that the existing test wells TW1 and TW2 can sustain individual flows of 26.7 and 19.9 L/s respectively over the dry period. The combined flow of the test wells is about 46.6 L/s (rounded to 47 L/s). This flow can be pumped from the aquifer over a 100-day drought period, without causing saltwater intrusion from Howe Sound. Groundwater flow simulations (rather than testing) revealed that a maximum combined sustainable aquifer yield of 56L/s to 72L/s might be feasible, assuming the use of the Test Wells plus two additional Proposed Wells, during a 100-day drought period.

The total aquifer withdrawal should be limited to 75L/s to avoid triggering an expensive and lengthy environmental assessment process, which is a provincial requirement if this amount is exceeded. This limitation suggests that the maximum pumping capacity of each well should be 75 L/s divided by the number of wells or:

- Two wells: 37.5 L/s
- Three wells: 25.0 L/s
- Four wells: 18.8 L/s

The groundwater is of the calcium-carbonate type, slightly acidic and very low in dissolved minerals and metals. Concentrations of all chemical parameters tested were less than the Guidelines for Canadian Drinking Water Quality (GCDWQ) and there were no detectable concentrations of hydrocarbons or herbicides associated with potential sources of contamination.

The water table was measured to rise to within 1m of the ground elevation in one of the monitoring wells. The aquifer soils consist of gravels and sands from the base of the aquifer to the ground surface therefore the aquifer is unconfined, meaning that surface water or contaminants can migrate through the soil to the aquifer. Groundwater at risk of containing pathogens (GARP) is defined as a groundwater supply that is likely to be contaminated by any source of pathogens (anthropogenic or natural), or disease-causing organisms. Therefore the aquifer is likely to be considered GARP and as such requires treatment by two-stage disinfection and filtration unless it can be demonstrated that filtration is not required. Given that the seasonal high water table is within a meter of the ground surface, it is highly unlikely that filtration will be exempt therefore treatment will consist of pH adjustment, filtration, UV disinfection and chlorination to provide a disinfection residual.

The following table summarizes the estimated water demands and aquifer capacity.

| Description | ADD | MDD |
|---|---|---|
| Total community potable water demand | 1995 m3/d<br>23.1 L/s | 3251 m3/d<br>37.6 L/s |
| Total Wavegarden potable water demand | 187 m3/d<br>2.2 L/s | 187 m3/d<br>2.2 L/s |
| TOTAL | 25.3 L/s | 39.8 L/s |
| Tested 2-well long term water supply | 47 L/s | 47 L/s |
| Percentage used | 54% | 85% |
| Estimated 4-well long term water supply | 56 to 72 L/s | 56 to 72 L/s |
| Percentage used | 46% to 35% | 71% to 55% |

ADD = Average (annual) Day Demand, MDD = Maximum (annual) Day Demand

The aquifer capacity using the two Test Wells is sufficient to satisfy the estimated maximum day demand for a continuous 100-day summer drought period with (100% - 85% =) 15% standby capacity. The average demand during the summer drought period will be between the ADD and the MDD, so the reserve capacity is likely 25% or greater.

The 4-well simulated aquifer capacity is sufficient to satisfy the estimated maximum day demand for a continuous 100-day summer period with 29% to 45% standby capacity where the realistic amount is greater.

The Wavegarden operations water demand is estimated to be 187 m3/d using raw (untreated) water. This will be supplied to the Wavegarden through a separate raw water main.

The Wavegarden filling demand is 26,000 m3 plus evaporation during the filling period. The well pumping capacity available for Wavegarden filling is 75 L/s minus the domestic demand. The pool filling time is estimated to be around 8 days depending depending on domestic demand. This filling time is adequate given that the pool is expected to be out of commission for one to two months for maintenance.

Untreated water will be pumped from the wells through a raw water main to the Wavegarden and the water treatment plant. Treated water will be pumped to two reservoir tanks, located immediately east of the BC Hydro right of way. A larger diameter distribution main will convey water to the community for

The reservoirs will be filled by an independent supply main to provide for chlorine contact time prior to the water reaching the reservoir and to force water turn-over. The inlet piping will include manifolds that use duck-billed check valves to create water jets that mix the water to maintain a chlorine residual and avoid stagnation zones. The water treatment plant will include a cross-connection between the fill and distribution pipes with a recirculation pump, automatic chlorine residual analyzer and re-chlorination equipment. This chlorine residual monitoring will determine if re-chlorination is required at the reservoir, especially during early stages of development when low water demands can result in long reservoir residence times that can lead to chlorine residual decay.

The proposed water supply and distribution system conforms with SLRD engineering requirements and is suitable for the intended purpose.

Next steps include the following:

1. Confirm water main crossing of the transmission line right of way with BC Hydro.
2. Confirm use of the BC Hydro access road for reservoir access.
3. Complete a pre-design study for the water treatment plant to define costs and phasing.
4. Drill and prove additional wells at locations to be determined after further definition of the layout.

## Section References

The report by Kerr Wood Leidal refer to previous versions of the development plan. The conceptual aspects of the reports remain valid but the layouts, flows and system sizing are updated by this summary report.


