

Cowichan Estuary Restoration Project

Dinsdale Field Flood Mitigation Features Design Summary

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1 INTRODUCTION

This report presents the detailed designs for proposed flood mitigation features located on the Dinsdale Farm property to address the transfer of flood risk that Northwest Hydraulic Consultants Ltd. (NHC) has identified to be associated with the decommissioning of Dinsdale Dike (Dike 49). The proposed dike decommissioning is part of the Cowichan Estuary Restoration Project, a Nature Trust of British Columbia (NTBC) initiative to help restore the Cowichan – Koksilah River Estuary (Cowichan Estuary) by removing barriers to estuarine marsh development. NTBC retained NHC to support scoping, analysis, design, construction, and Deputy Inspector of Dikes' approval under the Dike Decommissioning Guidelines (BC MFLNRORD, 2022) for the proposed marsh restoration project.

To initiate the dike decommissioning permitting process, NTBC commissioned NHC to prepare a preliminary design for flood mitigation features to address project-related transfer of flood risk that NHC identified (NHC, 2022b). NHC presented a preliminary flood mitigation concept design to address transfer of flood risk from Dinsdale Field and *Issued-for-Permitting* drawings on June 23, 2022 (NHC, 2022a). Since then, NHC has advanced the flood mitigation design process, and this report presents the detailed designs for proposed flood mitigation features located on the Dinsdale Farm property. The proposed flood mitigation features located on the Dinsdale Farm property (Block 2 [DD 4629], Plan 1725; Property Identification 002-032-783) are referred to herein as the *Dinsdale Field mitigation*, and include the following elements:

- Four wave attenuation features (WAFs).
- Elevation Tie-In Feature (ETIF) along Cowichan Bay Road, including
  - Compacted soil fill
  - A *Floodbox Assembly* through the compacted soil fill
  - *Collector swale* upstream of the Floodbox Assembly
  - *Outflow swale* downstream of the Floodbox Assembly

Figure 1.1 presents the proposed Dinsdale Field flood mitigation features described in this report. Appendix A presents the *Issued-for-Review* drawing set to accompany this design summary report. Appendix B presents hydraulic modelling completed using HEC RAS[1] to support the analyses and design. Appendix C presents Thurber Engineering Ltd.'s (Thurber's) geotechnical report for project input. Other proposed flood mitigation features associated with the proposed project are located along the northern edge of Dinsdale Field, and on Lot 2, Lochmanetz Road (Section 10 Range 2 and District Lot 690 Cowichan District Plan VIP70020), which is located to the north of Dinsdale Field and was purchased by NTBC in October 2024 (T.

[1] HEC-RAS refers to the US Army Corps of Engineers Hydraulic Engineering Center River Analysis System.

Reid, personal communication, November 29, 2024). The material presented in this report does not include proposed flood mitigation features located along the northern edge of Dinsdale Field or on Lot 2.

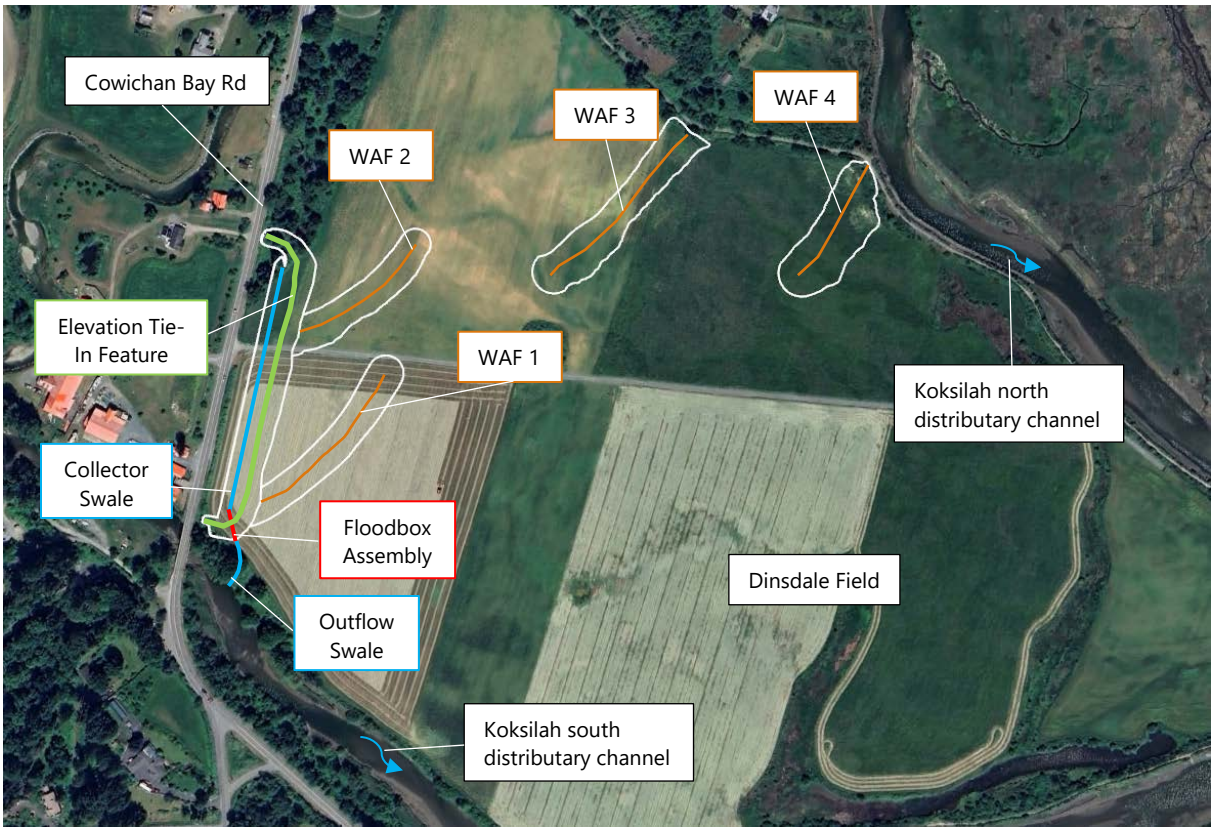


Figure 1.1 Proposed Dinsdale Field Flood Mitigation design features (imagery source: Google, 2024).

This design summary report documents the following:

- Design rationale for the proposed flood mitigation features located on Dinsdale field
- Hydraulic and wave modelling updates to support detailed design of the ETIF and WAFs
- Operations, maintenance, and surveillance recommendations relating to the design
- Guidance for next steps and construction.

1.1 Background

Provincial dike decommissioning guidelines require that dike removal projects must not transfer flood risk to other properties (BC MFLNRORD, 2022). The guidelines stipulate that properties affected by dike removal must be protected to their existing level against flood hazards or to

withstand the 10-year flood, whichever is greater. The flood mitigation features located on Dinsdale Field are components of the overall flood mitigation works proposed for the Cowichan Estuary restoration project. The ETIF and WAFs 1 and 2 mitigate the transfer of coastal flood risk to a low-lying portion of Cowichan Bay Road and properties west of Cowichan Bay Road. WAFs 3 and 4 mitigate the transfer of wave-induced erosion and flood risk to the north of Dinsdale Field. All features provide a co-benefit of elevation diversity for vegetation succession and adaption to sea-level rise induced by climate change.

NHC proposes grading improvements along the northern Dinsdale Field property boundary and on Lot 2 to aid in overland riverine drainage and mitigate infrequent coastal inundation of low-lying portions of Lot 1 after removing Dike 49 (NHC, 2023b). The proposed design for those features is not described in this design summary report but will be a part of the overall project-related mitigation. The proposed extents of removal of Dike 49 are illustrated in Figure 1.2. Lot 1 and Lot 2 Lochmanetz Road, and other features discussed in the report are labelled for reference.

The following list of documents were prepared by NHC to support the application that NTBC submitted to the offices of the Deputy Inspector of Dikes on March 14, 2023:

1. Cowichan Estuary Marsh Restoration Project - Assessment of Physical Processes and Restoration Opportunities. Final, Rev. 0, March 9, 2022 (NHC, 2022a).
2. Cowichan Estuary Marsh Restoration Preliminary Design Basis. Final, Rev. 0, June 23, 2022 (NHC, 2022b), which includes Issued-for-Permitting drawings as Appendix A.
3. Cowichan Estuary Marsh Restoration Project – Summary of the Transfer of Flood Risk. Final, Rev. 1. March 16, 2023 (NHC, 2023a).
4. A professional letter of commitment that relates to the design of dike works subject to approval under the *Dike Maintenance Act* (DMA), authenticated by G. Hill, PEng, NHC, March 16, 2023.

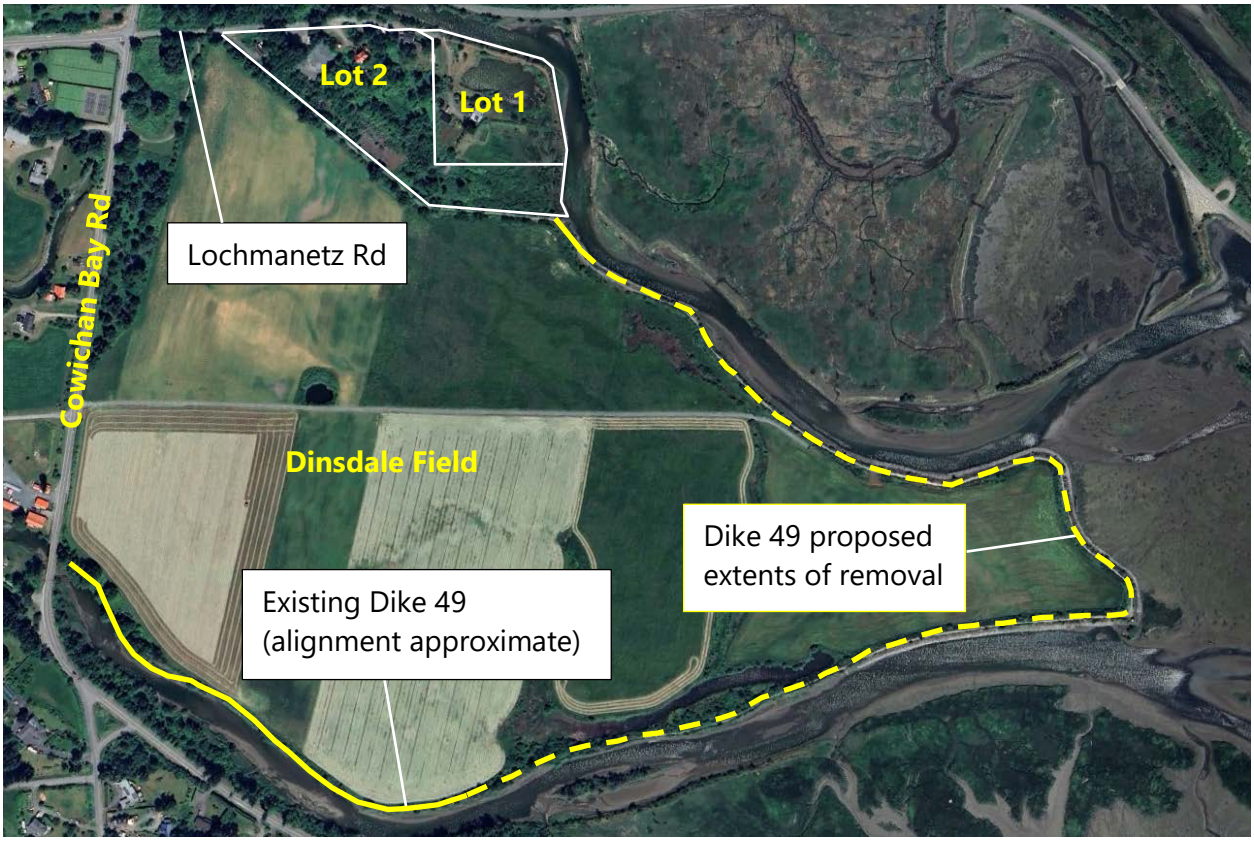


Figure 1.2 Existing Dike 49 alignment (yellow solid and dashed lines), and proposed extents of removal of Dike 49 (dashed yellow line). Boundary lines are approximate only, for illustrative purposes. Imagery source: Google, 2024.

1.2 Design References and Guidelines

The following guidelines were referenced as part of the design process of the flood mitigation features described in this report:

- Procedural Guidelines: Decommissioning of a Regulated Dike (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2022).
- Technical Manual: Overtopping Protection for Dams (FEMA, 2014).
- Manual on Wave Overtopping of Sea Defences and Related Structures (EurOtop, 2018).
- MMCD 2009 Platinum Edition (The Master Municipal Construction Documents Association, 2009).
- Design of Rock Chutes (Robinson et al., 1998).
- Hydraulic Design of Highway Culverts, Third Edition (Federal Highway Administration, 2012).

- Guidelines for Management of Flood Protection Works in British Columbia (MELP, 1999).
- Design of Riprap Revetment (Brown and Clyde, 1989).
- Riprap Installation Guide (BC MOTI, 2013).

2 RIVER AND WAVE MODELLING SUMMARY

Hydraulic modelling in HEC RAS and wave modelling in SWAN were completed to support the design of the project. The HEC RAS modelling included updating the geometry, portions of the terrain, and boundary conditions of the model used for previous phases of the project to reflect the Dinsdale Field flood mitigation features, which can interact with overbank riverine flows. Sensitivity testing and validation runs were completed. The HEC-RAS modelling was used to determine static design water levels, design the road mitigation drainage features, and assess overland drainage impacts of the project. This modelling work is described in Appendix B.

Wave modelling was completed in SWAN to validate the design and confirm adequate attenuation of wave energy during the design storms. Pertinent results are described in Section 3.3.

3 FLOOD MITIGATION FEATURES LOCATED ON DINSDALE FIELD

The flood mitigation design was completed by NHC and Thurber with input from NTBC and includes hydraulic and geometric design elements. McElhanney Associate Land Surveying Ltd. provided topographic and property line surveys for the project. Field investigation reports prepared by Thurber Engineering Ltd. have been relied on for material gradations and field conditions (Thurber, 2023), and Appendix C presents the Thurber Engineering Ltd. geotechnical report prepared for the design presented herein.

The design elements are described below, along with the design rationale. Other design elements on Dinsdale Field that are associated with the project include the grading of land to elevations determined by NTBC, establishing vegetation, and constructing marsh channels. The material presented in this report does not include these design details. However, to include context of these other restoration design elements, an illustrative marsh channel layout provided by NTBC on May 23, 2024, has been included in the design drawings.

The design details presented in this report exclude flood mitigation features located along the northern Dinsdale Field property boundary and on Lot 2. Those features are included in the proposed Lot 2 flood mitigation design, which is being prepared separately by NHC upon request by NTBC. The Lot 2 flood mitigation features are complimentary to the Dinsdale Field

flood mitigation features, and they must be completed to satisfy the Dike Decommissioning Guidelines (BC MFLNRORD, 2022).

3.1 Design Intent

The purpose of the proposed flood mitigation design features presented herein is to either reduce or maintain similar-to-existing flood hazards under present climate conditions after Dike 49 is removed. The proposed design has three primary objectives:

- Provide wave attenuation during high ocean levels.
- Accommodate or improve overland riverine drainage during river-driven flood events.
- Mitigate the altered attenuating effects of the Dinsdale Field and Dike 49 complex on ocean levels; together, the field and dike create a receiving basin for ocean water.

The design consists of the ETIF and four WAFs. The primary function of the ETIF is to prevent tidally driven coastal water from overtopping a low point along Cowichan Bay Road (flooding east to west) while minimizing impacts to overland drainage from riverine flooding and stormwater runoff (from west to east). The primary function of the four WAFs are to dampen waves that may pass across Dinsdale Field once Dike 49 is removed.

Other proposed design elements have a primary function of providing habitat complexity and enhancement, including the removal of Dike 49, construction of raised-elevation topographic features and estuary channels. The design of these proposed features is not presented in this report; however, they will be incorporated into the overall project and may offer *additive* flood mitigation benefits by respectively removing a barrier to riverine floodwater, dampening wave effects and increasing the density of drainage pathways in the marsh.

The gentle side-slopes featured in the design have additional co-benefits, to accommodate other design elements such as marsh benches, vegetation planting, and marsh channels. The gentle gradients and vegetation features will help dampen wave energy and marsh channels will improve drainage from Dinsdale field.

The design features are proposed in an area that can experience both coastal and river-driven flooding under existing conditions (i.e., with Dike 49 in place). Furthermore, flood hazards to the area are expected to increase with climate change. The Cowichan Valley Regional District (CVRD) Flood Maps prepared by NHC (NHC, 2021) show that the project area is within the *coastal-flood-construction-level* zone. The Phase 1 Assessment of Physical Processes and Restoration report identifies flood risks to the project site and surrounding area under climate change conditions (NHC, 2022b).

The design presented herein has been developed to support the NTBC's goal of promoting natural estuarine processes as a key element of the restoration project. NHC undertook a broad

range of hydraulic model simulations to inform the design of the proposed flood mitigation features. In total, NHC undertook thirty-three HEC-RAS simulations that covered eleven joint riverine and ocean-level flood conditions for three conditions: existing, with Dike 49; with Dike 49 removed, and with-project (with Dike 49 removed and proposed Dinsdale Field flood mitigation measures in place). Modelling undertaken for the flood mitigation design elements did not include the habitat enhancement components of the design, such as the raised-elevation topographic features and estuary channels. The overall project, which includes these proposed features, may offer additional flood mitigation.