1) Engineering Servicing for South Britannia Beach, Kerr Wood Leidal Associates Ltd, Final Report, November, 2014.
2) Hydrogeologic Assessment for Groundwater Supply, Britannia South, Britannia Beach, BC – Phase 3, Piteau Associates Engineering Ltd., March 11, 2014.
3) Updated Groundwater Flow Simulations for Britannia Beach South Project, Britannia Beach, BC, Piteau Associates Engineering Ltd., March 4, 2016.
4) Britannia Hydrogeology, email response to S Olmstead comments, Piteau Associates Engineering Ltd., February 26, 2020.

# WASTE WATER SERVICING

## Existing Waste Water Treatment Plant

The existing North Britannia community is serviced by a gravity collection system and sewage pump stations (aka lift stations) discharging to a Waste Water Treatment Plant (WWTP) located on the north side of Britannia Creek and on the east side of Hwy 99. The treated effluent discharges through a marine outfall into Howe Sound.

The existing treatment plant includes the following components:

- Headworks with coarse screening, fine screening, flow measurement and flow distribution to the treatment units.
- Sequencing Batch Reactor (SBR) treatment units.
- Ultraviolet disinfection.
- Piped marine outfall.
- Odour control.
- Biosolids treatment (aerobic digestion, thickening, dewatering and disposal).

The level of treatment provided by the plant is suitable for marine discharge using the regulations in force in 2007. The treatment level does not conform to current regulations, nor does it provide treatment sufficient for water reuse.

The designed capacities of the existing WWTP are listed below (as derived from the referenced KWL report)

*Table 18: Design Capacity of WWTP*

| Component | North Britannia | South Britannia | TOTAL |
|---|---|---|---|
| Population Equivalent | 2042 | 4000 | 6042 |
| Outfall Design Flow | | | 11,000 m3/d |
| Average Dry Weather Flow (ADWF) | 715 m3/d | 1400 m3/d | 2,115 m3/d |

The WWTP was registered under the provincial Municipal Sewage Regulation (MSR) in 2007 and its design conforms to the requirements of that registration. The system was sized using the SLRD subdivision bylaw wastewater flow criteria of 350 L/person/d, which is a reasonable criterion for systems that do not use water conservation, but greater than necessary when using modest water conservation when a sewage generation rate of 200 to 250 L/p/d is more likely. The WWTP inlet, treatment system and outfall are sized to handle an average dry weather flow (ADWF) of 715 m3/d of wastewater from North Britannia. Space is available for expansion of the plant to treat an ADWF of up to 1,400 m3/d for flows from South Britannia. Any expansion beyond this flow will require more extensive upgrades.

The WWTP was designed to accept the flow from both North and South Britannia. The plant headworks and outfall were built to accept the anticipated total community flow. The plant power supply and treatment systems were built to accept only the flow from North Britannia with space provided for the addition of treatment units and other components required to treat flows from South Britannia.

## Regulatory Requirements

Current provincial and federal wastewater disposal regulations both apply to sewage discharges from the site and are inconsistent. A summary of the governing criteria of both are shown in the following table (from KWL):

*Table 19: Britannia WWTP Effluent Quality Requirements*

| Parameter | Effluent Quality |
|---|---|
| Carbonaceous BOD | < 25 mg/L average (BOD5 < 45 mg/L) |
| Suspended solids | <25 mg/L average and not to exceed 45 mg/L |
| Effluent disinfection | ≤200 MPN/100 mL in the effluent based on 30-day geometric mean |
| Total residual chlorine | <0.02 mg/L average, if chlorine used for effluent disinfection at WWTP |
| Un-ionized ammonia | <1.25 mg N/L, at 15°C, maximum |

Again, we note that the current treatment criteria require a higher standard of treatment than the standard in force when the existing WWTP was built. This might, subject to clarification, imply a requirement to both upgrade the plant for current flows and expand the plant to accommodate additional flows.

Connection of South Britannia to the WWTP is the most appropriate sewage treatment and disposal option and no other options were explored.

## Waste Water Criteria and Flows

The following wastewater design criteria are specified in the SLRD Subdivision and Development Bylaw and are used to estimate the design flows for the WWTP:

- Residential Average Daily Dry Weather Flow (AADWF)= 350 L/p/d = 0.35 m3/p/d (water conservation would reduce this volume)
- Commercial and Institutional Average Daily Dry Weather Flow (land area occupied) = 40,000 L/ha/d = 40 m3/ha/d
- Dry Weather Flow peaking factor = 80% of Harmon Factor = 2.74
- Infiltration and Inflow (I&I) allowance based on serviced land area = 11,200 L/ha/da = 11.2 m3/ha/d

The serviced land area for inflow and infiltration calculations do not include the following land areas:

- Greenspace, riparian, roads, parks, transit area.
- Wavegarden because the land area does not represent the serviced area, which is very small.
- Cabin/glamping area as this site will use a low-pressure sewer system and thus will not be subject to infiltration

The land area served by gravity sewers (susceptible to I&I) is the sum of the development parcel areas not including the Wavegarden parcel and is equal to 15 ha.

The calculation of wastewater flows is derived partially from the SLRD criteria and partially from the detailed water demand calculations as illustrated in the following table.

*Table 20: Sewage criteria and flows*

| Use | Facility size | Criteria | ADWF m3/d |
|---|---|---|---|
| Residential | 1050 units * 2.6 p/unit = 2730 p | 375 L/p/d | 1023.8 |
| Commercial | 1.3 ha land area | 40 m3/ha/d | 52.0 |
| Childcare centre | 24 toddlers, 50 preschoolers,<br>6 staff | 75 L/child/d<br>50 L/staff/d | 5.6<br>0.3 |
| Accommodation rooms | 110 units | 2p/unit*600 L/guest/d | 132.0 |
| Accommodation cabins & glamping | 80 units | 2p/unit *400 L/guest/d | 64.0 |
| Municipal office allowance | 5 staff<br>50 visitors/d | 50 L/staff/d<br>10 L/visitor/d | 0.25<br>0.50 |
| School allowance | 176 student<br>11 staff | 30 L/student/d<br>50 L/staff/d | 5.3<br>0.6 |
| Wavegarden domestic demand | 1400 guest/d<br>50 staff/d<br>water treatment housekeeping | 25 L/guest/d<br>50 L/staff/d<br>200 L/d | 35.0<br>2.5<br>0.2 |
| Average Dry Weather Flow, ADWF | | (sum of the above) | 1322 |
| Peak Dry Weather Flow, PDWF | | ADWF x 0.80 x (PF) where PF= 3.4 (1) | 3596 |
| Inflow and Infiltration (I&I) allowance | 15.0 ha of serviced land area from the preceding table | 11.2m3/ha/d | 168 |
| Design condition for low flow | | ADWF | 1322 |
| Design condition for treatment units | | PDWF | 3596 |
| Design condition for hydraulic design of headworks and outfall, PWWF | | PDWF + I&I | 3764 |

ADWF = Average Dry Weather Flow,
(1) Harmon Peaking Factor = (1+(14/(4+(P/1000)^0.5))) = 3.4 where P= population of 2730 persons

The designed ADWF capacity of the plant allocated to South Britannia is 1,400 m3/d compared to the estimated flow of 1322 m3/d.

The PDWF and PWWF capacities of the plant were not reported and must be confirmed and accommodated in the design.

The designed PWWF capacity of the outfall is 11,000 m3/da and the estimated flow is 2,350 (allocated to North Britannia) + 3843 (estimated for South Britannia) = 6193 m3/d, therefore the outfall capacity of 11,000 m3/d is sufficient.

## Sewage Collection and Pumping

The sewage collection system will consist of:

- conventional gravity sewers serving Area A, and
- a low-pressure sewage pumping system serving the lodge, resort, cabins and glamping sites in Areas B and C.

The gravity collection system will discharge to one sewage pumping station located next in the Public Works Yard between the highway and the Wavegarden.

All resort facilities in Areas B and C will be served by grinder pumps that discharge into a common pressurized sewage force main. This system will provide great flexibility in locating facilities and routing sewer pipes and the high-density polyethylene piping will provide flexibility in the event of soil settlement. The force main will discharge into the first gravity sewer manhole north of the tunnel and will flow by gravity to the main sewage lift station, which is located centrally beside the Wavegarden. This lift station will pump the entire sewage flow from the development through a force main to the existing wastewater treatment plant.

The lift station force main, constructed in common trench with a gravity sewer pipe, will extend to the pedestrian and utility corridor beside the highway. The force main will then extend to Britannia North withing the proposed connecting path to Copper Drive. The force main will then proceed within the highway right of way, crossing the existing highway bridge, to the wastewater treatment plant. This routing is subject to the approval of the Ministry of Transportation and Infrastructure and should be approvable as it is similar to the route taken by the new sewage forcemain extended from the developments at North Britannia.

## Sewage Treatment

The existing Waste Water Treatment Plant will be upgraded to accommodate the flow from South Britannia with the addition of the following:

- Upgrading of the existing coarse screening;
- Automatic fine screen in the overflow channel;
- Grit removal tank and grit classifier, if deemed necessary from operating experience;
- New flow distribution piping connected to existing blind flanged connection points;
- Additional Sequencing Batch Reactor (SBR) tanks with aerobic digesters on the north side of the existing tanks;
- Upgrading of biosolids handling facilities if required;
- Pumps, piping and aerators associated with the new SBR tanks;
- Blowers and air piping added to pads and piping connections already included in the mechanical room;
- Upsized power supply to the plant;
- Expanded electrical supply works, motor control centres and control panels in the existing electrical room of the WWTP.
- Additional ultraviolet disinfection modules.

*Figure 36: Sewage system*


- Upgrading of the odour control equipment if required.
- Additional piping connections to the existing discharge/outfall if required.

Kerr Wood Leidal & Associates Ltd. designed the existing plant and they will likely be retained to design the upgrading to maintain continuity of responsibility for the functioning of the system.

## Summary

The existing North Britannia community is serviced by a gravity collection system and sewage pump stations (aka lift stations) discharging to a Waste Water Treatment Plant (WWTP) located on the north side of Britannia Creek and on the east side of Hwy 99. The treated effluent discharges through a marine outfall into Howe Sound.