Appreciable water level *increases* were observed on NTBC's Dinsdale Field property for some joint riverine and ocean-level flood conditions, which is a recognized and desired outcome of the project (T. Reid, personal communication, November 29, 2024). Appendix B presents the model simulations undertaken, results, and limitations. The modelling completed by NHC indicates that the project will either *reduce* or *maintain-similar-to-existing* flood hazards for present climate conditions for Cowichan Bay Road and the properties west of the road after Dike 49 is decommissioned. In three of the eleven joint riverine and ocean-level flood scenarios that were simulated for the with-project condition, there were small incremental water level increases (i.e., less than 0.05 m) with the project mitigation features in place; in NHC's opinion water level changes of 0.05 m or less are within the model's uncertainty limits. For large river-driven simulations (e.g., simulations with a riverine return period of 50- or 100-years), the model simulations indicate *decreases* in water level on Cowichan Bay Road and the properties west of Cowichan Bay Road with Dike 49 removed.

3.2 Elevation Tie-In Feature

The ETIF crest elevation was selected to mitigate project-related coastal inundation while balancing the complex flood mechanisms of the system, which includes both riverine and coastal flooding. Model simulations identified that overland, riverine flood flows are sensitive to the crest elevation of the ETIF feature. Freeboard has not been included in the designed ETIF crest elevation because additional elevation of the feature would interfere with drainage of riverine flood flows.

The engineered fill component of the ETIF runs parallel to Cowichan Bay Road and connects with the road embankment at each end of the feature. The south end of the feature connects with the embankment on NTBC property, and the north end of the feature connects with the road embankment on provincial highway land. WAFs 1 and 2 are connected on the east side of the ETIF. The following summarizes key aspects of the design:

- The ETIF will join the Cowichan Bay Road embankment at elevation 2.45 m CGVD2013, and the crest elevation will be 2.45 m CGVD2013 along its full length. The crest elevation was refined through iterative model simulations. A compacted soil core, grass treatment, wide crest, and gentle side-slopes provide overtop stability.

- The core of the ETIF will be structural fill compacted to 95% proctor dry density (see Appendix C). The side slopes of the compacted core will be 2:1 (H:V) on both the eastern and western sides, with a top width of 4 m.
  - The eastern core slope will be overlaid with soils and gravels and treated with grass to achieve a 20:1 (H:V) slope. This gentler slope is to improve resiliency to wave effects.
  - The western core slope will be overlaid with soils and gravels and treated with grass to achieve a 6:1 (H:V) slope. This slope in combination with grass treatment provides stability in the event of minor overtopping.

Part of the ETIF design will include a relocation of the driveway access that connects Cowichan Bay Road to Dinsdale Field, approximately 100 m to the north. The design lies wholly within Dinsdale Field, except at the northern end of the EITF where it ties into the embankment of Cowichan Bay Road, which is located on highway land.

3.2.1 Field Access

The field access is not a flood mitigation feature but is a component of the overall ETIF that will maintain access to Dinsdale Field. Existing field access is via a gravel driveway off Cowichan Bay Road. This access will be rerouted approximately 100 m to the north to where the ETIF connects to Cowichan Bay Road. The existing gate will be relocated to the new access location. The top of the ETIF has a width of 4 m to accommodate driving, and the curve has an inside radius of 15 m to accommodate access for construction equipment.

3.2.2 Collector Swale

The design features the Collector Swale on the west side of the ETIF. The swale will direct water between Cowichan Bay Road and the engineered fill to the Floodbox Assembly. Components of the Collector Swale are:

- A bottom width of 1 m at elevation 1.15 m CGVD2013, with 6:1 (H:V) side slopes, the east of which will be a continuation of the 6:1 (H:V) side slope of the elevation tie-in feature.
- The bottom length of the swale is 220 m.
- The surface of the swale will be vegetated with grasses.

3.2.3 Floodbox Assembly

At the southern end of the swale is the Floodbox Assembly; it will drain stormwater and assist in draining floodwaters. The Floodbox Assembly has been included in the design to drain any water that may otherwise be impounded below the overtopping crest of the ETIF. Key aspects of the Floodbox Assembly include:

- A 12.2 m long, 600 mm diameter concrete pipe laid at a 1% gradient towards the Koksilah south distributary channel. The concrete pipe will be unreinforced pre-cast concrete sections joined with rubber gasketed bell and spigot joints.
- Each end of the assembly will have pre-cast concrete headwall that accommodates a 600 mm inner diameter pipe. Each headwall rests on a concrete curb, that will allow for adequate compaction under the headwall. The downstream headwall will have space around the opening that allows the tidal flapgate to be bolted on.
- The pipe will be *haunched* with pipe backfill soil of a gradation satisfying the specifications in Section 31 05 17 of the MMCD 2009 Platinum Edition. The material will be compacted to 95% proctor dry density in 150 mm lifts, with hand tamping as required to achieve adequate compaction under the *springline* of the pipe as described in Appendix C.
- The downstream headwall will have a *Waterman SSF-41* stainless steel flapgate, or approved equivalent, with a vertical hinge. The flapgate is to prevent return flow up the culvert when ocean levels are high. Vertically hinged flapgates are suitable in circumstances where fish passage is not desirable.
- The pipe accommodates the following flows:
  - 370 L/s, with a headwater depth of 0.6 m, which is the diameter of the pipe.
  - 620 L/s, with a headwater depth of 1.03 m, which is the difference between the lowest elevation of the crown of Cowichan Bay Road and the culvert inlet invert.
- The upstream headwall will have a fitted, bolt-on trash rack to minimize debris build-up in the pipe.
- Both headwalls will be fitted with a bolt-on handrail.

3.2.4 Outflow Swale

Downstream of the Floodbox Assembly is the Outflow Swale that conveys the culvert flow to the Koksilah south distributary channel. The swale drains away from the Floodbox Assembly at an approximately 1% gradient and features a buried launchable riprap apron to mitigate the potential for head cutting. The riprap was sized according to Robinson's drop chute design method (Robinson et al., 1998). Cobbles line the swale downstream of the riprap to another section of riprap, which connects to the channel. Both the initial riprap and cobble portions of the Outflow Swale are underlaid by a 0.3 m thick granular filter layer. Key aspects of the swale geometry are summarized below:

- The swale has a bottom width of 1 m, and 2:1 (H:V) side slopes, which rise 0.75 m. Beyond the rock side slopes, in-situ materials will be excavated and sloped at 3:1 (H:V) to daylight.
- The riprap thickness is 520 mm, which is two times the D_{50} (median diameter) of BC Ministry of Transportation and Transit (MOTT)I Class 25 kg riprap (BC MOTI, 2013). The cobble downstream of the riprap will have a depth of 300 mm.

- The launchable apron is 2 m downstream of the headwall, and has sufficient rock volume to launch into a 2.5:1 (H:V) slope down to elevation 0 m CGVD2013 while maintaining the design thickness.
- The total length of the Outflow Swale from the headwall to the confluence with the Koksilah south distributary channel is approximately 45 m.
- The final 4.5 m of the Outflow Swale where it connects to the Koksilah south distributary channel will be constructed with Class 25 kg riprap, with a thickness of 0.7 m. Granular material will be flushed into the voids of the riprap. This riprap is to provide additional stability to the Outflow Swale where it interacts with the channel.

3.3 Wave Attenuation Features

The proposed WAFs are designed to dissipate wave energy and reduce wave propagation off Dinsdale Field. The WAFs are not intended to obstruct water from flowing around them and NHC has assumed occasional overtopping of these features is acceptable because they are located wholly on Dinsdale Field and are designed with gentle side-slopes to help reduce erosional forces.

The design includes four curved WAFs that shelter areas east of the features from wave effects during high ocean levels and provide elevation complexity for planting. WAFs 1 and 2 shelter Cowichan Bay Road and WAFs 3 and 4 shelter the unnamed road and Lochmanetz Road along the north edge of Dinsdale Field.

The crest elevation of the WAFs is 2.5 m CGVD2013. Table 3.1 presents the wave heights for the project area near to Cowichan Bay Road. The wave heights are reduced to be less than 0.2 m with wave periods less than two seconds for the areas of the property adjacent to the Cowichan Bay Road for design storms at present day year-2020 water levels (i.e., without sea level rise).

Table 3.1 Wave heights on Dinsdale Field with wave attenuation features.

Model Run [1]	P1	P2	P3	P4	P5
2020 (10-yr WL)	0.10 m	0.08 m	0.11 m	0.13 m	0.13 m
2020 (200-yr WL)	0.13 m	0.11 m	0.14 m	0.17 m	0.16 m

[1] 2020 refers to the year-2020 present day water level without forecasted future sea level rise. The 10-yr WL refers to a coastal water level with an annual exceedance probability of 10%. The 200-yr WL refers to a coastal water level with an annual exceedance probability of 0.05%.

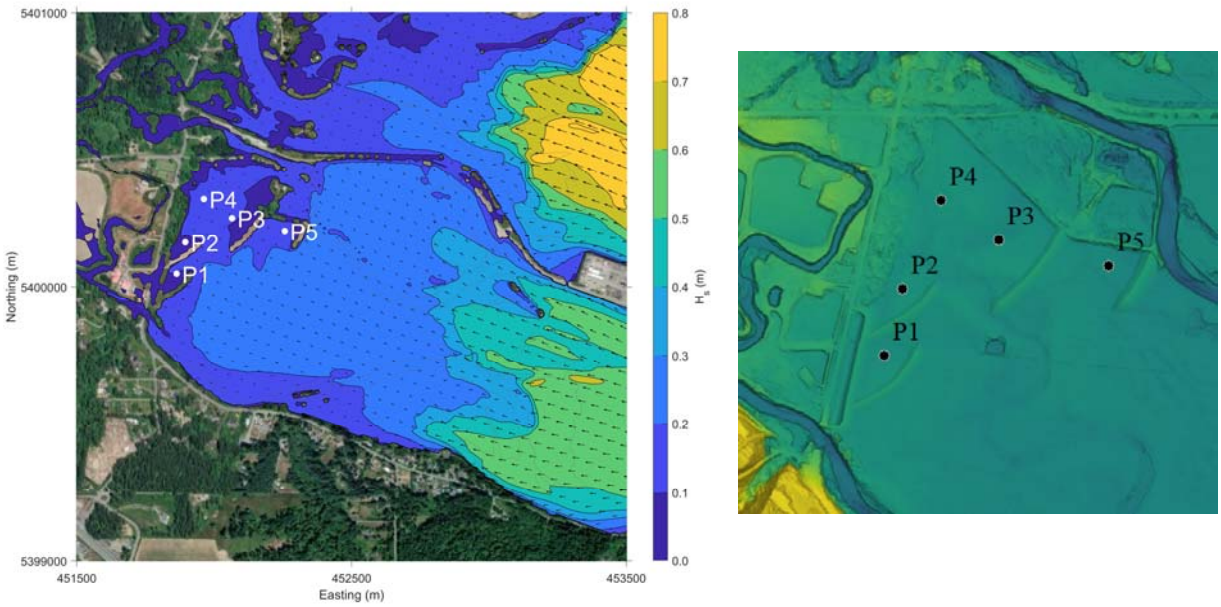


Figure 3.1 Wave model output for a 2020 10-year WL storm (left) and output locations (right).

The following are key aspects of the design:

- The features' eastward-facing slopes will be 20:1 (H:V) or gentler, and the westward-facing slopes will be 10:1 (H:V), with a top width of 4 m. The gentle slopes will create a long run-up slope to dissipate wave energy. The 4 m crest width will allow construction equipment to operate on a level surface.
- The bulk material used to construct the features may be comprised of soil, sand, and gravel. A surficial layer of organic soil will be installed to support vegetation growth. Cobbles up to 150 mm in diameter will be placed on the WAF tips for wave armouring, with an underlying granular filter layer 0.3 m thick. The cobble coverage will extend up the slopes and over the crest from the outermost point on the WAFs for approximately 20% of their length. The cobble armouring depth will be 0.2 m.
- The shallow slopes and slightly higher elevations of the WAFs compared to Dinsdale Field will provide planting surface area and elevation diversity, allowing for plant adaptation during sea level rise induced by climate change.

3.4 Marsh Channels

For context, the preliminary marsh channel design provided by NTBC is included in the Issued-for-Review drawings in Appendix A. Geometric details and planform changes are expected as the design is further developed.

3.5 Assumptions and Limitations

The proposed design has been prepared using available data, design guidelines, detailed analyses and assessments, and professional judgement. Assumptions and limitations for the analysis and design of the Dinsdale Field mitigation features are summarized below.

3.5.1 Analysis

The HEC-RAS and SWAN models are updated versions of those originally developed for the Cowichan-Koksilah Floodplain Mapping project (NHC, 2021). Assumptions and limitations related to the previous model may be found in the *Updated Cowichan-Koksilah Flood Mapping – Final Report* (NHC, 2021).

Assumptions and limitations associated with the HEC-RAS modelling component are described in Appendix B.

Notable limitations with specific relevance to the updated SWAN model for this project are listed below:

- The model's water level is static (i.e., not a function of time) and set to the offshore ocean level. The model does not account for riverine levels, which may increase water levels above those modelled in SWAN; however, these factors are captured within the HEC-RAS model
- The model grid size is 10 m, meaning that features smaller than this size are not captured. Specifically for diking, the *DAM OBSTACLES* function was used to account for this.
- The extent of the vegetation is set with the model to the year 2020 extent and does not reflect changes in salt marsh extent that will occur once the dike is removed or with sea level rise. Model results are not expected to be sensitive to changes in the marsh vegetation extent across relatively small areas on the order of 10 to 100 m.

The design flows associated with the floodbox structure do not include groundwater surcharge or recharge. Overland flooding in the HEC-RAS model was used to estimate flows routed through the floodbox. The flow capacity of the floodbox exceeds the estimated surficial drainage flows from the simulated riverine flooding and from stormwater runoff. NHC assumed that magnitude of flow contributed by groundwater are minor.

Other proposed design features that have a primary function of habitat enhancement and added complexity have not been included in the modelling analysis undertaken for the design features presented in this report. The overall project, which includes these proposed features, may offer additional flood mitigation that is not represented in the model simulations undertaken.

3.5.2 Design

The topographic data is sourced from a combination of surveys, including remote sensing, topographic, and bathymetric. We have assumed that the surveys have reasonably captured the topography of the project site and nearby areas, and that the surveys form a reasonable basis for design.

A limitation is that the flood mitigation features do not protect nearby properties to the provincial flood protection standard (i.e. 1-in-200 year flood conditions). The purpose of the project's mitigation features is to mitigate the transfer of flood risk to adjacent properties from the removal of Dike 49, as outlined in the provincial dike decommissioning guidelines. The project and nearby properties are located within the coastal flood construction level (NHC, 2021). It is not a DMA requirement to mitigate *all* flooding in the project area. The mitigation features do meet the DMA requirements by maintaining or decreasing the flood hazards to Cowichan Bay Road and the properties immediately west of the road. However, extreme floods are still expected to cause widespread flooding in the area.

Coastal design features apply run-up calculations based on empirical equations and relationships for idealized slopes. A freeboard has not been applied, and individual waves may produce run-up that is beyond the $R_{2\%}$ value. NHC assumed the presence of wood debris and vegetation on the restored estuary would further decrease erosion hazards and wave run-up.

The geotechnical design is based on limited field information. Field reviews by the engineers during construction are required to verify the subsurface conditions. NHC assumes that the Dinsdale field material excavated from the tidal marsh channels associated with the restoration design concept will be suitable for reuse to construct the WAF and ETIF slopes. If the material is deemed unsuitable, then alternative sources will be required.

The design details presented in this report exclude flood mitigation features located along the northern Dinsdale Field property boundary and on Lot 2. Those features are included in the proposed Lot 2 designs, which are being prepared separately by NHC upon request by NTBC. The Lot 2 flood mitigation features are complimentary to the Dinsdale Field flood mitigation features, and they must be completed to satisfy the Dike Decommissioning Guidelines (BC MFLNRORD, 2022). We have assumed that the Dinsdale Field mitigation features, the Lot 2 mitigation features, and decommissioning Dike 49 will be constructed in a sequence that minimizes flood risk to nearby properties.

Estuaries are complex and dynamic systems and hydro-morphological change is expected over time. NHC assumes that NTBC will implement an adaptive management approach as the restored estuary is shaped by natural processes, incorporating a recurring program of monitoring, data analysis, assessment, evaluation, and adaptation over time.

4 OPERATION, MAINTENANCE, AND SURVEILLANCE

NTBC prefers to adaptively manage the project site (NHC, 2022b). NHC referenced Guidelines for Management of Flood Protection Works in BC (MELP, 1999) to help develop a preliminary list of activities to monitor, maintain, and operate the Dinsdale Field flood mitigation features:

- Ensure that the road gate off Cowichan Bay Road is clear and in good order for vehicular access to the ETIF crest.
- Mow the slopes and crest of the ETIF twice annually. This is to ensure the crest can be inspected and to keep the area passable for other maintenance items.
- Check that the culvert and flap gate are free of obstructions, and that the gate seals in the closed position and can swing open to pass flow. This should be completed twice annually, once in the spring and once in the fall.
- Survey the crest of the ETIF annually for the first five years, and immediately after an over-topping event. If the crest elevation does not meet the specified 2.45 m CGVD2013 0 to +0.05 m elevation tolerance, supplement the crest with lifts of material meeting the specifications for gradation and compaction described in the drawings so that the crest elevation ranges between 2.45 m and 2.50 m CGVD2013.
- Inspect the riprap and cobble in the Outlet Swale annually for any gaps or movement. Repair or replace if there are gaps in the riprap coverage or if riprap no longer conforms to the design geometry.
- Visually inspect the WAFs annually. Note any erosion. If the WAFs visibly do not conform to the design geometry, undertake a hydrotechnical assessment to determine if any action is required.
- Establish photo points and take photos annually from the same position and in the same direction. The photos should capture the Dinsdale Field mitigation features, particularly the east slopes of the WAFs, the ETIF, the Floodbox Assembly, and the swales.