The WWTP was designed to accept the flow from both North and South Britannia. The plant headworks and outfall were built to accept the anticipated total community flow. The plant power supply and treatment system was built to accept only the flow from North Britannia with space provided for the addition of treatment units and other components required to treat flows from South Britannia. Tiger Bay will therefore be responsible for increasing the treatment capacity of the WWTP to handle the flows from South Britannia.

The sewage collection system will consist of:

- conventional gravity sewers serving Area A, and
- a low-pressure sewage pumping system serving the lodge, resort, cabins and glamping sites in Areas B and C.

The gravity collection system will discharge to one sewage pumping station located next in the Public Works Yard between the highway and the Wavegarden.

All resort facilities in Areas B and C will be served by grinder pumps that discharge into a common pressurized sewage force main. This system will provide flexibility in locating facilities and routing sewer pipes. The high-density polyethylene piping will provide flexibility in the event of soil settlement. The force main will discharge into the first gravity sewer manhole north of the tunnel and will flow by gravity to the central sewage lift station, which is located centrally beside the Wavegarden. This lift station will pump the entire sewage flow from the development through a force main to the existing wastewater treatment plant.

The development parcels in Area A will discharge by gravity into the gravity sewer in Britannia Blvd. The exceptions are development parcels P6 and P8, which are lower than the gravity sewers and will be required to pump their flows into the main gravity sewer. In all cases, the developers of each parcel will be responsible for the design and construction of the sewers that service their parcels, and the strata corporations of each parcel will be responsible for operation and maintenance.

Next steps include:

1. Complete a pre-design study for upgrading, phasing and cost of the upgrading of the wastewater treatment plan.
2. Confirm sewer elevations after completing the preliminary design of the site grading.

## Section References

The referenced reports by Kerr Wood Leidal refer to previous versions of the development plan. The conceptual aspects of the reports remain valid, but the collection system layouts, flow and system sizing are updated by this report.


1) Engineering Servicing for South Britannia Beach, Project No. 2957.006-300, Kerr Wood Leidal Associates, November 2014

# STORMWATER

The site slopes toward and drains into Howe Sound via one defined drainage crossing of the highway and CN Rail at Thistle Creek, and two crossings of CN Rail at Daisy and Minaty Creeks. The majority of the proposed development is located on pervious fluvial outwash sediments on the fan formed by four small ephemeral creeks. The development will be designed to maintain and enhance the hydrologic values of the site, using protected streamside riparian areas, re-establishment of creeks and riparian areas, and naturalistic constructed features such as rain gardens, swales and ponds to maximize bio-filtration of sediment and contaminants, and infiltration of water. The pervious native soil will facilitate the use of a variety of best management practices to reduce site discharge of stormwater.

Drainage patterns are dominated by steep slopes to the east and the four creeks and associated low land wetland areas. The site experiences generally dry summers and wet winters. Large runoff events can be generated by winter storms, and peak runoff is often generated by heavy rain associated with warm Pacific fronts falling on and melting snowpack in the mountains. These peak events can also generate debris flows in susceptible creeks.

There are eight development parcels delineated on the drawings, plus the sportsfield parcel and Areas B and C. Each parcel is accessible to one or more drainage discharges (streams or ocean). Each parcel will be required to independently manage its own storm water discharges in compliance with the requirements outlined in this chapter.

This chapter of the report will address clear water flows, and an earlier section addresses the potential debris flow hazard associated with Daisy Creek.

## DFO Requirements

The stormwater generated within the site will discharge to sensitive fisheries habitat. Therefore, the following Fisheries and Oceans Canada (DFO) guidelines will guide the design of the drainage systems:

- Urban Stormwater Guidelines; and
- Best Management Practices for Protection of Fish and Fish Habitat (draft 2001).

A summary of the stormwater guidelines follows:

- Volume Reduction: 6-month/24-hour post-development volumes from impervious areas are not discharged and are infiltrated to ground. If infiltration is not possible, the rate-of-discharge from volume reduction Best Management Practices (BMPs) will be equal to the calculated release rate of an infiltration system.
- Water Quality Control: Collect and treat the volume of the 24-hour precipitation event equaling 90% of the total rainfall from impervious areas with suitable BMPs. Rate of discharge will not be greater than required to provide suitable hydraulic retention time in order to maximize the effectiveness of the specific BMP. Remove 80% of Total Suspended Solids (TSS) and 95% of floatable free oil.
- Rate Control or Detention: Post-development flows match the volume, shape and peak instantaneous rates of pre-development flows for the following precipitation events: 6-month/24-hour, 2-year/24-hour, 5-year/24-hour.

The applicable technologies for stormwater treatment (water quality control from above) will include the following:

- Source controls (land development practices that reduce the impact to the environment), for frequently occurring and small events, including:
    - Bio-filtration
    - Minimize impervious surfaces
    - Maximize hydraulic disconnects
    - Disperse runoff
    - Maximize flow path length
    - Increase surface roughness
    - Promote infiltration, evaporation and transpiration
- Slow (detain) flows;
- Preserve natural features;
- Discharge flows into natural and constructed wetlands;
- Oil and grit separators;
- Sediment and erosion control during construction;
- Settling and wet detention ponds;
- Operational management such as street sweeping;
- Pollutant removal through physical and biological treatment processes that occur in the plant and soil complex such as filtration, decomposition, ion exchange, adsorption and volatilization.

## SLRD Requirements

SLRD Bylaw 746 specifies the requirements for the following:

> **Minor System** – consisting of storm sewers, culverts and channels to convey up to the 10-year return period event.
>
> **Major System** – surface flood paths, swales and roadways to convey the 100-year return period event.

The guidelines and regulations promote a three-tiered approach:

> **Level 1** – The lowest level is source controls and treatment, as described above, that apply to frequent and small events (0.5, 2 and 5-year events) and that account for the majority of the cumulative impacts.
>
> **Level 2** – The next level is the SLRD Minor System requirement for the conveyance of 10-year events in a manner that avoids flooding of public areas to maintain convenience.
>
> **Level 3** – The highest level is the SLRD Major System requirement for the conveyance of 100-year events where inconvenience is permitted but flood damage is avoided.

## Level 1 – Source Control Elements

The Level 1 elements are the primary means of returning precipitation to the ground to maintain groundwater base flows, which is important for aquifer recharge for the water supply wells. Note that the usual pattern of groundwater flowing to and maintaining stream flows does not occur on this site where the opposite occurs, namely, the streams infiltrate into the ground and recharge the aquifer. The following are examples of source control elements that will be used for frequent and small events (0.5 to 2-year):

*Table 21: Source control elements*

| Surface | System |
|---|---|
| Public Areas – town center and commons | • Roof runoff directed to garden areas and infiltrated to the ground or directed to infiltration facilities<br>• Porous paving and rain gardens in pedestrian areas.<br>• Treat runoff from paved parking and truck loading areas. Cover if possible to divert precipitation.<br>• Direct runoff to irrigation storage.<br>• Porous road and parking pavements. |
| Housing – multi-family, cluster and single-family housing | • Topsoil or amended soil applied to pervious areas to store and treat runoff.<br>• Direct roof runoff to French Drains or rock pits with Major Flows directed to the downslope yard. If it is not possible to disconnect roof drains, then direct to infiltration that is part of the road system. Overflow to the drainage collection system.<br>• Direct runoff to irrigation storage.<br>• Porous road and parking pavements. |
| Major roads | • Use catch basins and curb cut-outs to direct runoff to off-line treatment and infiltration areas such as rain gardens and underground infiltration or storage.<br>• Porous road and parking pavements. |
| Minor and local roads | • Ditch or swale on both sides of the road to detain 6-month rainfall.<br>• Direct runoff from on-lot French Drains with excess road runoff to infiltration, detention and treatment facility.<br>• Porous road and parking pavements. |
| Parking lot | • Infiltration swales to detain, treat and infiltrate runoff<br>• Local detention and infiltration facilities to capture the 6-month event.<br>• Porous pavements |
| Boulevards and landscaping | • Provide topsoil cover and vegetation to maintain infiltration to underlying permeable soils. |
| Natural area | • Preserve and protect<br>• Ditches beside paths and trails to convey major flows without washing out trails |

## Level 2 – Minor System Elements

The minor system will carry 10-year return period runoff flows that exceed the capacity of the Level 1 source controls, in a manner that avoids inconvenience to residents. The Minor System typically consists of a system of high-level diversions, catch basins and curb cuts leading to ditches and underground pipes, that carry the flow to the same wetlands system and streams described above. Short term detention for flow attenuation will be provided by the wetland freeboard. The minor systems will discharge to detention facilities on each development parcel which in turn discharge to the creeks. Although the wetland will provide some treatment (primarily sedimentation) and infiltration, the contribution is relatively minor when compared to the Level 1 contribution, due to the short residence time in the wetland.

## Level 3 – Major System Elements

The major system provides an emergency overflow of the 100-year return period flows to avoid flooding of property. This is done by directing flows along roads and lower elevation pathways to a suitable outlet and raising of buildings to provide freeboard above the major flow elevation. The major system provides emergency relief to flooding caused by intense and rare precipitation events, or more commonly caused by intense warm frontal system rains on previously frozen ground and snow. There is no pretense of convenience, but only avoiding property damage or life hazard to the degree possible.

All development parcels will be required to direct their major system flows into a neighbouring stream.

## Design Concepts

All development sites will be designed with Level 1 source controls with the goal to limit the post-development runoff volume/pattern to the pre-development conditions, as well as to reduce contaminant loading as much as practical.

A central stormwater detention pond is located on the north edge of the wetland. This will capture and treat runoff from the Village Centre that is discharged to the ocean at the outlet of Thistle Creek. The multi-family developments will be responsible for stormwater treatment and detention on their properties.

The drainage concept is illustrated on the drawing *Site Plan, Final* and on the following figure. A preliminary drainage layout and design will be prepared upon completion of a preliminary site grading plan.