After construction, NHC recommends developing an operation, maintenance, and surveillance document for the design features. Additional items may be identified during project implementation.

5 NEXT STEPS

This section discusses the next steps that are anticipated following the submission of this design summary report. The items are categorized into pre-construction, construction, and general project sequencing. Prior to construction of the Dinsdale Field mitigation works, NHC recommends the following actions:

- Provide to the provincial office of the Deputy Inspector of Dikes the updated design for Dinsdale Field mitigation works, including engineered drawings, design summary report, and supporting modelling appendices. Per the authorization letter dated April 13, 2023, the office of the Deputy Inspector of Dikes must be notified prior to the commencement of construction.
- Obtain any necessary permits and permissions prior to construction. These may include:
  - Change approval for works in and about a stream, under Section 11 of the provincial Water Sustainability Act (WSA). This is likely not required until the Outflow Swale downstream of the Floodbox Assembly is connected to the Koksilah south distributary channel.
  - DFO project authorization, this is also not likely required until the Outlet Swale downstream of the Floodbox Assembly is connected to the Koksilah south distributary channel.
  - Any applicable BC MOTT permits, pending direction from MOTT (described in next bullet).
- NHC recommends meeting with the following entities to discuss the project:
  - Cowichan Tribes: to ensure their knowledge and input is incorporated into the site grading, mitigation features, and planting plan.
  - Cowichan Valley Regional District: to discuss the conceptual Cowichan Bay Road multiuse trail.
  - MOTT: to determine permitting requirements, including the re-routing of the access path and the accommodation of a small portion of the Elevation Tie-In Feature on highway land.
- Develop *Issued-for-Tender* (IFT), if applicable, and subsequent *Issued-for-Construction* (IFC) drawings:

  - Marsh channel planforms will be incorporated into the IFC drawings. The planform and typical geometries by channel order will be provided by NTBC with input from NHC.
  - A planting plan (to be provided by NTBC with input from Cowichan Tribes) should be included on the drawing set.
  - Construction costs will be refined at the IFC drawing stage, based on the updated topographic surveys, design geometry, and volumes.
- Contractor engagement and retention.
- Material sourcing for the materials identified in the drawing set (Appendix A; material gradations provided on the notes sheet).
- Arranging for the geotechnical on-site support to oversee the construction of the core of the Elevation Tie-In Feature.

5.1 Cowichan Estuary Restoration Project Sequencing

The project's suite of mitigative measures must be constructed prior to decommissioning Dike 49, including notching the dike for the *Outflow Swale* described in this report. Prior to decommissioning Dike 49, the following work must be completed:

- Construction of the Dinsdale Field mitigation features described in this report
- Topography features on Lot 2 as described in the Summary of Lot 2 Purchase Implications Final Report (NHC, 2023b) to prevent infrequent inundation of low-lying portions of Lot 1, Lochmanetz Road.
- Construction of the marsh channels in Dinsdale Field.

6 REFERENCES

BC MFLNRORD (2022). *Procedural Guidelines: Decommissioning of a Regulated Dike*. BC Ministry of Environment, Lands, Natural Resource Operations and Rural Development, Water Management Branch, Flood Safety Section, Office of the Inspector of Dikes, Victoria, BC. 4 pp. [online] Available from: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/decommissioning_guidelines.pdf.

BC MOTI (2013). *Riprap Installation Guide - 1*. Prepared by Ministry of Transportation and Infrastructure. 2 pp. [online] Available from: https://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/bridge/volume-6/guidelines/riprap-installation.pdf (Accessed 20 November 2023).

Brown, S. A., and Clyde, E. S. (1989). *Design of Riprap Revetment* (FHWA-IP-89016). Prepared by Sutron Corporation for U.S. Federal Highway Administration, Washinton, DC.

EurOtop (2018). *Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application.* Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B. [online] Available from: www.overtopping-manual.com.

Federal Highway Administration (2012). *HDS-05 - Hydraulic Design of Highway Culverts, Third Edition*. [online] Available from: https://www.fhwa.dot.gov/engineering/hydraulics/pubs/12026/hif12026.pdf.

FEMA (2014). *Technical Manual: Overtopping Protection for Dams. Best Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair*. (FEMA P-1015).

MELP (1999). *Guidelines for Management of Flood Protection Works in British Columbia*. Province of British Columbia, Ministry of Environment, Lands & Parks.

NHC (2021). *Updated Cowichan-Koksilah Flood Mapping Project Final Report*. Prepared for Cowichan Valley Regional District.

NHC (2022a). *Cowichan Estuary Marsh Restoration - Preliminary Design Basis* (Final, Rev. 0). The Nature Trust of British Columbia.

NHC (2022b). *Cowichan Estuary Marsh Restoration Project - Assessment of Physical Processes and Restoration Opportunities* (Final, Rev. 0). The Nature Trust of British Columbia.

NHC (2023a). *Cowichan Estuary Marsh Restoration Project - Summary of the Transfer of Flood Risk* (Final, Rev. 1). The Nature Trust of British Columbia.

NHC (2023b). *Cowichan Estuary Restoration Project Summary of Lot 2 Purchase Implications Final Report* (Rev. 0). Letter Report. Nanaimo, British Columbia. 5 pp.

Robinson, K. M., Rice, C. E., and Kadavy, K. C. (1998). Design of Rock Chutes. *American Society of Agricultural Engineers*, 41(3), 621–626.

The Master Municipal Construction Documents Association (2009). *MMCD Platinum Edition*.

Thurber (2023). *Cowichan Estuary Restoration Project Lochmanetz Road Upgrades and Dinsdale Setback Dike (NHC Reference 3006733) Geotechnical Data Report*.

APPENDIX A

ISSUED-FOR-REVIEW DRAWINGS

COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

ISSUED FOR REVIEW, FEBRUARY, 2025

DRAWING INDEX		
SHEET No.	SHEET DESCRIPTION	REVISION
001	TITLE SHEET & KEY MAP	1
002	NOTES	1
100	PLAN VIEW | EXISTING CONDITIONS	1
101	PLAN VIEW | SITE MAP	1
102	PLAN AND PROFILE | ELEVATION TIE-IN FEATURE (ETIF)	1
103	PLAN AND PROFILE | WAVE ATTENUATION FEATURE (WAF)	1
104	PLAN AND PROFILE | CULVERT AND OUTLET	1
300	TYPICAL SECTIONS	1
500	DETAILS	1



1. IMAGE SOURCE: ESRI OPEN SOURCE IMAGERY (DATE UNKNOWN, RETRIEVED JULY 07, 2024)

KEY MAP
SCALE 1:10,000

NOT FOR CONSTRUCTION

CLIENT:

THE NATURE TRUST OF B.C.
1080 LABIEUX ROAD
NANAIMO, B.C
B9T 6J9

NATURE TRUST BRITISH COLUMBIA

REV.	DATE	DESCRIPTION
0	2024-08-09	ISSUED FOR REVIEW
1	2025-02-19	ISSUED FOR REVIEW

nhc northwest hydraulic consultants

SEAL: PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA G. R. HILL # 28209
2025-02-24

PERMIT TO PRACTICE: 1003221

COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

TITLE SHEET & KEY MAP

DESIGNED:	L.DUNBAR	SHEET ID:	3006733-PROD-IFR-COWEST_WAVEMIT_R1I-001 R1
DRAFTED:	R.CLARK	STATUS:	ISSUED FOR REVIEW
CHECKED:	G.HILL	SCALE:	AS SHOWN WHEN PLOTTED D SIZE
APPROVED:	G.HILL	DATE:	19 FEB 2025

SHEET No: 001
REV No: R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING

FILENAME: \\mainfile-van\Projects\Active\3006733 Cowichan Estuary Marsh Restoration\06 CAD\02_Production\000_Set\2_IFR\Wave Mit - Dinsdale Dike\3006733-PROD-IFR-CowEst_WaveMit_R1I.dwg, 19 Feb 2025, 12:57 PM

1. GENERAL

1.1. THE DESIGN DRAWINGS REPRESENT THE NATURE AND GENERAL LAYOUT OF THE WORK UNDER CONTRACT AND NOT NECESSARILY THE WORKS AS THEY WILL BE CONSTRUCTED.

1.2. THESE DRAWINGS, INCLUDING DIMENSIONS, SHALL BE READ IN CONJUNCTION WITH ALL OTHER PROJECT DRAWINGS, REPORTS, AND SPECIFICATIONS.

1.3. THE CONTRACTOR SHALL INSTALL ALL PRODUCTS IN STRICT ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDED PRACTICE.

1.4. COPIES OF ALL PERMITS AND APPROVALS ARE REQUIRED AT THE WORK SITE AT ALL TIMES.

1.5. THE CONTRACTOR IS RESPONSIBLE FOR ANTICIPATING AND LOCATING ALL EXISTING UTILITIES AND BURIED WORKS.

2. SURVEY AND DIMENSIONS

2.1. MCELHANNEY COMPLETED TOPOGRAPHIC AND LEGAL SURVEYS ALONG COWICHAN BAY ROAD. ALL OTHER PARCEL INFORMATION IS FROM THE CVRD'S ONLINE WEBMAP. OTHER TOPOGRAPHY IS BASED ON 2019 BC LIDAR.

2.2. ELEVATIONS AND HORIZONTAL LOCATIONS ARE EXPRESSED IN METERS AND ARE BASED ON GEODETIC DATA:

2.2.1. HORIZONTAL DATUM: NAD83 (CSRS)
2.2.2. VERTICAL DATUM: CGVD2013
2.2.3. GEOID MODEL: CGG2013A
2.2.4. PROJECTION: UTM 10 N

2.3. DIMENSION TOLERANCES FOR EARTHWORKS:

2.3.1. 1.0 m LATERALLY FOR WAVE ATTENUATION FEATURES
2.3.2. +/- 0.2 m LATERALLY FOR ELEVATION TIE-IN FEATURE
2.3.3. 0 TO + 0.05 m (VARIES) VERTICALLY FOR FINAL GRADE OF ELEVATION TIE-IN FEATURE CREST
2.3.4. 0 TO + 0.15 m VERTICALLY FOR WAVE ATTENUATION FEATURES
2.3.5. +/- 0.02 m VERTICALLY FOR FLOODBOX ASSEMBLY

2.4. THE CONTRACTOR SHALL ASSUME FULL RESPONSIBILITY FOR ESTABLISHING SURVEY CONTROL, STAKING AND LAYOUT, TO ENSURE PROPER ALIGNMENT, DIMENSIONS, AND ELEVATIONS FOR ALL ASPECTS OF THE WORK. ALL ELEVATIONS, DIMENSIONS, AND STATIONING SHALL BE VERIFIED BY THE CONTRACTOR BEFORE CONSTRUCTION COMMENCEMENT, WITH ANY DISCREPANCIES COMMUNICATED IMMEDIATELY TO THE ENGINEER.

3. DESIGN

3.1. GENERAL CIVIL AND HYDROTECHNICAL DESIGN COMPLETED BY NORTHWEST HYDRAULIC CONSULTANTS LTD. (NHC).

3.2. GEOTECHNICAL DESIGN COMPLETED BY THURBER ENGINEERING LTD.

3.3. MARSH CHANNEL DESIGN COMPLETED BY NORTHWEST HYDRAULIC CONSULTANTS LTD. WITH INPUT FROM THE NATURE TRUST OF BRITISH COLUMBIA

3.4. DESIGN STANDARDS AND CRITERIA ARE SUMMARIZED IN COWICHAN ESTUARY RESTORATION PROJECT DINSDALE FIELD MITIGATION DESIGN SUMMARY DRAFT REPORT, REV. 2.

4. SUBMITTALS

4.1. THE CONTRACTOR SHALL PREPARE SUBMITTALS FOR THE ENGINEER'S REVIEW WHEN REQUESTED. SUBMITTALS MAY INCLUDE SHOP DRAWINGS, MATERIALS SPECIFICATIONS, TRAFFIC CONTROL PLANS, OR OTHER DOCUMENTS REQUIRED TO VERIFY CONFORMANCE TO THE DESIGN.

4.2. THE CONTRACTOR SHALL SUBMIT SIEVE REPORTS FOR ALL BULK MATERIALS SPECIFIED IN SECTION 6 AT LEAST 5 WORKING DAYS PRIOR TO TRANSPORT OF MATERIALS TO THE SITE.

5. QUALITY CONTROL

5.1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE QUALITY CONTROL OF ALL ACTIVITIES ASSOCIATED WITH THE WORK.

5.2. THE CONTRACTOR IS RESPONSIBLE FOR COMPLYING WITH ALL FIELD REVIEWS PROCEDURES AND SHALL NOTIFY THE ENGINEER AT LEAST 24 HOURS PRIOR TO CARRYING OUT WORK FOR WHICH FIELD REVIEWS ARE REQUIRED. THE FOLLOWING FIELD REVIEWS ARE REQUIRED; ADDITIONAL FIELD REVIEWS MAY BE SPECIFIED BY THE ENGINEER DURING CONSTRUCTION:

5.2.1. AT COMPLETION OF THE INITIAL STAKING AND LAYOUT.
5.2.2. AT DELIVERY OF RIPRAP
5.2.3. AT COMPLETION OF GRUBBING, STRIPPING, AND PREPARATION OF SUBGRADE.
5.2.4. DURING EMBANKMENT CONSTRUCTION TO OBSERVE COMPACTION.
5.2.5. PRIOR TO AND DURING CONSTRUCTION OF THE FLOOD BOX ASSEMBLY.
5.2.6. AT COMPLETION OF EMBANKMENT CONSTRUCTION PRIOR TO FINAL GRADING.
5.2.7. DURING AND AT COMPLETION OF PLACEMENT OF COBBLE (TYPE 6 MATERIAL)

5.3. THE CONTRACTOR SHALL PROVIDE PROGRESS SURVEY DATA DURING CONSTRUCTION WHEN REQUESTED BY THE ENGINEER.

6. MATERIALS

6.1. QUANTITIES

6.1.1. A SCHEDULE OF QUANTITIES IS PROVIDED IN TABLE 1.
6.1.2. THE CONTRACTOR IS RESPONSIBLE FOR CALCULATING ALL VOLUMES FOR THE WORK. THE VOLUMES PROVIDED HEREIN ARE OFFERED AS A GENERAL GUIDELINE ONLY.
6.1.3. ALL SOIL VOLUMES ARE COMPACTED IN PLACE