*Figure 37: Drainage plan*

## Summary

Drainage patterns are dominated by steep slopes to the east and the four creeks and associated low land wetland areas. The site experiences generally dry summers and wet winters. Large runoff events can be generated by winter storms, and peak runoff is often generated by heavy rain associated with warm Pacific fronts falling on and melting snowpack in the mountains. These peak events can generate debris flows in susceptible creeks.

There are eight development parcels delineated on the drawings, plus the sportsfield parcel and Areas B and C. Each parcel is accessible to one or more drainage discharges (streams or ocean), and each parcel will be required to independently manage its own stormwater discharges in compliance with the requirements outlined in this chapter.

Next steps include:

1. Prepare a preliminary drainage layout and design upon completion of the site grading plan.

## References

1) Engineering Servicing for South Britannia Beach, Project No. 2957.006-300, Kerr Wood Leidal Associates, November 2014
2) http://www.rainwatermanagement.ca/wp-content/uploads/2014/04/Draft-BC-Land-Development-Guidelines-Section-4.pdf

# OTHER SERVICES

## Electricity

BC Hydro is responsible for the power system planning, design and installation, with the construction of associated civil works remaining as the responsibility of the Developer. The electrical load for system design is estimated on the basis of building types, and projected energy uses, and this will be completed during the next stage of design.  The Wavegarden has a substantial power demand that must be accommodated by the system.

BC Hydro transmission lines run along the eastern boundary of the development area. North Britannia is serviced from a sub-station above the mine building on the north boundary of the development area. The sub-station will require upgrading, and costs and details are subject to negotiation with BC Hydro.

The electrical distribution system will be constructed underground in the boulevard behind the curb line or in the road shoulder in the public road right-of-way. Major structures such as pull boxes, transformers and switching kiosks will be located in boulevards with protection provided from snow removal equipment.

## Natural Gas

Natural gas system design and installation is the responsibility of FortisBC. There is currently no natural gas supply near the site, and preliminary discussions indicated that the system could be extended to Britannia but at substantial cost to the developer due to the long time required to sell the properties and therefore recoup the infrastructure investment. Further discussions will completed to determine if the cost can be absorbed by the project. The fall-back position is to use electricity for heating combined with high-efficiency building envelopes and appliances to reduce energy use and cost to the building owners, and load on the grid.

## Telecommunications

Bell Canada is the telecommunications service provider for the Britannia community. The developer will be responsible for installation of the civil works (ducts, vaults, boxes) in the streets and into buildings, normally in common trench with the underground electrical distribution system. The utility company will install the wire/fibre.

The Cablevision provider is responsible for system planning and design and is normally responsible for all installation costs, including underground civil works.

## Public Safety

The community will require the usual public safety facilities that will be integrated with those presently serving North Britannia. Specifically, the Britannia Beach Volunteer Fire Department must be expanded to provide fire protection and first responder services. This might also include an ambulance service. Tiger Bay anticipates a requirement to make a contribution to the upgrading of the existing public safety services to expand their capacity.

## Wildfire

The community is surrounded on three sides by forested land that could pose a wild-fire hazard. However, the development area is separated by cleared rights of way for electrical transmission lines and Highway 99, which will provide a degree of protection to the community. The next stage of design will include a wildfire assessment and mitigation plan. The key elements are expected to include use of non-combustable roofing and siding on buildings.

## Section References


1) Engineering Servicing for South Britannia Beach, Project No. 2957.006-300, Kerr Wood Leidal Associates, June 2014

# PHASING

Construction of the development will be phased over many years to suit market conditions and infrastructure sequencing.

## Phase 1 (present - 2025)

Phase 1 development (also referred to as the Interim development) will include the Wavegarden, recreation area (pump track, skate park, etc.), brewpub and up to 20 cabins and glamping sites temporarily located beside the Wavegarden configured as a surfing village. The cabins/glamps will be relocated to Area B in a future phase.

Access to the site will be provided by the existing North Access only. Phase 1 will operate with interim servicing to allow deferral of many servicing elements. The utilities will be built to a long term but not municipal standard with the understanding that the interim facilities will be replaced by the permanent facilities in subsequent phases. The intention is to allow the site to be occupied for an indeterminate time without the need to initially build the expensive full build-out services.

All roads and utilities in Phase 1 will be private and will be built and operated by Tiger Bay. Servicing elements that will be incorporated into the final servicing will be built to SLRD and MoTI standards with the details of inspections and approvals to be negotiated.

Phase 1 site development and utilities are illustrated on the drawing entitled *Site Plan, Interim* and will include the work described below.

### Grading

- Raise the site sufficiently to allow permanent buildings to be constructed to a flood construction level of 5.0 m. The cabins will be portable and will not be flood-proofed as they can be vacated if a flood is imminent. Floods depths are very low and the only hazard is to property, not life.

### Stream and debris hazard protection

- Regrade and stabilize the steep slopes surrounding the upland area of Gravel Ck.
- Realign Gravel Creek into its final configuration complete with training berms, channel hardening and bank erosion protection in the steep upland area.
- Construct the small debris basin and associated works on Daisy Ck.
- Confirm if a debris flow on Daisy Ck can affect the Interim Phase 1 development and how this can be mitigated. It is unlikely that the Wavegarden will be affected as it will be raised significantly to mitigate high water table. The brew pub will likewise be raised to conform to the generally raised site required to conform to the raised Wavegarden. The cabins, being temporary, are not intended to be raised but this might prove to be necessary. The need for debris flow mitigation will be confirmed by ongoing hazard studies.