6.2. BULK MATERIALS (EXCEPT ORGANIC PLANTING MATERIALS)

6.2.1. IMPORTED GRANULAR MATERIALS SHALL BE COMPOSED OF INERT, DURABLE MATERIAL, REASONABLY UNIFORM IN QUALITY, AND FREE FROM SOFT OR DISINTEGRATED PARTICLES.
6.2.2. RE-USE OF NATIVE GRANULAR MATERIALS SHALL BE APPROVED BY THE PROJECT ENGINEER. SUCH MATERIAL SHALL BE FREE OF ORGANIC AND FOREIGN MATTER EXCEPT WHERE NOTED.
6.2.3. RIPRAP
6.2.3.1. ALL RIPRAP MATERIAL SHALL MEET TESTING REQUIREMENTS OF TABLE 7. CONTRACTOR SHALL SUPPLY A COPY OF TEST RESULTS FOR ROCK MATERIALS FROM A LOCATION IN THE QUARRY NEAR TO THE RIPRAP SOURCE FOR THE PROJECT NO LESS THAN FIVE (5) DAYS PRIOR TO DELIVERY OF MATERIALS TO SITE.
6.2.3.2. RIPRAP SHALL BE ANGULAR QUARRY STONE, BLOCKY IN DIMENSION WITH LENGTH NOT MORE THAN 3.0 TIMES THE WIDTH OR THICKNESS AS MEASURED IN THE MIDDLE OF THE STONE.
6.2.4. COBBLE FILL SHALL BE ROUNDED TO SUB-ROUNDED STONE OF FLUVIAL OR GLACIAL ORIGIN, SIMILAR TO COARSE INTERTIDAL BEACH SUBSTRATE.
6.2.5. ANY IMPORTED OR NATIVE MATERIALS USED AS ADDITIONAL EMBANKMENT FILL SHALL BE APPROVED IN ADVANCE BY THE ENGINEER.
6.2.6. TYPE 1 TO 6 MATERIALS:
6.2.6.1. TYPE 1 MATERIAL SHALL BE FILL CONFORMING TO THE GRADATION IN TABLE 2.
6.2.6.2. TYPE 2 MATERIAL (GENERAL FILL) SHALL BE MAINLY INORGANIC SOIL RELOCATED FROM ANOTHER AREA ON DINSDALE FIELD SUCH AS DIKE 49 AND THE DRAINAGE CHANNELS. THE MATERIAL SHALL BE APPROVED PRIOR TO PLACEMENT BY THE PROJECT ENGINEER. MATERIAL MUST HAVE NO GREATER THEN 10% ORGANICS.
6.2.6.3. TYPE 3 MATERIAL SHALL BE FLOODBOX PIPE HAUNCHING CONFORMING TO THE GRADATION IN TABLE 4. GRADATION SHALL BE DETERMINED IN ACCORDANCE WITH ASTM C 117 (WASH TEST).
6.2.6.4. TYPE 4 MATERIAL SHALL BE ORGANIC PLANTING SOIL.
6.2.6.5. TYPE 5 SHALL BE BC MOTI CLASS 25 kg RIPRAP CONFORMING TO THE GRADATION IN TABLE 4.
6.2.6.6. TYPE 6 MATERIAL SHALL BE COBBLE CONFORMING TO THE GRADATION IN TABLE 5.
6.2.6.7. TYPE 7 MATERIAL SHALL BE GRANULAR SAND AND GRAVEL CONFORMING TO THE GRADATION IN TABLE 6.
6.2.7. PRECAST CONCRETE PIPE
6.2.7.1. THE FLOOD BOX PIPE SHALL BE 600 mm INNER DIA. PRE-CAST NON-REINFORCED CONCRETE PIPE (LANGLEY CONCRETE BELL & SPIGOT OR APPROVED EQUIVALENT) IN ACCORDANCE WITH ASTM C14M AND CSA A257.1.
6.2.8. RUBBER PIPE GASKETS
6.2.8.1. RUBBER PIPE GASKET SHALL BE A LANGLEY CONCRETE SUPERSEAL GASKET OR APPROVED EQUIVALENT IN ACCORDANCE WITH ASTM C 443 AND CAS 257.3.
6.2.9. CONCRETE CURB
6.2.9.1. CONCRETE CURB TO BE STEEL REINFORCED PRE-CAST, WITH MINIMUM SIZE 300 mm X 300 mm X 2900 mm IN ACCORDANCE WITH ASTM C14M AND CSA A257.1.
6.2.10. PRECAST PIPE HEADWALLS
6.2.10.1. THE PRECAST CONCRETE HEADWALLS SHALL FIT A 600 mm INNER DIA. PIPE.
6.2.10.2. LANGLEY CONCRETE 11-13 HEADWALL STRUCTURE OR SIMILAR MAY BE USED, SUBJECT TO ADVANCE APPROVAL BY THE ENGINEER.
6.2.10.3. THE DOWNSTREAM HEADWALL MUST ALLOW FOR BOLTING ON THE TIDAL FLAPGATE.
6.2.10.4. LANGLEY CONCRETE TRASH RACK MAY BE USED, OR APPROVED EQUIVALENT
6.2.10.5. LANGLEY GALVANIZED STEEL HEADWALL HANDRAILS MAY BE USED, OR APPROVED EQUIVALENT
6.2.11. FLAP GATE
6.2.11.1. THE TIDAL FLAP GATE SHALL BE A WATERMANN (ARMTEC) SSF-41 STAINLESS STEEL FLATBACK GATE OR APPROVED EQUIVALENT.
6.2.12. WOVEN WIRE FENCE
6.2.12.1. FENCE POSTS SHALL BE PRESSURE TREATED 100/125 mm X 1.8 m (4/5" X 7')
6.2.12.2. FENCE WIRE SHALL BE HEAVY DUTY FIELD FENCE 9.75 GAUGE TOP AND BOTTOM, 12 GAUGE MIDDLE. CLASS 1 GALVANIZED. 100X150 mm HOLES AT THE BOTTOM PROGRESSING TO 150X175 HOLES AT THE TOP.
6.2.12.3. FENCE STAPLES SHALL BE 38 mm (1.5") 9 GAUGE.

7. EXECUTION

7.1. MOBILIZATION/DEMOBILIZATION AND SITE ACCESS

7.1.1. THE CONTRACTOR SHALL MOBILIZE ALL REQUIRED EQUIPMENT, MATERIALS, AND PERSONNEL TO AND FROM THE WORK SITE. THE CONTRACTOR SHALL OBTAIN ALL NECESSARY ROAD PERMITS AND OTHER AUTHORIZATIONS FOR MOBILIZATION/DEMOBILIZATION.
7.1.2. THE PROJECT SITE IS SUBJECT TO OCCASIONAL FLOODING FROM HIGH TIDES AND STORM SURGE. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO FAMILIARIZE THEMSELVES WITH TIDE AND WEATHER PREDICTIONS AND PLAN THE WORK ACCORDINGLY TO AVOID DELAYS, STANDBY TIME, OR QUALITY CONTROL ISSUES

7.2. TRAFFIC CONTROL

7.2.1. PROVIDE TRAFFIC CONTROL WHEN REQUIRED TO DO SO UNDER BC OHS REGULATIONS AND MOTI REQUIREMENTS.

7.3. CLEARING, GRUBBING, AND STRIPPING

7.3.1. PRIOR TO CLEARING, VERIFY LIMITS OF CLEARING WITH THE ENGINEER AND DETERMINE ANY RESTRICTIONS REGARDING THE PRESERVATION OF EXISTING TREES, SHRUBS, OR NATURAL FEATURES.
7.3.2. THE PROJECT ENGINEER SHALL REVIEW THE PREPARED SUBGRADE FOLLOWING STRIPPING AND PRIOR TO FILL PLACEMENT.
7.3.3. WHERE SUBGRADE IS DEEMED UNSUITABLE, THE CONTRACTOR SHALL COMPLETE ADDITIONAL SUBGRADE PREPARATION AS DIRECTED BY THE PROJECT ENGINEER. THIS MAY INCLUDE OVER-EXCAVATION AND BACKFILL/COMPACTION TO THE DESIGN GRADES.
7.3.4. CLEARING
7.3.4.1. CLEAR TREES, SHRUBS, UPROOTED STUMPS, AND SURFACE DEBRIS NOT DESIGNATED TO REMAIN.
7.3.5. GRUBBING
7.3.5.1. GRUB ALL STUMPS, ROOTS, BURIED LOGS, OLD PILING, OLD PAVING, DRAINS, AND OTHER OBJECTIONABLE BURIED MATTER.
7.3.5.2. ROOTS OR OTHER INTRUSIONS OVER 50 mm IN DIAMETER SHALL BE REMOVED WITHIN THE FOUNDATIONS TO A DEPTH OF 1 m BELOW NATURAL GROUND SURFACE.
7.3.5.3. ALL HOLES AND DEPRESSIONS CAUSED BY GRUBBING SHALL BE FLATTENED AND THEN BACKFILLED, AND WELL-COMPACTED TO AVOID SOFT SPOTS UNDER THE DESIGN AND MAINTAIN CONTINUITY OF THE NATURAL BLANKET.
7.3.5.4. ALL GRUBBED MATERIALS MUST BE DISPOSED BY APPROPRIATE MEANS AS PER THE CEMP.
7.3.6. STRIPPING
7.3.6.1. STRIPPING OF ORGANIC TOPSOIL SHALL OCCUR TO A DEPTH OF 300 mm BENEATH THE GRUBBED SURFACE WHERE INDICATED BY DRAWINGS PRIOR TO FILL PLACEMENT.
7.3.6.2. THE STRIPPED SURFACE SHALL BE SCARIFIED PARALLEL TO THE BERM ALIGNMENT.

7.4. EXCAVATION

7.4.1. CARRY OUT EXCAVATION AND TEMPORARY SLOPING IN ACCORDANCE WITH WORKSAFE BC REQUIREMENTS.
7.4.2. EXCAVATION SHALL BE COMPLETED TO THE DEPTH AND THE GRADE REQUIRED TO REMOVE THE EXISTING SOIL AND TO ACCOMMODATE ALL MATERIAL PLACEMENT.

7.5. EMBANKMENT CONSTRUCTION (ELEVATION TIE-IN FEATURE)

7.5.1. TYPE 1 MATERIAL (ETIF FILL) SHOULD BE PLACED IN MAXIMUM 250 MM LIFTS AND COMPACTED TO AT LEAST 95% OF THE MODIFIED PROCTOR MAXIMUM DRY DENSITY VALUE. THINNER LIFTS (I.E., DOWN TO 150 MM) MAY BE REQUIRED DEPENDING ON THE CONSISTENCY AND MOISTURE CONTENT OF THE MATERIAL AT THE TIME OF PLACEMENT. WHERE THERE IS SUFFICIENT WIDTH TO PERMIT USE, COMPACTION SHOULD BE UNDERTAKEN USING A SHEEPSFOOT ROLLER OR SIMILAR EQUIPMENT.
7.5.2. TYPE 3 MATERIAL (PIPE HAUNCHING) SHOULD BE PLACED IN MAXIMUM 250 MM LIFTS AND COMPACTED TO AT LEAST 95% OF THE MODIFIED PROCTOR MAXIMUM DRY DENSITY VALUE. THINNER LIFTS (I.E., DOWN TO 150 MM) MAY BE REQUIRED DEPENDING ON THE CONSISTENCY AND MOISTURE CONTENT OF THE MATERIAL AT THE TIME OF PLACEMENT. A HEAVY DIESEL PLATE TAMPER (OR EQUIVALENT) SHOULD BE USED TO COMPACT TYPE 3 MATERIAL BELOW AND AROUND THE CULVERT. HAND TAMPING WILL BE REQUIRED IN ADDITION TO PLATE TAMPING TO ENSURE ADEQUATE COMPACTION OF TYPE 3 MATERIAL PLACED BELOW SPRINGLINE.
7.5.3. IF USING ANY ROLLER THAT LEAVES A SMOOTH SURFACE AFTER COMPACTION, THE COMPACTED SURFACE MUST BE SCARIFIED PRIOR TO PLACEMENT OF THE NEXT LIFT.
7.5.4. PRIOR TO FINAL GRADING, THE CREST SHALL BE SURVEYED TO ENSURE THERE ARE NO LOW AREAS. ALL LOW AREAS SHALL BE FILLED PRIOR TO GRADING.
7.5.5. SIDE SLOPES ARE TO BE TRIMMED TO THE REQUIRED SLOPE.

7.6. EMBANKMENT CONSTRUCTION (WAVE ATTENUATION FEATURES)

7.6.1. TYPE 2 MATERIAL (GENERAL FILL) SHOULD BE PLACED IN 250 MM LIFTS AND COMPACTED WITH 2-6 PASSES OF A SHEEPSFOOT ROLLER (OR SIMILAR EQUIPMENT) DEPENDING ON SOIL CONDITIONS, TO BE APPROVED BY THE PROJECT ENGINEER.
7.6.2. IF USING ANY ROLLER THAT LEAVES A SMOOTH SURFACE AFTER COMPACTION, THE COMPACTED SURFACE MUST BE SCARIFIED PRIOR TO PLACEMENT OF THE NEXT LIFT.
7.6.3. PRIOR TO FINAL GRADING, THE CREST SHALL BE SURVEYED TO ENSURE THERE ARE NO LOW AREAS. ALL LOW AREAS SHALL BE FILLED PRIOR TO GRADING.
7.6.4. SIDE SLOPES ARE TO BE TRIMMED TO THE REQUIRED SLOPE

7.7. FLOOD BOX ASSEMBLY

7.7.1. PRECAST CONCRETE HEADWALLS SHALL BE SEALED TO THE PIPE WITH RUBBER GASKETS OR A WATERSTOP APPROVED BY THE ENGINEER ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS.
7.7.1. CONCRETE CURB TO BE PLACED LEVEL AT THE ELEVATION INDICATED IN THE DRAWINGS, AND HAUNCHING SOIL TO BE COMPACTED ALONGSIDE TO PROCTOR 95% DRY DENSITY TO FORM LEVEL FOUNDATION FOR HEADWALL.

7.8. RIPRAP PLACEMENT

7.8.1. MACHINE PLACED OR HAND-LAID RIPRAP SHALL PRODUCE A WELL-GRADED MASS WITH MINIMAL VOIDS, END DUMPING OF RIPRAP IS NOT ACCEPTABLE.

7.9. FENCE

7.9.1. FENCE POSTS SHALL BE INSTALLED TO A DEPTH OF 500 mm ON 2.4 m CENTERS
7.9.2. INSTALL TOP BRACE OF PRESSURE TREATED WOOD AT THE ENDS OF THE FENCE AND EVERY 50 m (MAX). INSTALL GALVANIZED DOUBLE STRAND 12.5 GAUGE BARBLESS WIRE CROSS BRACES UNDER THE TOP BRACES.

8. ENVIRONMENT

8.1. THE CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN (CEMP) SHALL BE SUPPLIED BY THE PROJECT OWNER AT NO CHARGE TO THE CONTRACTOR.

8.2. THE CONTRACTOR SHALL COMPLY WITH THE CEMP. THE OWNER'S ENVIRONMENTAL MONITOR HAS THE AUTHORITY TO STOP WORK.

8.3. MATERIAL DISPOSAL

8.3.1. THE CONTRACTOR SHALL ENSURE THAT THE HANDLING AND DISPOSAL OF WASTE COMPLIES WITH ALL FEDERAL, PROVINCIAL, MUNICIPAL, AND REGIONAL BY-LAWS AND REGULATIONS, AS WELL AS WITH THE REQUIREMENTS OF THE CEMP.
8.3.2. SOLID INORGANIC, ORGANIC, AND WOOD WASTE NOT APPROVED FOR ON-SITE DISPOSAL SHALL BE REMOVED TO A DISPOSAL SITE SELECTED BY THE CONTRACTOR.

8.4. COMPLETE ALL WORK IN ACCORDANCE WITH APPLICABLE LAWS, REGULATIONS, AND BEST PRACTICES.

8.5. NORTHWEST HYDRAULIC CONSULTANTS LTD. IS NOT RESPONSIBLE FOR ENVIRONMENTAL PERMITS, ENVIRONMENTAL MONITORING, AND ENVIRONMENTAL COMPLIANCE.

9. ARCHAEOLOGY

9.1. THE ARCHAEOLOGICAL MONITOR WILL BE SUPPLIED BY THE PROJECT OWNER AT NO CHARGE TO THE CONTRACTOR

9.2. AN ARCHAEOLOGICAL MONITOR SHALL BE PRESENT FOR ALL EXCAVATIONS IN KNOWN ARCHAEOLOGICAL ZONES

9.3. THE CONTRACTOR SHALL COMPLY WITH PROVINCIAL CHANCE FIND PROCEDURES IN COMPLIANCE WITH THE HERITAGE CONSERVATION ACT.

NOT FOR CONSTRUCTION

TABLE 1. SCHEDULE OF QUANTITIES

MATERIAL	QUANTITY / UNITS
TYPE 1 MATERIAL	1,790 m^3
TYPE 2 MATERIAL	12,620 m^3
TYPE 3 MATERIAL	30 m^3
TYPE 4 MATERIAL	AS REQUIRED FOR PLANTING
TYPE 5 MATERIAL	58 m^3
TYPE 6 MATERIAL	900 m^3
TYPE 7 MATERIAL	1,190 m^3
PRECAST HEADWALLS	2 ea
FLAP GATE	1 ea
300 x 300 x 2900 mm CURBS	2 ea
Ø 600 mm RUBBER GASKETS	6 ea
MOTI VANCOUVER ISLAND/COAST SEED MIX	AS REQUIRED FOR PLANTING
75 mm MINUS CRUSHED ROCK	AS REQUIRED FOR ACCESS ROAD SURFACING
GALVANIZED WIRE FENCE	360 lin. m

TABLE 2: TYPE 1 MATERIAL (ETIF) GRADATIONS

SIEVE DESIGNATION (mm)	PERCENT PASSING (%)
150	100
100	70-100
25	55-90
4.75	40-70
0.075	0-15

TABLE 3: TYPE 3 MATERIAL (PIPE HAUNCHING) GRADATIONS

SIEVE DESIGNATION (mm)	PERCENT PASSING (%)
25	100
19	90-100
12.5	65-85
9.5	50-75
4.75	25-50
2.36	10-35
1.18	6-26
0.6	3-17
0.075	0-5

TABLE 4: TYPE 5 MATERIAL (BC MOTI CLASS 25 kg RIPRAP) GRADATIONS

GRADATION	MATERIAL SIZE (B-AXIS)
D_{100}	450 mm
D_{85}	380 mm
D_{50}	260 mm
D_{15}	120 mm

TABLE 5: TYPE 6 MATERIAL (COBBLE) GRADATIONS

SIEVE DESIGNATION (mm)	PERCENT PASSING (%)
150	90-100
130	70-90
80	35-65
50	5-25
25	0-5

TABLE 6: TYPE 7 MATERIAL (GRANULAR FILTER) GRADATIONS

SIEVE DESIGNATION (mm)	PERCENT PASSING (%)
13	100
9	60-100
8.5	50-95
7.5	38-85
7	32-80
6	20-60
5.5	18-50
4.5	15-41
2	7-20
1	3-15

TABLE 7: TESTS FOR PHYSICAL PROPERTIES OF ARMOUR ROCK

PROPERTY	TEST	REQUIREMENT
SPECIFIC GRAVITY	ASTM 6473	≤ 2.60
ABSORBTION	ASTM D6473	≥ 2%
SOUNDNESS BY MAGNESIUM SULPHATE	ASTM D5240	≤ 10% (5 CYCLES)
MICRO-DEVAL ABRASION LOSS FACTOR	BC MOE TECH CIRCULAR T10-04	≤ 20%
ACID ROCK DRAINAGE (ARD) AND METAL LEACHING	BC MOE TECH CIRCULAR T10-04	NO ARD OR METAL LEACHING
DURABILITY INDEX	ASTM D3744	≥ 35

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0	2024-08-09	ISSUED FOR REVIEW
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SEAL:

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — G. R. HILL — # 28209

2025-02-24

PERMIT TO PRACTICE: 1003221

COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

NOTES

DESIGNED: L.DUNBAR	SHEET ID: 3006733-PROD-IFR-COWEST_WAVEMIT_R1I-002 R1	SHEET No:	002
DRAFTED: R.CLARK	STATUS: ISSUED FOR REVIEW		
CHECKED: G.HILL	SCALE: AS SHOWN WHEN PLOTTED D SIZE		
APPROVED: G.HILL	DATE: 19 FEB 2025	REV No:	R1

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FILENAME: \\mainfile-van\Projects\Active\3006733 Cowichan Estuary Marsh Restoration\06 CAD\02_Production\000_Set\2- IFR\Wave Mit - Dinsdale Dike\3006733-PROD-IFR-CowEst_WaveMit_R1I.dwg, 19 Feb 2025, 12:57 PM



GENERAL NOTES
1. BACKGROUND IMAGE FROM 2021 SUAV-AIR DRONE FLIGHT
2. PARCEL AND LEGAL BOUNDARIES RETRIEVED FROM
   2.1. "ACAD-22330120600-V-SITE-002-MODEL" FROM 2024-11-12 McELHANNEY TOPOGRAPHIC SURVEY
   2.2. CVRD ONLINE WEB MAP, APPROXIMATE ONLY.