### Environmental mitigation

- The Wavegarden will occupy a substantial portion of the existing riparian areas associated with the Gravel Ck wetlands. Phase 1 will include construction of the new wetland and pond system, new riparian areas surrounding the realigned Gravel Ck, and retention of the existing riparian areas in Parcel P6 that are not used for development in this phase.

- The permanent riparian areas set aside in Phase 1 will be smaller than the area lost to development. We anticipate the need to negotiate a suitable agreement with the environmental agencies, that might be registered as a covenant on title, to provide assurance that the total agreed upon riparian compensation will ultimately be provided.

- Establish covenants over the permanent riparian areas related to Gravel Ck and the new wetland/pond.

### Roads, parking and paths

- Construct minor improvements to the existing North Access including an improved northbound deceleration lane and ramp into the site and an improved northbound ramp with acceleration lane out of the site, while maintaining operation as a full movement stop-controlled intersection.
- Build a short section of Britannia Blvd. from the North Access to a temporary roundabout at the intersection of Britannia Blvd and the service road to the public works yard. This will provide access to the Wavepark, surface parking lot, brewpub, cabins and the farmer's market. Note that the farmer's market is a separate initiative that incorporates its own parking lot. This road will be a private two-lane road using seal coat surfacing with gravel shoulders and ditches.
- Gravel surfaced two lane 6m wide service road from Britannia Blvd. to the works yard and Wavegarden operations buildings. This road will also provide access to the 20 cabins.
- A gravel-surfaced guest parking lot with lighting and interim landscaping using native drought resistant plants.
- Upgraded private access road from the Ph.1 Britannia Blvd. through the culvert underpass, CN Rail surface crossing and to Minaty Bay. The service road will be used for operations and maintenance access to the property and for fire protection access in the event of a wildfire. The access road will continue to use the existing highway underpass and stream crossing bridges and culverts.
- Upgraded CN Rail private surface crossing to conform with permit requirements.
- Interim street lighting mounted on overhead utility poles and pedestrian lighting along formal pedestrian paths.

## Water

The following table summarizes the estimated Phase 1 potable water system demands:

*Table 22: Phase 1 water demands*

| | |
|---|---|
| Average Day Demand, ADD (m3/d) | 81 |
| Maximum Day Demand, MDD (m3/d) | 161 |
| Peak Hour Demand, PHD (m3/d) | 282 |
| Fire flow requirement to brew pub (L/s) (1) | 73 L/s for 1.6 hr |
| Water treatment capacity = MDD (m3/d) | 161 |
| Reservoir capacity 2 days x ADD (m3) | 161 |
| Standard tank size 24 ft dia x 16ft high actual capacity (m3) | 212 |
| Raw water buffer tank in treatment plant, 1hr @ MDD (m3) | 6.7 |

(1) from Water Supply for Public Fire Protection, Fire Underwriters Association. The system will supply 50 L/s from the wells through fire hydrants.

The Phase 1 water system consists of the following components:

- Outfit both existing wells (TW1 & TW2) with 25 L/s pumps with VFD control, pumping through the raw water watermain installed in its permanent location to the Wavegarden operations centre and Public Works Yard that will contain a containerized interim water treatment plant. This water will be used untreated for filling the Wavegarden pool and treated for supplying potable water demands of the Wavegarden, brewpub, market and cabins. The pumps are controlled by the water level in the ground-level reservoir. Note that the well capacities will fluctuate seasonally so use well level sensors to control the VFD to limit the well pumping rate to avoid over-pumping the wells.
- Permanent raw water main from the wells to the interim water treatment plant that is located in the Works Yard. The raw water main will supply untreated water to the treatment plant and to the Wavegarden for pool filling. It will also supply 50 L/s fire flow from the wells through a cross-connection to the future domestic water distribution main noted below.
- Containerized water treatment plant in the Public Works Yard containing a 1-hour volume flow equalization tank, pH adjustment, filtration, UV disinfection and chlorination sized to provide Ph.1 potable water demands.
- Treated water main from the treatment plant to the ground level reservoir. The UV treatment allows direct discharge of the treated water into the reservoir without providing additional chlorine contact time.
- Bolted steel ground level water storage reservoir sized for two days of emergency supply, flow equalization and cabin fire sprinkler storage for the Phase 1 development.
- Containerized potable water booster station to pump domestic and cabin fire sprinkler demands through small diameter water mains from the reservoir to the Ph. 1 buildings.
- 100 mm (4”) high density polyethylene treated water distribution loop around the Wavegarden that will be used in the final configuration as an irrigation supply pipe.
- Build the future water distribution mains in Britannia Blvd and the service road complete with fire hydrants. Cross-connect these distribution mains to the raw water supply pipe from the wells to distribute raw water to the hydrants for fire protection.

- Fire hydrants on the large diameter water distribution main to supply fire trucks and fire mains to the fire sprinklers in the brewpub and Wavegarden buildings. The well pumps will supply the sprinkler flows. This strategy is subject to the approval of the fire commissioner and the insurance underwriters.