PLAN VIEW
SCALE 1:1,250

LEGEND:
- PROPERTY BOUNDARY
- APPROXIMATE EDGE OF ROAD SURFACE/SLOPE
- EXISTING FENCELINE
- RoW — MOTI RIGHT OF WAY (ROW)

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CLIENT:
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NANAIMO, B.C
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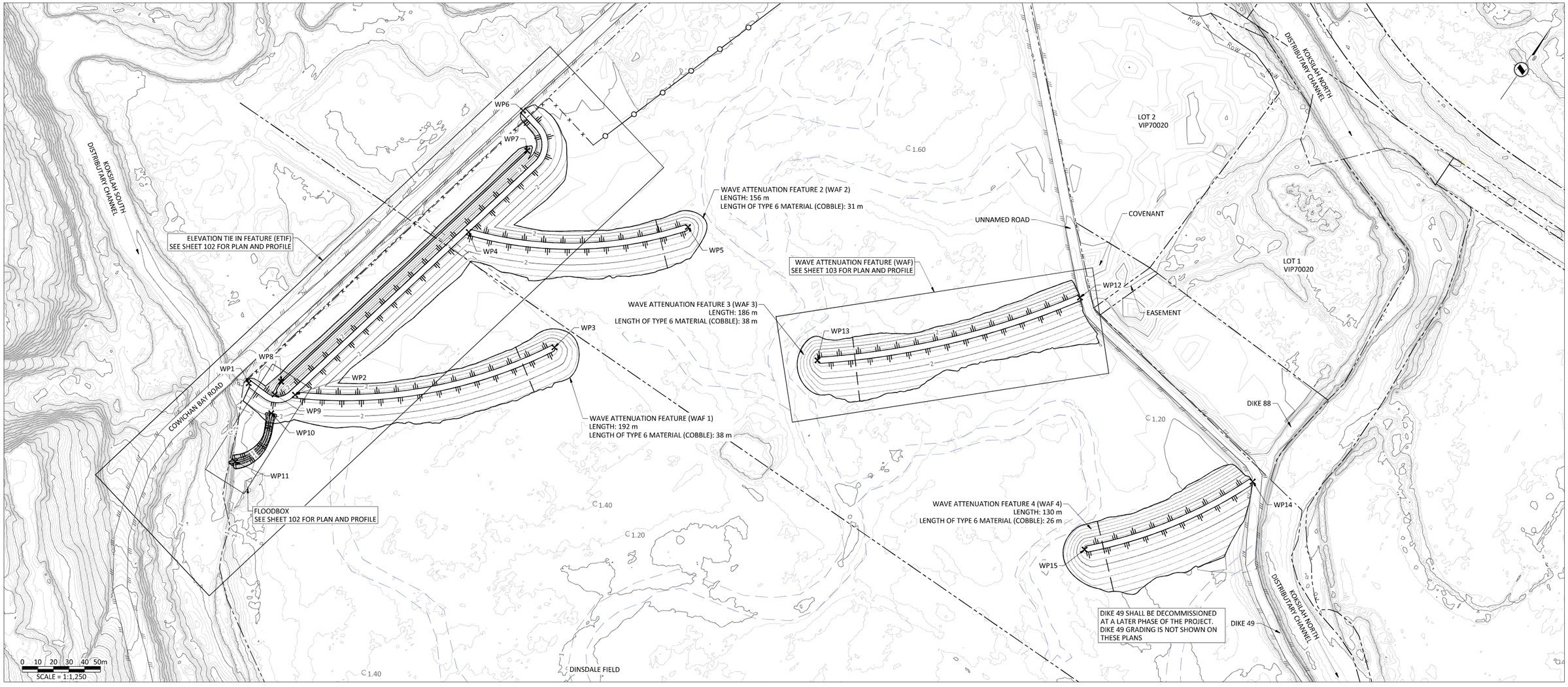
PERMIT TO PRACTICE: 1003221

COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION
PLAN VIEW | EXISTING CONDITIONS

DESIGNED:	L.DUNBAR	SHEET ID: 3006733-PROD-IFR-COWEST_WAVEMIT_R1I-100 R1	SHEET No: 100
DRAFTED:	R.CLARK	STATUS: ISSUED FOR REVIEW	
CHECKED:	G.HILL	SCALE: AS SHOWN WHEN PLOTTED D SIZE	
APPROVED:	G.HILL	DATE: 19 FEB 2025	REV No: R1

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PLAN VIEW
SCALE 1:1,250

GENERAL NOTES
1. EXISTING GROUND CREATED FROM A COMBINATION OF NHC TOPO (2024-03-25) AND BC LIDAR (2019).
2. COORDINATE SYSTEM
   2.1. PROJECTION: NAD83 UTM ZONE 10 N
   2.2. VERTICAL DATUM: CGVD2013
3. CONTOUR INTERVAL
   3.1. MAJOR: 1.0 m
   3.2. MINOR: 0.5 m
4. PRELIMINARY MARSH CHANNEL PLANFORM PROVIDED BY NTBC. TO BE REFINED FOR IFC DRAWINGS
5. PARCEL AND LEGAL BOUNDARIES RETRIEVED FROM
   5.1. "ACAD-22330120600-V-SITE-002-MODEL" FROM 2024-11-12 MCELHANNEY TOPOGRAPHIC SURVEY
   5.2. CVRD ONLINE WEB MAP, APPROXIMATE ONLY.

NOT FOR CONSTRUCTION

WORKPOINTS TABLE

WORKPOINT	EASTING (m)	NORTHING (m)	ELEVATION (m)	DESCRIPTION
WP1	451765.80	5399924.15	2.45	CENTER OF ETIF CREST AT SOUTH TIE IN
WP2	451794.66	5399934.37	2.45	CENTER OF WAF 1 CREST WHERE IT MEETS ETIF CREST
WP3	451916.21	5400051.81	2.50	WAF 1 CREST CL WHERE IT MEETS EDGE OF SLOPE
WP4	451829.53	5400082.80	2.45	CENTER OF WAF 2 CREST WHERE IT MEETS ETIF CREST
WP5	451944.73	5400163.33	2.50	WAF 2 CREST CL WHERE IT MEETS EDGE OF SLOPE
WP6	451815.46	5400166.86	2.45	CENTER OF ETIF CREST AT NORTH TIE-IN
WP7	451831.92	5400146.94	1.15	CL OF NORTH END OF COLLECTOR SWALE INVERT
WP8	451782.56	5399936.47	1.15	CL OF COLLECTOR SWALE INVERT BEFORE CURVE TO MEET HEADWALL

WORKPOINTS TABLE

WORKPOINT	EASTING (m)	NORTHING (m)	ELEVATION (m)	DESCRIPTION
WP9	451783.57	5399927.35	1.15	CULVERT INLET INVERT WHERE HEADWALL APRON MEETS HEADWALL OPENING
WP10	451788.48	5399916.08	0.93	CULVERT OUTLET INVERT WHERE HEADWALL APRON MEETS HEADWALL OPENING
WP11	451786.44	5399877.48	0.52	CL OF OUTLET SWALE INVERT WHERE COBBLE MEETS RIPRAP
WP12	452178.88	5400264.93	2.24	CL OF WAF 3 WHERE IT MEETS EDGE OF SLOPE
WP13	452061.16	5400138.24	2.50	WAF3 CREST WHERE IT MEETS EDGE OF SLOPE
WP14	452270.79	5400132.22	2.50	CL OF WAF 3 WHERE IT TIES INTO EMBANKMENT
WP15	452336.35	5400228.12	2.50	WAF 4 CREST CL WHERE IT MEETS EDGE OF SLOPE

LEGEND:
- PROPERTY BOUNDARY
- PRELIMINARY MARSH CHANNEL PLANFORM
- APPROXIMATE EDGE OF ROAD SURFACE/SLOPE
- RoW — MOTI RIGHT OF WAY (ROW)
- DESIGN LINEWORK
- PROPOSED FENCING
- EXISTING FENCELINE

CLIENT:
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2025-02-24

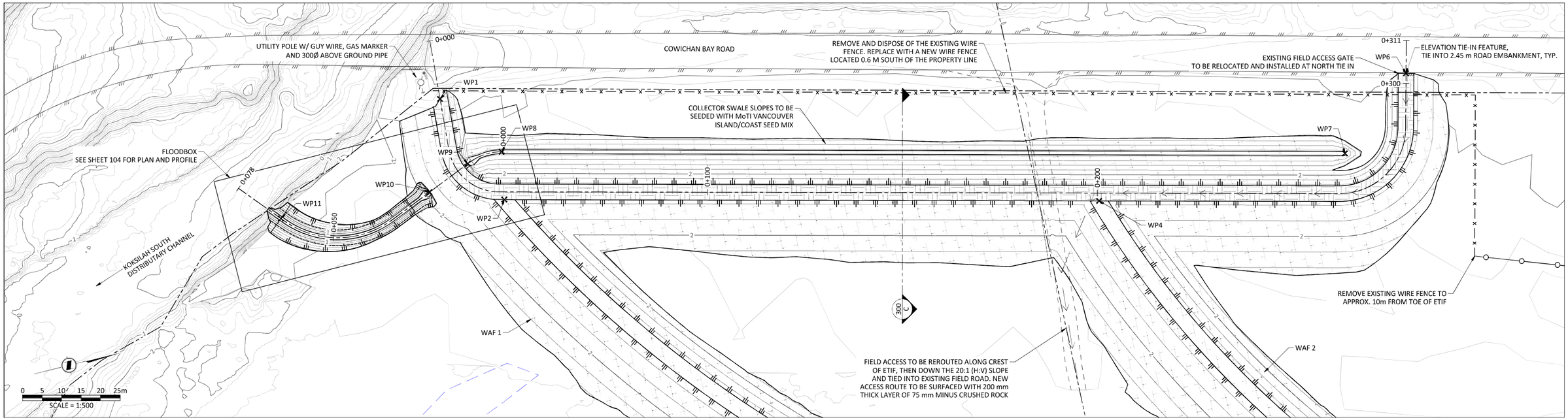
PERMIT TO PRACTICE: 1003221

COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION
PLAN VIEW | SITE MAP

DESIGNED:	L.DUNBAR	SHEET ID: 3006733-PROD-IFR-COWEST_WAVEMIT_R1I-101 R1	SHEET No: 101
DRAFTED:	R.CLARK	STATUS: ISSUED FOR REVIEW	
CHECKED:	G.HILL	SCALE: AS SHOWN WHEN PLOTTED D SIZE	
APPROVED:	G.HILL	DATE: 19 FEB 2025	REV No: R1

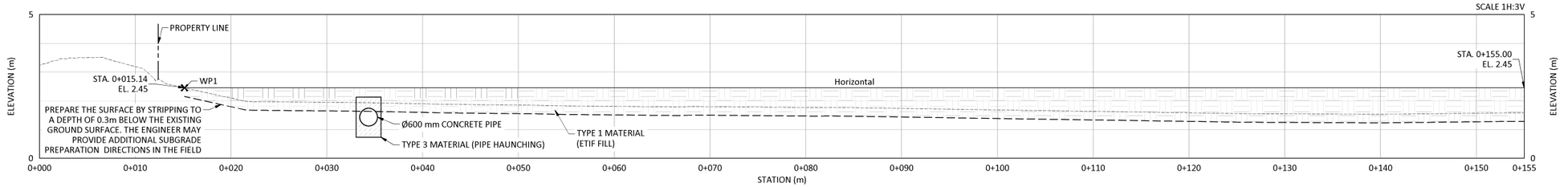
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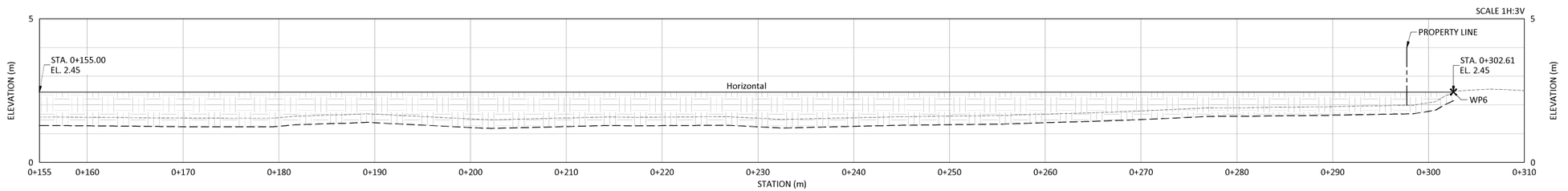
PLAN VIEW | ELEVATION TIE IN FEATURE (ETIF)

SCALE 1:500



ELEVATION TIE IN FEATURE (ETIF) PROFILE | STA 0+000 TO STA 0+155

SCALE 1:250 | 3x VERTICAL EXAGGERATION



ELEVATION TIE IN FEATURE (ETIF) PROFILE | STA 0+155 TO STA 0+310

SCALE 1:250 | 3x VERTICAL EXAGGERATION

LEGEND:

- PROPERTY BOUNDARY
- DESIGN LINEWORK
- APPROXIMATE EDGE OF ROAD SURFACE/SLOPE
- EXISTING FENCELINE
- PROPOSED FENCING
- TYPE 1 MATERIAL (ETIF FILL)
- TYPE 2 MATERIAL (GENERAL FILL)
- TYPE 3 MATERIAL (PIPE HAUNCHING)

NOT FOR CONSTRUCTION

CLIENT:

THE NATURE TRUST OF B.C.
1080 LABIEUX ROAD
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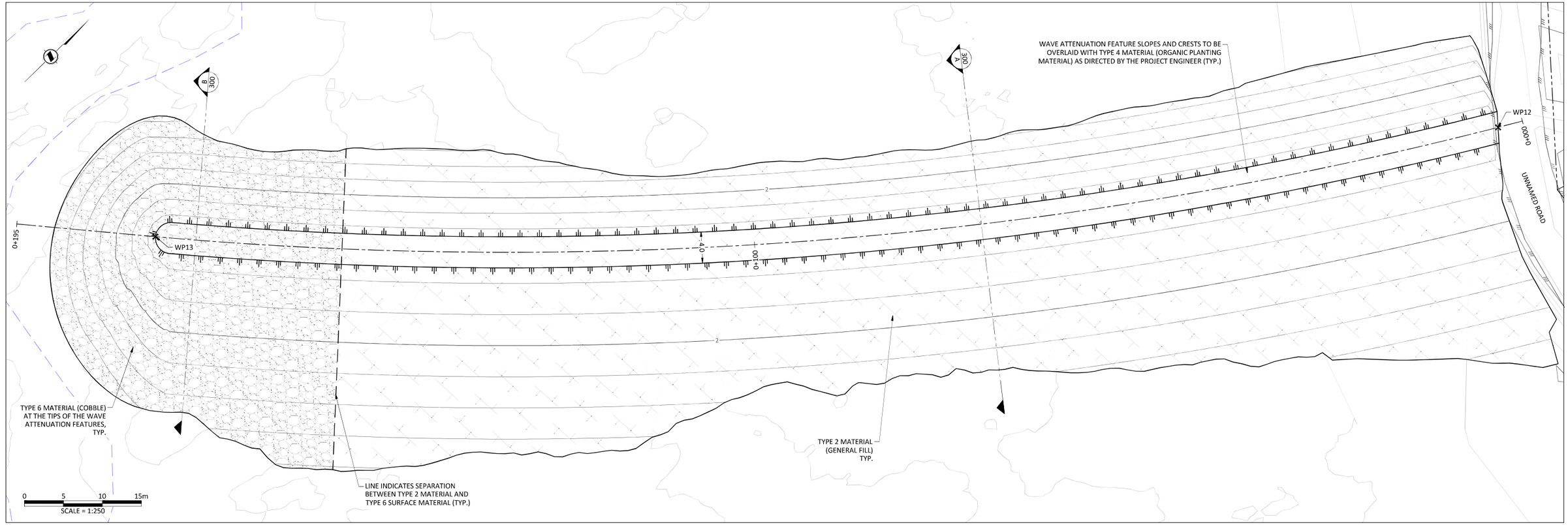
COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

PLAN AND PROFILE | ELEVATION TIE-IN FEATURE (ETIF)

DESIGNED: L.DUNBAR	SHEET ID: 3006733-PROD-IFR-COWEST_WAVEMIT_R1I-102 R1	SHEET No: 102	
DRAFTED: R.CLARK	STATUS: ISSUED FOR REVIEW		
CHECKED: G.HILL	SCALE: AS SHOWN WHEN PLOTTED D SIZE		
APPROVED: G.HILL	DATE: 19 FEB 2025	REV No: R1	

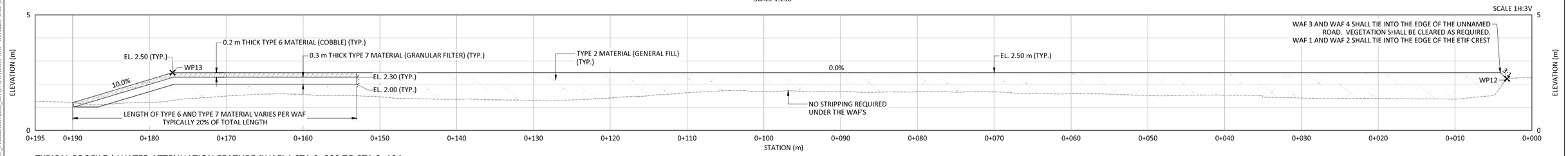
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PLAN VIEW

SCALE 1:250



TYPICAL PROFILE | WATER ATTENUATION FEATURE (WAF) | STA 0+000 TO STA 0+194

SCALE 1:250 | 3x VERTICAL EXAGGERATION

LEGEND:

- DESIGN LINEWORK
- TOP OF SLOPE
- APPROX. EDGE OF ROAD SURFACE/SLOPE
- TYPE 2 MATERIAL (GENERAL FILL)
- TYPE 6 MATERIAL (COBBLE)
- TYPE 7 MATERIAL (GRANULAR FILTER)

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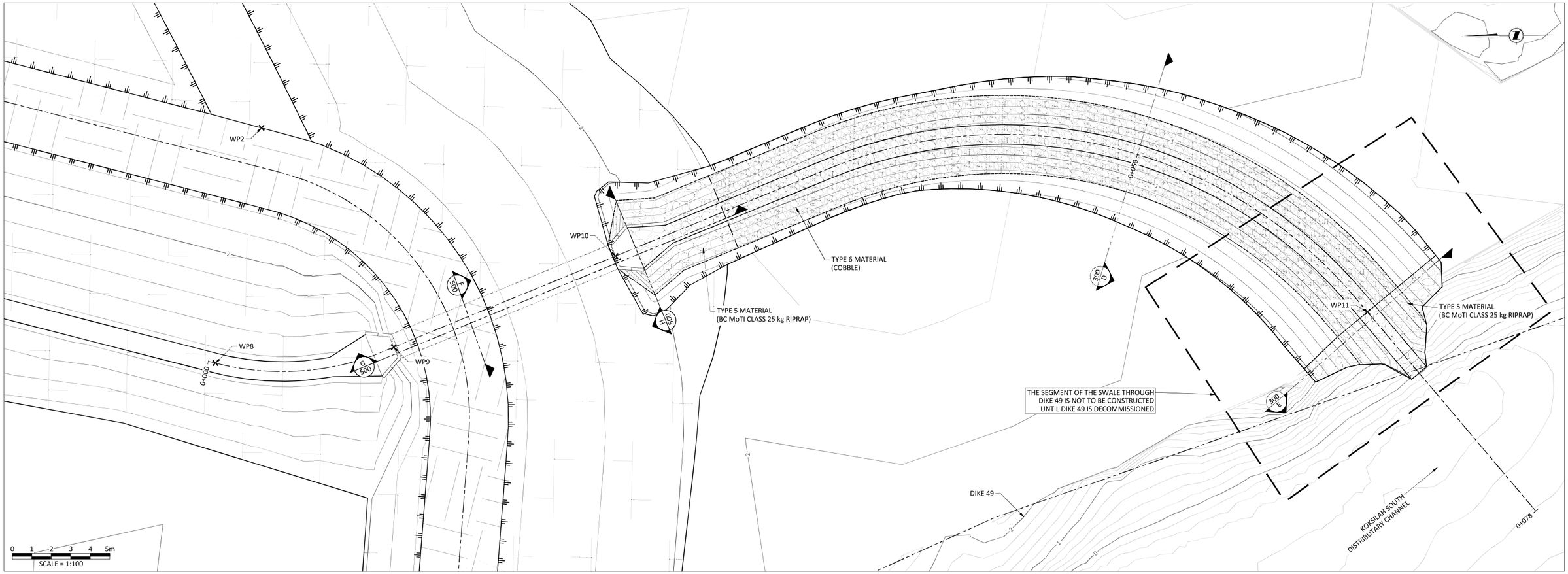
COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

PLAN AND PROFILE | WATER ATTENUATION FEATURE (WAF)

DESIGNED:	L.DUNBAR	SHEET ID:	3006733-PROD-IFR-COWEST_WAVEMIT_R1I-103 R1	SHEET No:	103
DRAFTED:	R.CLARK	STATUS:	ISSUED FOR REVIEW		
CHECKED:	G.HILL	SCALE:	AS SHOWN WHEN PLOTTED D SIZE		
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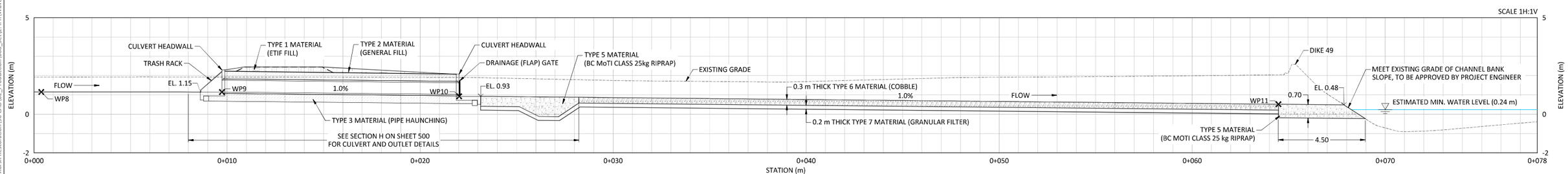
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OUTLET PLAN VIEW

SCALE 1:100



OUTLET SWALE PROFILE | STA 0+000 TO STA 0+070

SCALE 1:100 | NO VERTICAL EXAGGERATION

LEGEND:

- EXISTING GRADE
- DESIGN FINAL GRADE
- DESIGN GRADE BREAK
- LOW WATER LEVEL (EL. 0.24 m) OBSERVED BY NHC (2022-01-05 AT 00:00)
- TYPE 1 MATERIAL (ETIF FILL)
- TYPE 2 MATERIAL (GENERAL FILL)
- TYPE 3 MATERIAL (PIPE HAUNCHING)
- TYPE 5 MATERIAL (BC MoTI CLASS 25 kg RIPRAP)
- TYPE 6 MATERIAL (COBBLE)
- TYPE 7 MATERIAL (GRANULAR FILTER)

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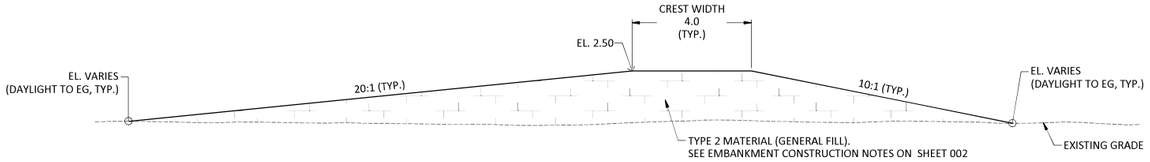
COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

PLAN AND PROFILE | CULVERT AND OUTLET

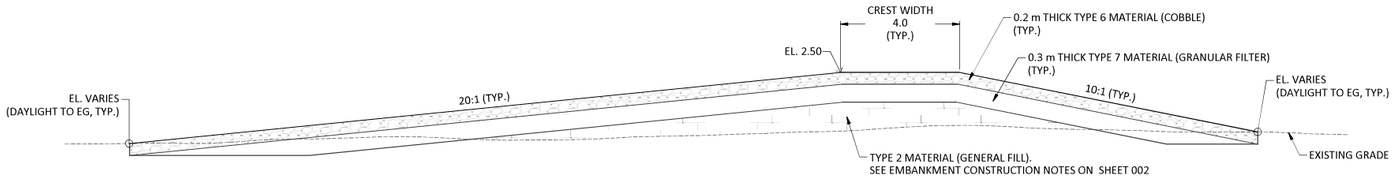
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APPROVED:	G.HILL	DATE: 19 FEB 2025	REV No: R1

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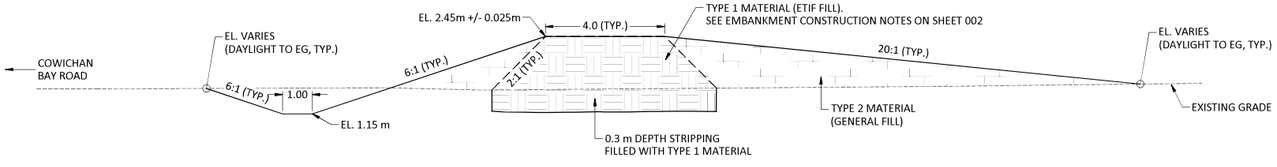
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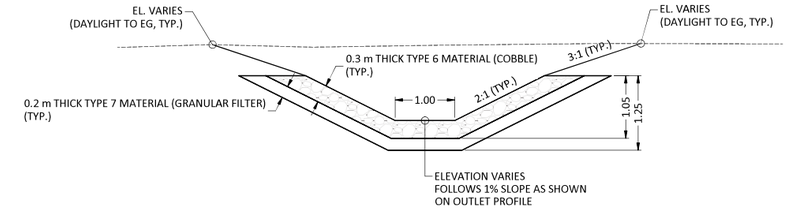
A 103 WAVE ATTENUATION FEATURE | TYPICAL
SCALE 1:100 | 2x VERTICAL EXAGGERATION



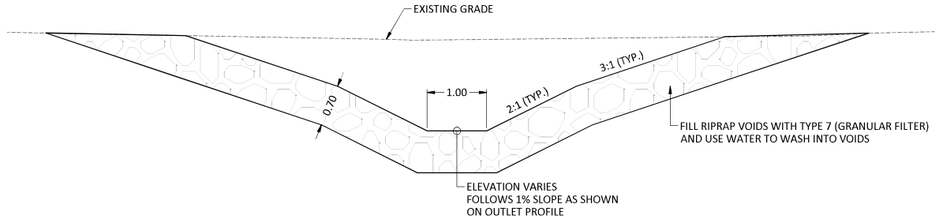
B 103 WAVE ATTENUATION FEATURE TIP| TYPICAL
SCALE 1:100 | 2x VERTICAL EXAGGERATION



C 101 ELEVATION TIE IN FEATURE |TYPICAL
SCALE 1:100 | 2x VERTICAL EXAGGERATION



D 104 OUTLET COBBLE SWALE | TYPICAL
SCALE 1:50 | NO VERTICAL EXAGGERATION



E 104 OUTLET SWALE CHANNEL CONNECTION| TYPICAL
SCALE 1:50 | NO VERTICAL EXAGGERATION

LEGEND:
- EXISTING GRADE
- DESIGN FINAL GRADE
- TYPE 1 MATERIAL (ETIF FILL)
- TYPE 2 MATERIAL (GENERAL FILL)
- TYPE 5 MATERIAL (BC MOTI CLASS 25 kg RIPRAP)
- TYPE 6 MATERIAL (COBBLE)
- TYPE 7 MATERIAL (GRANULAR FILTER)

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CLIENT:

THE NATURE TRUST OF B.C.
1080 LABIEUX ROAD
NANAIMO, B.C
B9T 6J9

NATURE TRUST BRITISH COLUMBIA

REV.	DATE	DESCRIPTION
0	2024-08-09	ISSUED FOR REVIEW
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2025-02-24

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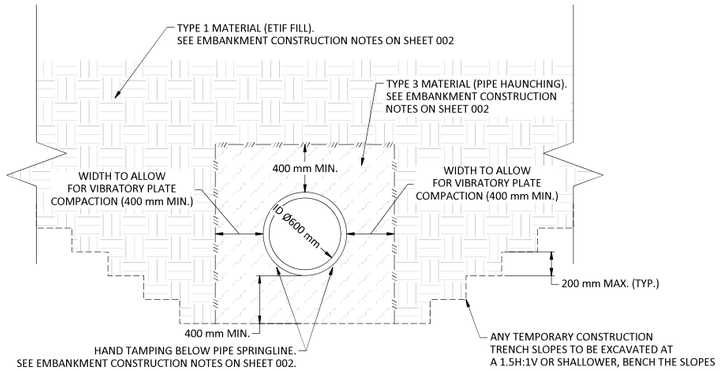
COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

TYPICAL SECTIONS

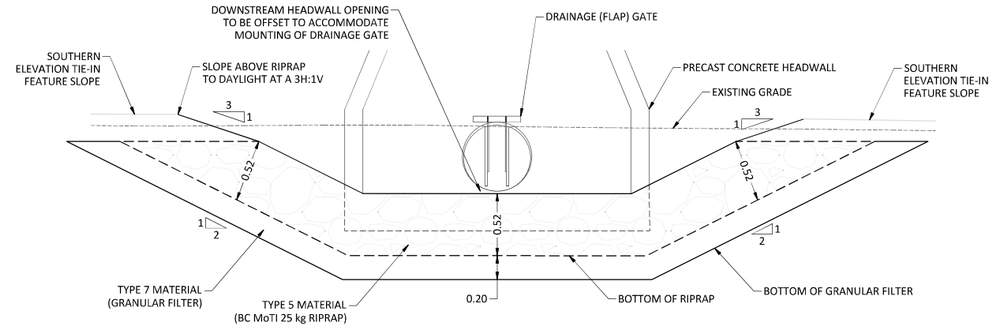
DESIGNED: L.DUNBAR	SHEET ID: 3006733-PROD-IFR-COWEST_WAVEMIT_R1I-300 R1	SHEET No:	300
DRAFTED: R.CLARK	STATUS: ISSUED FOR REVIEW		
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APPROVED: G.HILL	DATE: 19 FEB 2025	REV No:	R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING

FILENAME: \\mainfile-van\Projects\Active\3006733 Cowichan Estuary Marsh Restoration\06 CAD\02_Production\000_Set\2_IFR\Wave Mit - Dinsdale Dike\3006733-PROD-IFR-CowEst_WaveMit_R1I.dwg, 19 Feb 2025, 12:57 PM



F 104 TYPICAL SECTION
SCALE 1:25



H 104 OUTLET DETAIL
SCALE 1:25

G 104 CULVERT DETAIL
SCALE 1:25

NOT FOR CONSTRUCTION

DRAFT

CLIENT:

THE NATURE TRUST OF B.C.
1080 LABIEUX ROAD
NANAIMO, B.C
B9T 6J9

NATURE TRUST BRITISH COLUMBIA

REV.	DATE	DESCRIPTION
0	2024-08-09	ISSUED FOR REVIEW
1	2025-02-19	ISSUED FOR REVIEW

nhc northwest hydraulic consultants

SEAL: PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA G. R. HILL # 28209 — 2025-02-24

PERMIT TO PRACTICE: 1003221

COWICHAN ESTUARY MARSH RESTORATION
DINSDALE FIELD MITIGATION

DETAILS

DESIGNED: L.DUNBAR	SHEET ID: 3006733-PROD-IFR-COWEST_WAVEMIT_R1I-500 R1	SHEET No:	500
DRAFTED: R.CLARK	STATUS: ISSUED FOR REVIEW		
CHECKED: G.HILL	SCALE: AS SHOWN WHEN PLOTTED D SIZE		
APPROVED: G.HILL	DATE: 19 FEB 2025	REV No:	R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING

FILENAME: \\mainfile-van\Projects\Active\3006733 Cowichan Estuary Marsh Restoration\06 CAD\02_Production\000_Set12_IFR\Wave Mit - Dinsdale Dike\3006733-PROD-IFR-CowEst_WaveMit_R1I.dwg, 19 Feb 2025, 12:57 PM

APPENDIX B

HEC RAS HYDRAULLIC MODELLING

APPENDIX B: HEC-RAS HYDRAULIC MODELLING

1 INTRODUCTION

Hydraulic modelling for this deliverable was completed using HEC-RAS software[1] version 6.2 to support the design of the Dinsdale Field mitigation features as part of the Cowichan Estuary Restoration Project led by the Nature Trust of BC. Updates were completed to the project model that was originally developed (using HEC-RAS version 6.1) for an earlier assessment of physical processes and restoration opportunities for the Cowichan Estuary marsh (NHC, 2022) for the present analysis. This appendix summarizes the model updates, sensitivity tests, validation simulations, and analysis completed to support this phase of analysis and design.

2 MODEL UPDATES

This section summarizes the updates to the existing model, which include:

- Upstream and downstream boundary condition updates
- Model terrain updates
- Geometry updates
- Sensitivity testing
- Validation simulations
- Design concept modelling.

2.1 Boundary Condition Updates

The upstream and downstream boundary conditions of the model were updated. Specifically, the Koksilah River inflow was updated, and the downstream ocean levels in Cowichan Bay were updated.

[1] HEC-RAS refers to the US Army Corps of Engineers Hydraulic Engineering Center River Analysis System.

2.1.1 River Boundary Condition Updates

NHC updated the flood frequency analysis for the Koksilah River that was originally undertaken for the Cowichan-Koksilah floodplain mapping project (NHC, 2021), to include WSC gauge data from 1991 to 2023. The purpose was to account for the recent flood events in 2020 and 2021 in the analysis. Synthetic hydrographs were reviewed and updated for 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 200-year events.

2.1.2 Coastal Boundary Condition Updates

The tidal signal's timestep was decreased from a 1 hour to 15-minute interval. The purpose was to capture the relatively brief, sub-hour high and low ocean levels in the model simulations.