### Sewer

- Permanent gravity sewers from the Wavegarden, brewpub, cabins and farmer's market to the permanent sewage lift station.
- Permanent sewage lift station with temporary smaller capacity sewer pumps and electrical controls and switchgear.
- Permanent sewage forcemain from the lift station to the Britannia wastewater treatment plant.
- Wastewater treatment plant upgrading necessary for the Phase 1 sewer flows.

### Landscaping

- Permanent landscaping for the Wavegarden, recreation area, and brewpub.
- Temporary landscaping for the cabin village, roads and surface parking lot.

### Power and communications

- Extend a permanent large capacity overhead electrical service from the BC Hydro transformer station above the Britannia mine building to the Wavegarden, brewpub and the service building for the cabins. This will require upgrading of the transformers at the transformer station.
- High speed wired and wireless internet and CCTV.

### Drainage

- All drainage will use surface ditches and swales discharging into ground, constructed rain gardens or to the drainage detention pond associated with the Public Works Yard.

## Phase 2 (2026-2030)

Phase 2 initiates construction of the permanent core utilities to service the initial phases of residential and commercial development in Parcels 1, 2, 4, 5 and 6 and the tourist accommodations in Area B. Phase 2 servicing will require most of the permanent "buildout" utilities and services that are illustrated on *Site Plan – Final*.

Developers of each of the development parcels will be responsible for planning, designing and building full servicing for each development parcel including private road or driveway entrance onto Britannia Blvd, metered utility connections for water and sewer, on site drainage, detention and overflow to the discharge location noted on Dwg. 2. The private services in Area B are not included in the following list.

The following elements of the buildout drawing are included in Phase 2.

### Grading

- Regrade and stabilize the steep slopes in Parcel P5 and Area B.

### Stream and debris hazard protection

- Daisy Creek training berms and debris basin improvements identified by subsequent study.
- Thistle Creek debris basin and channel training.

### Environmental mitigation

- Complete Thistle Creek and Daisy Creek riparian area upgrading.

### Roads, parking, paths

- North Access built to final configuration.
- South Access built to final configuration
- Upgraded highway underpass. The extent of upgrading or replacement will be determined through negotiations with MoTI and is currently uncertain. It will consist at least of structural upgrading of the existing underpass and configuration as a signalized single lane underpass.
- Britannia Boulevard connecting the North Access to the South Access built to final configuration complete with paving, boulevards, multi-use trail, pedestrian crossing, rain gardens, parking and lighting.
- Permanent stream crossings over Gravel, Thistle and Daisy Creeks.
- Restricted access service road from Britannia Blvd to the existing CN Rail surface crossing. It remains to be determined if this crossing will remain private or if it will be located in a statutory right of way for restricted public use to service the park and the future waterfront lodge.
- Minor upgrading of the BC Hydro access road to provide all weather access to the reservoir site.
- Public path through the Daisy Ck riparian area.
- Public path beside Thistle Ck located in the water main easement.

### Water

- Decommission temporary water treatment, storage and pumping at the Public Works Yard.
- Drill one or two additional wells (contingent on yield) at locations PW#1 and PW#2 and outfit all wells with VFD controlled pumps. Reconfigure maximum pumping rates to match well capacity and so that total yield remains below the environmental review threshold of 75 L/s.
- Connect new wells to the Ph. 1 raw water main. Extend the raw water main to the water treatment plant.
- Construct one of two 50% capacity treatment trains at the new water treatment plant.
- Build the treated water supply main to the reservoirs.
- Build the final configuration of reservoirs. Both reservoirs are required for reliability, serviceability and for fire protection capacity.
- Water distribution main from the reservoir to the Britannia Blvd water distribution main.
- Water distribution main from the north side of the Highway 99 casing pipes connecting to the interim distribution mains in Britannia Blvd.
- Water main connection between N. and S. Britannia with pressure regulating station.

### Sewer

- Decommission Phase 1 temporary sewer works.
- Extend force main and gravity sewers from the proposed Highway 99 sewer casing pipe along Britannia Blvd to connect to the interim sewer main in Britannia Blvd.
- Outfit the sewage lift station with full capacity pumps and controls.
- Upgrade the wastewater treatment plant to accept flows from Phase 2.

### Power and communications

- Extend power and communication ducts and cabling through the length of Britannia Blvd. between the North and South Access.

### Drainage

- Construct the permanent drainage facilities in Britannia Blvd including minor system piping, rain gardens, the works yard detention pond and the permanent major system flow paths.

## Phase 3

Remaining infrastructure as required including:

- Second treatment train in the water treatment plant when required.
- Upgrading of the sewage treatment plant to service anticipated flows.
- CN Rail pedestrian overpass if required by subsequent negotiations.
- Upgraded existing service road to the cliff top park and restaurant.
- Remainder of paths and trails
- Regrade and stabilize the steep slopes in Parcel 8.
- Restricted access public service road through Area C (waterfront lodge) to the regional park.

- No additional works required.

- No additional works required.
- No additional power or communication works required.
- Additional drainage works required.