2.2 Geometry and Terrain Updates

The model geometry and terrain contained in the digital elevation model were updated to increase the granularity of the hydraulic model in the area of Cowichan Bay Road. The terrain updates included the following:

- Incorporating a March 2024 real-time-kinematic global-navigation-satellite-system survey of Cowichan Bay Road by NHC, which included points along the road crown and edges of pavement. This survey excluded topography to the west of the road, which is private property.
- Incorporating survey data along the crest of the southwestern, low-lying portion of Dike 49 (Dinsdale Dike) from a November 2024 survey completed by McElhanney Associate Land Surveying Ltd.
- Interpolations were made along vegetated portions of a berm located west of Cowichan Bay Road on private property, based on interpolations made from adjacent, unvegetated sections of berm where the topography data quality is considered relatively more reliable. The topography data source relies on light detection and ranging survey methods (LiDAR), for which the ground-surface-data-accuracy is typically more accurate where the ground is bare than it is where the ground is covered with vegetation. These interpolations were undertaken by referencing observations and field photos collected in March 2024.
- Terrain interpolations on the private lots located west of Cowichan Bay were made based on reference to unvegetated sections of adjacent LiDAR data on the private lots west of Cowichan Bay Road where low spots in the LiDAR did not match field photos and March 2024 observations.
- Buildings were digitized, based on reference to Google Earth imagery.

Geometry updates included:

- Computational cell size refinement was completed in the project area. An in-channel cell size of 4 m was selected, and an 8 m cell size was selected for the properties west of Cowichan Bay Road. Multiple cell sizes were trialed, and the results compared. The cells sizes were selected to balance computation time and the model's ability to simulate the hydraulic parameters at the project site.
- Breaklines were added or refined to capture important topographical high points such as Cowichan Bay Road, the top of channel slopes, and berms adjacent to the road.
- For the design simulations with Dike 49 removed and the mitigation features, the terrain was modified to represent the design geometry.

2.3 Sensitivity Tests

Sensitivity testing was completed to better understand the influence of model parameters. Cell size, terrain roughness (Manning's n), and flows were varied to better understand their influence on model results.

2.3.1 Cell Size

Different cell sizes were tested for the Koksilah south distributary channel. Cell size was iteratively reduced and checked against the previous size to determine relative differences. An in-channel cell size of 4 m was selected, which balanced computational time to complete simulations, and produced results similar to those of smaller cell sizes.

2.3.2 Roughness Sensitivity

To assess the model's sensitivity to land cover roughness (represented as a Manning's n value), in-channel n values were varied by +10% and -10%. Differences in WSE greater than 0.01 m were not observed, indicating the model has minimal sensitivity to Manning roughness.

2.3.3 Flow Sensitivity

To assess the model's sensitivity to flow changes, flow in the Koksilah mainstem were varied by +10% and -10% for two riverine events, a 2-year and a 10-year. These adjustments in the mainstem flow translated to a 2% to 4% variance in the Koksilah south distributary channel. The project area is sensitive to variances in flow in the Koksilah River. Variances in flow could be the result of morphological changes such as debris accumulations or bedform changes in the Koksilah mainstem, which is susceptible to log jams and sediment accumulations near the South Distributary B channel.

Small flow changes can be the difference whether the Koksilah south distributary channel conveys the flow or if it spills onto the floodplain at the tennis courts, crosses Cowichan Bay Road, and spills onto Dinsdale Field. This is illustrated in Figure 2.1.

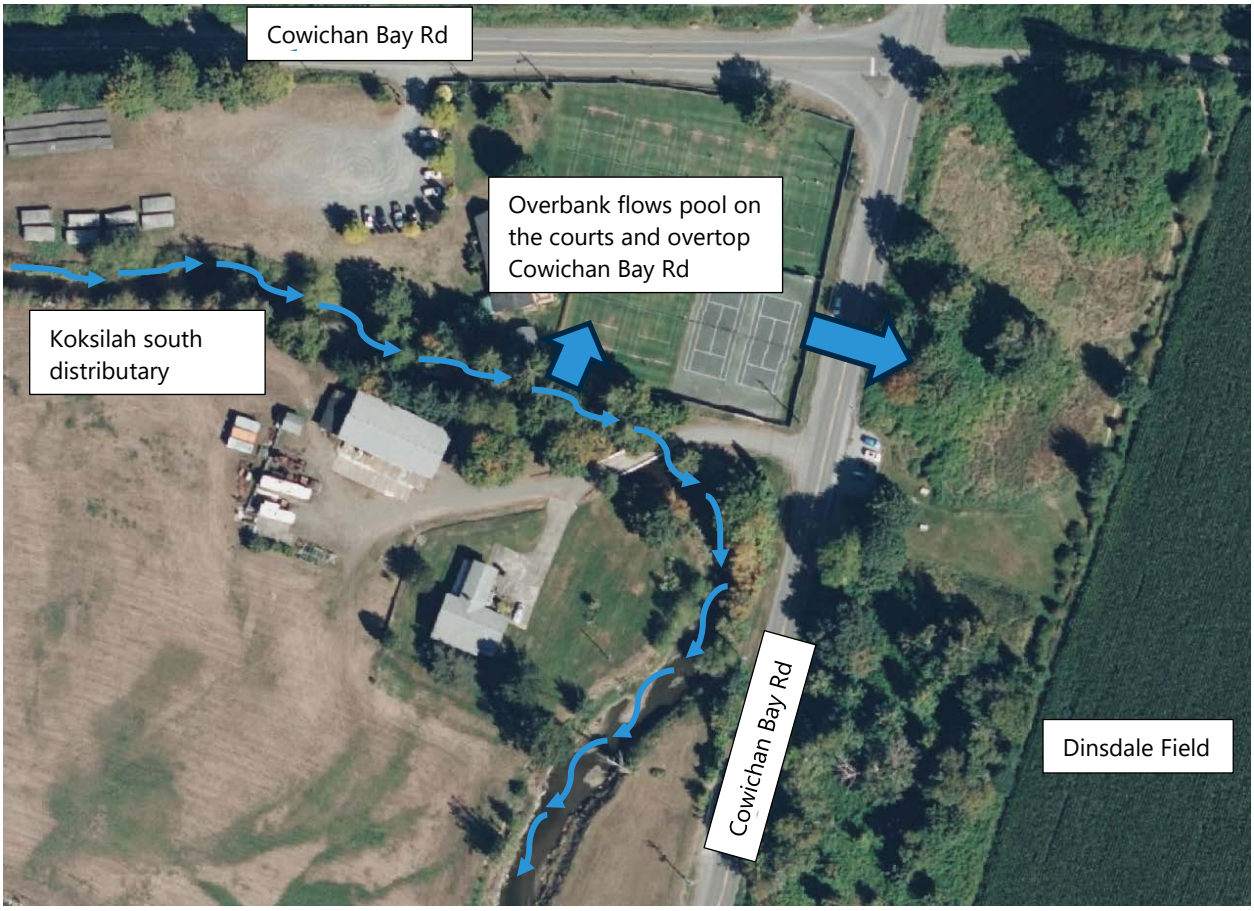


Figure 2.1 Overtopping sensitivity near the Cowichan Bay Road tennis courts.

2.4 Validation Simulations

Three model validation runs were completed for periods when data were available. The data included continuously recorded water levels from October 2021 to March 2022, and three discrete flow measurements. Water levels were recorded with a *Solinst Levellogger*, and flow measurements were taken with an *Acoustic Doppler Current Profiler* (ADCP).

The water level data was recorded on the upstream side of the Cowichan Bay Road bridge over the Koksilah south distributary channel as illustrated in Figure 2.2. The flow measurements were completed approximately 60 m downstream of the bridge.



Figure 2.2 NHC level logger and ADCP measurement locations [imagery: Bing].

Three simulations were completed:

1. November 13 to 18, 2021: the Koksilah River flow was between a 5 and 10-year peak
2. January 3 to 7, 2021: the coastal water level was 2.02 m, which is very close to the 2-year coastal water level (2.04 m)
3. February 27 to March 3, 2022: there was an ADCP measurement at low tide on March 3.

Key takeaways from the validation simulations are summarized below:

- Variances are substantially larger for the first two to three days of simulation, during which time the model presumably finds steady solutions during a warm-up period; results below exclude simulations during model warm-up.
- Validation data is very localized; interpretation of the results in areas more distant from the validation data collection points are less certain.
- Model tracked observed data reasonably well:
    - Within 0.05 m during the November 2021 flood peak, and varying by up to 0.18 m before and after the event

- Within 0.05 m during the peak January 2022 tide event, and varying by up to 0.19 m before and after the event
- Maximum variation of 0.18 m during the February to March 2022 monitoring period. The flow measured on March 3 was 9.49 m^3/s at 23:30, compared to the model, which simulated 11.65 m^3/s.

2.5 Joint Probability Simulations

The Cowichan and Koksilah Rivers discharge into Cowichan Bay. In the lower reaches of these rivers, the water levels are governed by the inflowing river discharge, the astronomical tide level and the magnitude of any storm surge. Extreme flood levels are governed by the complex interaction of discharge, tide and surge; the highest water levels at any location do not necessarily correspond to the highest inflow discharge or highest ocean level.

The Koksilah River is the main riverine driver for the project site. The south arm of the Cowichan River converges with the Koksilah River downstream of the Koksilah south distributary channel. Additionally, the WestCan Terminal causeway divides the estuary between the project area and the Cowichan River.

Simulations were selected for multiple event return periods. For each return period, reciprocal simulations were completed, one of which had a higher river, and the other which had a higher ocean level (e.g., for the 10-year joint probability, two simulations were completed, a 10-year river combined with a 2-year ocean level, and its reciprocal, a 2-year river combined with a 10-year ocean level). The simulated boundary conditions are summarized in Table 2.2.

Table 2.1 Summary of the joint probabilities of the model boundary conditions.

Joint Probability Return Period[1]	Koksilah River Return Period	Cowichan Bay Return Period
10-year	10-year	2-year
	2-year	10-year
13-year	20-year	1.5-year
	1.5-year	20-year
22-year	50-year	1.5-year
	1.5-year	50-year
26-year	10-year	10-year
33-year	100-year	1.5-year
	1.5-year	100-year

Joint Probability Return Period[1]	Koksilah River Return Period	Cowichan Bay Return Period
48-year	200-year	1.5-year
	1.5-year	200-year

Notes:
1. Joint probabilities based on 85% confidence matrix for Cowichan Bay ocean levels and Koksilah River discharges.

The project area and neighbouring properties are below the 200-year flood construction level indicated in the CVRD flood maps prepared by NHC (NHC, 2021), illustrated in Figure 2.3.

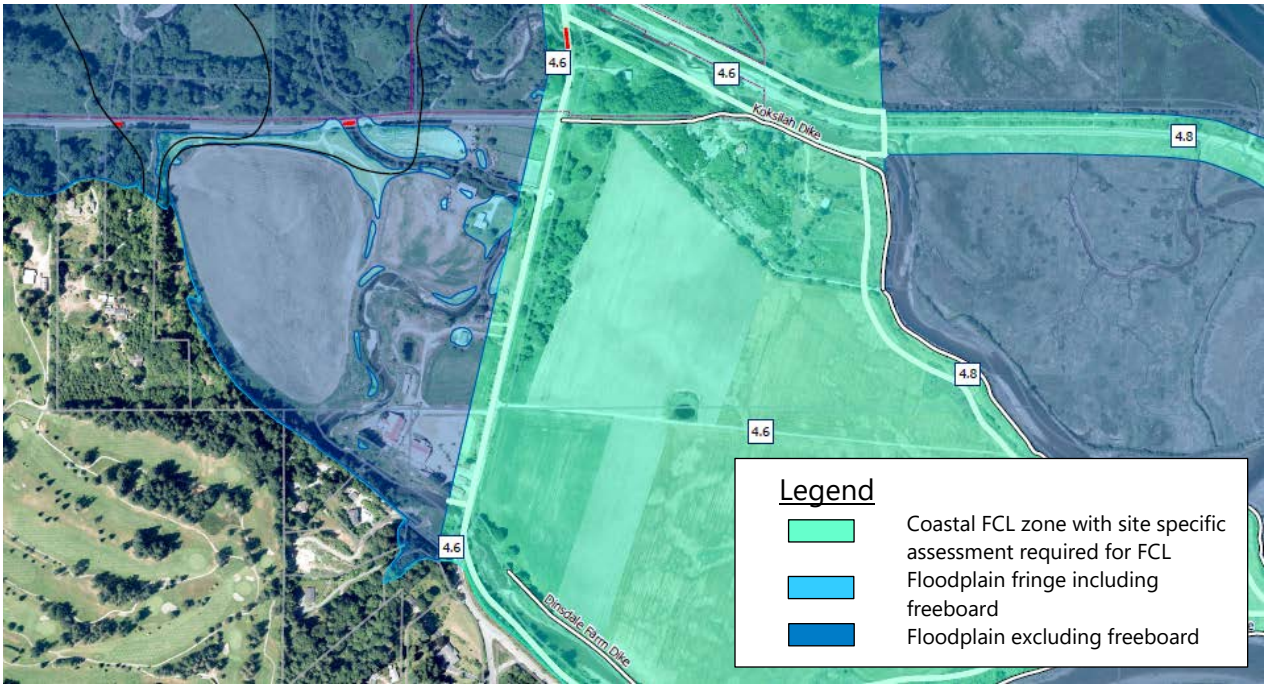


Figure 2.3 Cowichan Valley Regional District flood maps indicating flood construction levels (FCLs) for the project and surrounding area (source: CVRD flood maps, prepared by NHC, available online).

At an approximately 2-year joint probability return period, there are no overbank flows. The boundary conditions and associated joint probabilities presented in Table 2.2 were selected because they allow study of the project area hydraulics between return periods where there are no flood hazards (i.e., at low return periods) and extreme flood hazards (i.e., high return periods associated with flood construction level [FCL] maps).

2.6 Model Results

This section presents detailed water surface elevation (WSE) results for existing (with dike) conditions, with dike removed (no mitigation) conditions, and with dike removed with mitigation (with project) conditions. Other proposed design features that have a primary function of habitat enhancement and added complexity have not been included in the modelling analysis undertaken for the design features presented in this report. The overall project, which includes these proposed features, is expected to offer additional flood mitigation that is not represented in the model simulations undertaken.

Figure 2.4 presents water surface elevation (WSE) comparison points, which are then tabulated in Table 2.3 with existing and with-project WSE for all the boundary conditions that were simulated.

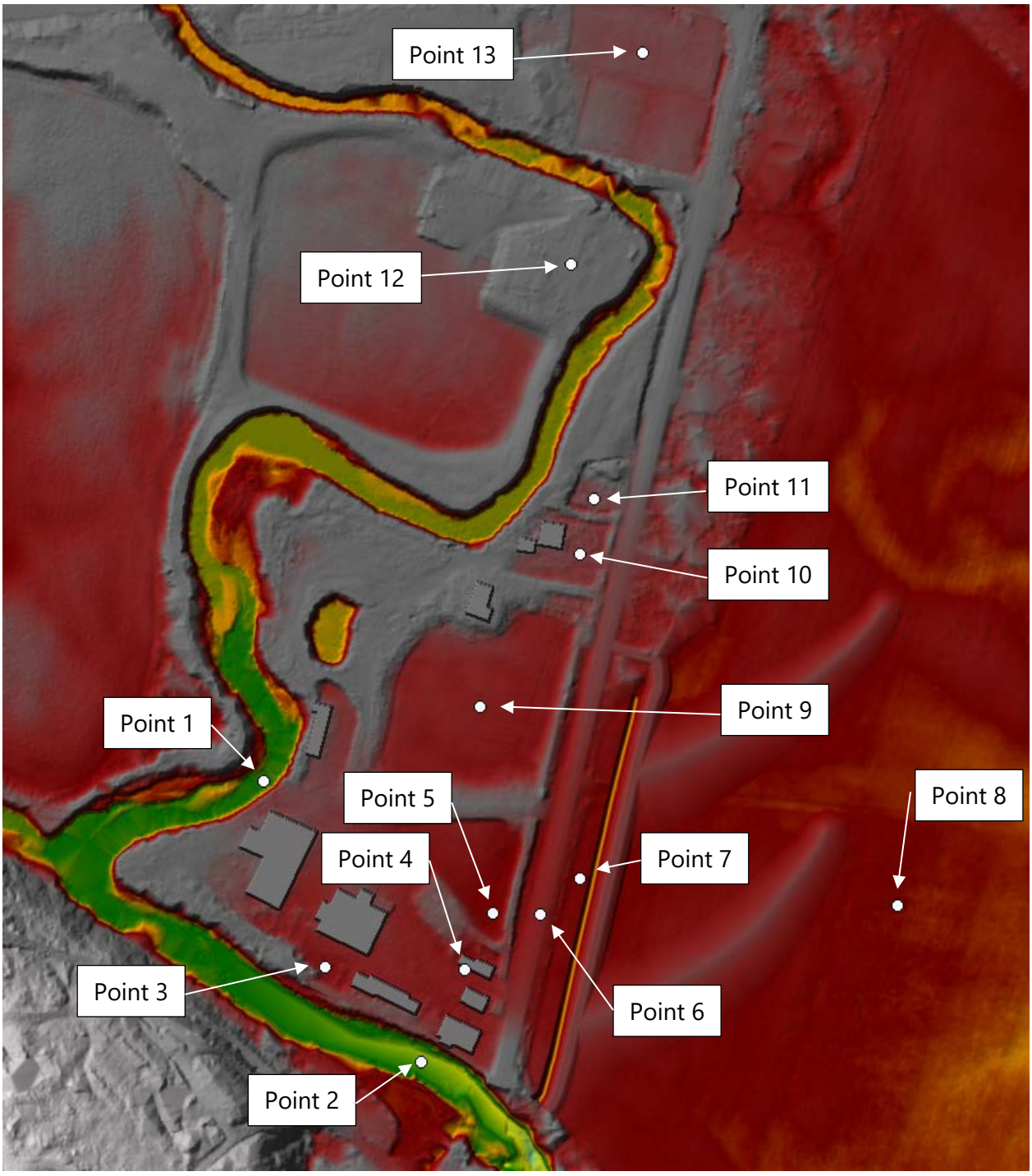


Figure 2.4 Water surface elevation comparison points

Table 2.3 presents the WSEs for existing conditions, Dike 49 removed with no mitigation, and Dike 49 removed with project.

Table 2.2 Water surface elevations in the project area in existing conditions and with project (m, CGVD2013).

Boundary Condition ID	Boundary Condition	Point	WSE, Dike 49 in place	WSE, Dike 49 Removed	WSE, Dike 49 removed with mitigation
A	10-year river + 2-year ocean level (joint probability[1]: 10-year)	1: Channel	2.48	2.48	2.48 (0.0)
		2: Channel by bridge	2.15	2.13	2.15 (0.0)
		3: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		4: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		5: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		6: Cowichan Bay Rd	2.20	2.19	2.20 (0.0)
		7: Field beside Rd (west of mitigation features)	1.92	2.07	1.92 (0.0)
		8: Field (east of mitigation features)	1.92	2.07	1.92 (0.0)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.54	2.54	2.54 (0.0)
		11: 2286 Cowichan Bay Rd	2.69	2.69	2.69 (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.22	3.22	3.22 (0.0)
B	2-year river + 10-year ocean level (JP: 10-year)	1: Channel	2.51	2.51	2.51 (0.0)
		2: Channel by bridge	2.29	2.29	2.29 (0.0)
		3: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		4: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		5: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		6: Cowichan Bay Rd	Dry	2.25	Dry (0.0)
		7: Field beside Rd (west of mitigation features)	Dry	2.25	Dry (0.0)
		8: Field (east of mitigation features)	Dry	2.25	Dry (0.0)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.50	2.50	2.50 (0.0)
		11: 2286 Cowichan Bay Rd	2.55	2.55	2.55 (0.0)

Boundary Condition ID	Boundary Condition	Point	WSE, Dike 49 in place	WSE, Dike 49 Removed	WSE, Dike 49 removed with mitigation
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.03	3.02	3.03 (0.0)
C	20-year river + 1.5-year ocean level (JP: 13-year)	1: Channel	2.49	2.49	2.49 (0.0)
		2: Channel by bridge	2.12	2.11	2.11 (-0.01)
		3: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		4: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		5: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		6: Cowichan Bay Rd	2.27	2.20	2.20 (-0.07)
		7: Field beside Rd (west of mitigation features)	2.27	2.04	Dry (-0.63)
		8: Field (east of mitigation features)	2.27	2.04	2.04 (-0.23)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.59	2.59	2.59 (0.0)
		11: 2286 Cowichan Bay Rd	2.74	2.74	2.74 (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.29	3.29	3.29 (0.0)
D	1.5-year river + 20-year ocean level (JP: 13-year)	1: Channel	2.52	2.53	2.53 (+0.01)
		2: Channel by bridge	2.32	2.33	2.33 (+0.01)
		3: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		4: 2276 Cowichan Bay Rd	Dry	2.03	Dry (0.0)
		5: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		6: Cowichan Bay Rd	Dry	2.30	Dry (0.0)
		7: Field beside Rd (west of mitigation features)	Dry	2.30	Dry (0.0)
		8: Field (east of mitigation features)	Dry	2.30	2.30 (+0.82)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.47	2.47	2.47 (0.0)

Boundary Condition ID	Boundary Condition	Point	WSE, Dike 49 in place	WSE, Dike 49 Removed	WSE, Dike 49 removed with mitigation
		11: 2286 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	2.99	2.99	2.99 (0.0)
E	50-year river + 1.5-year ocean level (JP: 22-year)	1: Channel	2.56	2.53	2.53 (-0.03)
		2: Channel by bridge	2.19	2.12	2.12 (-0.07)
		3: 2276 Cowichan Bay Rd	2.26	2.01	2.01 (-0.25)
		4: 2276 Cowichan Bay Rd	2.26	Dry	Dry (-0.26)
		5: 2276 Cowichan Bay Rd	2.22	1.62	1.62 (-0.6)
		6: Cowichan Bay Rd	2.37	2.20	2.20 (-0.17)
		7: Field beside Rd (west of mitigation features)	2.37	2.04	1.64 (-0.73)
		8: Field (east of mitigation features)	2.37	2.04	2.05 (-0.32)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.61	2.61	2.61 (0.0)
		11: 2286 Cowichan Bay Rd	2.76	2.76	2.76 (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.36	3.36	3.36 (0.0)
F	1.5-year river + 50-year ocean level (JP: 22-year)	1: Channel	2.56	2.57	2.56 (0.0)
		2: Channel by bridge	2.37	2.39	2.39 (+0.02)
		3: 2276 Cowichan Bay Rd	2.05	2.07	2.07 (+0.02)
		4: 2276 Cowichan Bay Rd	Dry	2.16	Dry (0.0)
		5: 2276 Cowichan Bay Rd	1.66	1.71	1.67 (+0.01)
		6: Cowichan Bay Rd	Dry	2.36	Dry (0.0)
		7: Field beside Rd (west of mitigation features)	Dry	2.36	Dry (0.0)
		8: Field (east of mitigation features)	Dry	2.36	2.36 (+0.88)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)

Boundary Condition ID	Boundary Condition	Point	WSE, Dike 49 in place	WSE, Dike 49 Removed	WSE, Dike 49 removed with mitigation
		10: 2284 Cowichan Bay Rd	2.47	2.47	2.47 (0.0)
		11: 2286 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.00	3.00	3.00 (0.0)
G	10-year river + 10-year ocean level (JP: 26-year)	1: Channel	2.57	2.57	2.56 (-0.01)
		2: Channel by bridge	2.30	2.30	2.30 (0.0)
		3: 2276 Cowichan Bay Rd	2.13	2.12	2.12 (-0.01)
		4: 2276 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		5: 2276 Cowichan Bay Rd	1.72	1.71	1.71 (-0.01)
		6: Cowichan Bay Rd	2.20	2.26	2.20 (0.0)
		7: Field beside Rd (west of mitigation features)	2.04	2.26	Dry (-0.4)
		8: Field (east of mitigation features)	2.04	2.26	2.26 (+0.22)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.58	2.58	2.58 (0.0)
		11: 2286 Cowichan Bay Rd	2.72	2.72	2.72 (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.23	3.23	3.23 (0.0)
H	100-year river + 1.5-year ocean level (JP: 33-year)	1: Channel	2.63	2.56	2.56 (-0.07)
		2: Channel by bridge	2.40	Dry	Dry (-0.4)
		3: 2276 Cowichan Bay Rd	2.40	2.15	2.15 (-0.25)
		4: 2276 Cowichan Bay Rd	2.40	Dry	Dry (-0.4)
		5: 2276 Cowichan Bay Rd	2.40	1.74	1.74 (-0.66)
		6: Cowichan Bay Rd	2.41	2.20	2.20 (-0.21)
		7: Field beside Rd (west of mitigation features)	2.41	2.05	1.69 (-0.72)
		8: Field (east of mitigation features)	2.41	2.05	2.06 (-0.35)

Boundary Condition ID	Boundary Condition	Point	WSE, Dike 49 in place	WSE, Dike 49 Removed	WSE, Dike 49 removed with mitigation
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.62	2.62	2.62 (0.0)
		11: 2286 Cowichan Bay Rd	2.77	2.77	2.77 (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.40	3.40	3.40 (0.0)
I	1.5-year river + 100-year ocean level (JP: 33-year)	1: Channel	2.58	2.59	2.59 (+0.01)
		2: Channel by bridge	2.41	2.43	2.43 (+0.02)
		3: 2276 Cow B Rd	2.15	2.24	2.17 (+0.02)
		4: 2276 Cow B Rd	Dry	2.27	Dry (0.0)
		5: 2276 Cow B Rd	1.74	2.07	1.77 (+0.03)
		6: Cow B Rd	Dry	2.40	Dry (0.0)
		7: Field beside Rd (west of mitigation features)	1.65	2.40	Dry (-0.01)
		8: Field (east of mitigation features)	1.65	2.40	2.40 (+0.75)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.48	2.47	2.47 (-0.01)
		11: 2286 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.00	3.00	3.00 (0.0)
J	200-year river + 1.5-year ocean level (JP: 48-year)	1: Channel	2.68	2.59	2.59 (-0.09)
		2: Channel by bridge	2.35	2.15	2.15 (-0.2)
		3: 2276 Cowichan Bay Rd	2.46	2.22	2.22 (-0.24)
		4: 2276 Cowichan Bay Rd	2.46	2.12	2.12 (-0.34)
		5: 2276 Cowichan Bay Rd	2.47	1.92	1.92 (-0.55)
		6: Cowichan Bay Rd	2.43	2.20	2.20 (-0.23)
		7: Field beside Rd (west of mitigation features)	2.43	2.06	1.73 (-0.7)

Boundary Condition ID	Boundary Condition	Point	WSE, Dike 49 in place	WSE, Dike 49 Removed	WSE, Dike 49 removed with mitigation
		8: Field (east of mitigation features)	2.43	2.06	2.07 (-0.36)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.62	2.62	2.62 (0.0)
		11: 2286 Cowichan Bay Rd	2.77	2.77	2.77 (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.44	3.44	3.44 (0.0)
K	1.5-year river + 200-year ocean level (JP: 48-year)	1: Channel	2.60	2.61	2.61 (+0.01)
		2: Channel by bridge	2.43	2.46	2.45 (+0.02)
		3: 2276 Cowichan Bay Rd	2.19	2.31	2.21 (+0.02)
		4: 2276 Cowichan Bay Rd	2.05	2.31	2.08 (+0.03)
		5: 2276 Cowichan Bay Rd	1.82	2.24	1.87 (+0.05)
		6: Cowichan Bay Rd	Dry	2.43	Dry (0.0)
		7: Field beside Rd (west of mitigation features)	1.83	2.43	2.15 (+0.32)
		8: Field (east of mitigation features)	1.83	2.43	2.43 (+0.6)
		9: 2274 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		10: 2284 Cowichan Bay Rd	2.48	2.47	2.47 (-0.01)
		11: 2286 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		12: 2288 Cowichan Bay Rd	Dry	Dry	Dry (0.0)
		13: 2290 Cowichan Bay Rd	3.01	3.01	3.01 (0.0)

2.7 Model Limitations

Key limitations particularly applicable to this project area as follows:

- Freshwater flow in the Koksilah south distributary channel is highly affected by log jams, topographic and bathymetric geometry, and anthropogenic works on the Koksilah River and its floodplain. Changes to these features can alter the flow split from the mainstem to the

distributary channel, thus affecting water levels and flow velocities. The flow sensitivity tests indicate that changes of this nature produce notable changes in project area hydraulics.

- The hydraulic model and wave model use floodplain, river channel, and coastal geometry data from several years ago. LiDAR and survey data incorporated in the model were collected between 2019 and 2024. The model terrain also includes some terrain interpolations on private property, based on 2024 NHC field observations (Section 2.2). Several large floods exceeding 10-year events have occurred in the watershed since the survey data used in the model development was collected. These large floods have caused morphological changes that are not represented in the bathymetries of the models.
- Documented water levels are used to calibrate hydraulic models. Validation was performed with available water level data, which provides a means of checking datapoints that lie within the south distributary channel located near Cowichan Bay Road. However, the model has not been calibrated for the entire project area because there is no water level monitoring data available for Dinsdale Field and nearby properties. Some unquantified uncertainty exists in areas where no flood level data exists.
- The model output is based on mathematical equations that attempt to simulate complex physical processes. There are inherent simplifications with this approach. The Navier-Stokes equations are a set of equations that describe the motion of fluid particles in three dimensions. The two-dimensional HEC-RAS model used for these analyses uses simplifications of the Navier-Stokes equations. For more information on the theoretical basis for two-dimensional hydrodynamic calculations, refer to the US Army Corps of Engineers' HEC-RAS, River Analysis System Hydraulic Reference Manual (Gary W. Brunner, 2020).
- The input flood flows, and coastal water levels are estimated using hindcasting methods. Hindcasting involves using historical data to estimate *past* discharges and coastal water levels for specified return periods. These methods may not accurately represent discharges, coastal water levels, and return periods for the near-term period and into the future.
- The hydraulic model uses limited survey-grade and remote-sensing-derived input data for the terrestrial areas included in the model. There are known inaccuracies with this data. Some issues have been identified and corrected with supplemental survey data collected in 2024 and incorporating assumptions based on NHC observations in the field (described in Section 2.2). Additional inaccuracies in the terrain data used for the hydraulic modelling may exist.

2.8 General Discussion

The water levels in the table are reported to the nearest centimeter to demonstrate the magnitudes of *relative* change associated with the project at the points presented in Figure 2.4. This should not be interpreted as an *absolute* level of centimeter accuracy. Validation simulations (described in section 2.4) completed with available field data indicate that in the

channel near the Cowichan Bay Road bridge the model is accurate to approximately 0.05 m for the verification simulations. However, this does not mean that the model is accurate to 0.05 m for the entire study area or for different hydrologic conditions (i.e., those that are higher or lower than the verification simulations). Overbank areas (such as in the field, on the road, and on neighbouring properties) have a higher level of uncertainty due to lack of flood level data to verify the results; NHC can not quantify the *absolute* values of the flood level output in those areas, though they are likely at least 0.05 m or greater. NHC's opinion is that the comparison of flood level output provides a reasonable means to assess the *relative* flood hazards in the study area.

The modelling that has been completed indicates that the project will either *reduce* or maintain similar-to-existing flood hazards for present climate conditions for Cowichan Bay Road and the properties west of the road. In a few instances (presented in Table 2.3), there were small incremental water level increases (i.e., less than 0.05 m); in NHC's opinion, water level changes of 0.05 m or less can be considered not appreciable since they are well within the model's uncertainty limits.

There were no computed incremental water level changes associated with the project at other properties along Cowichan Bay Road for the flood simulations. Simulated flood levels for other properties along Cowichan Bay Road were the same for model parameters that represent existing (i.e., pre-project), with Dike 49 decommissioned, and with project.

Appreciable water level increases were observed on NTBC's Dinsdale Field property (point 8); inundation of Dinsdale Field is inherent to the project's intent to reestablish estuarine natural processes. Section 2.9 provides additional discussion of the results.

The model also did not simulate meaningful increases in velocity that were not on NTBC-owned property. Velocity changes are expected on the marsh fringe with dike removal.

2.9 Simulation-Specific Discussion

The following bullets provide simulation-specific discussion about the model outputs presented in Table 2.3:

- For the 10-year simulations (A and B), water level differences are within model uncertainty, except points 7 and 8 (Dinsdale Field) in simulation B, which indicate a notable decrease in water levels west of the mitigation features, and a notable increase in water levels on the field west of the mitigation features. The points on 2276 Cowichan Bay Road were dry for these simulations. For these simulations, the points on 2276 Cowichan Bay Road saw no appreciable changes in water levels (i.e. the water level changes were 0.04 m or less).
- For the 15-year simulations (C and D), water level differences are within the model's uncertainty, except point 7 (Dinsdale Field) in both simulations where there were notable

decreases in water levels west of the mitigation structures. The points on 2276 Cowichan Bay Road were dry for these simulations.

- For the 22-year simulations (E and F), there are some notable decreases in simulation E, which is the simulation with the higher riverine influence. There are some notable decreases on 2276 Cowichan Bay Road, in the river channel, and on Dinsdale Field. For simulation F, the only notable change is a decrease at point 7 (Dinsdale Field), west of the mitigation features. There is water on 2276 Cowichan Bay Road both existing conditions and with-project conditions; the simulations show the water level differences range from 0.05 m to -0.06 m.
- For the 26-year simulation (G), the only notable change is a decrease at point 7 (Dinsdale Field) west of the mitigation features. There was some water on 2276 Cowichan Bay Road both existing conditions and with-project conditions; the simulations show the water level difference up to -0.05 m.
- For the 33-year (H and I) and 48-year (J and K) joint probabilities simulations, most decreases in water level for the simulation with the higher river influence (H and J) are notable, with water levels on 2276 Cowichan Bay Road decreasing by up to 0.5 m (i.e. -0.50 m). The changes (increases *and* decreases) in the high ocean level simulations (I and K) are not appreciable (i.e. 0.04 m or less). There was notable inundation of 2276 Cowichan Bay Road both existing conditions and with-project conditions.

In summary, water level changes on the 2276 Cowichan Bay Road property for all simulations were not appreciable (i.e. 0.05 m or less) when comparing the existing conditions to the with-project conditions, except for the with-project conditions with less frequent return periods such as the 33- and 48-year events that were driven by high coastal water levels. For these simulations, the water levels on 2276 Cowichan Bay Road were notably decreased (e.g., up to 0.50 m lower). Thus, the removal of Dike 49 with the Dinsdale Field mitigation features will either reduce or maintain similar-to-existing flood hazards for present climate conditions at 2276 Cowichan Bay Road. There was no simulated appreciable water level difference for the address at 2274, 2284, 2286, 2288, and 2290 Cowichan Bay Road. The project will result in increased water levels on Dinsdale Field east of the mitigation features; however, the landowner, NTBC, is aware of and accepts these increased flood hazards (T. Reid, personal communication, November 29, 2024).

3 REFERENCES

Gary W. Brunner (2020). *HEC-RAS Hydraulic Reference Manual Version 6.0*. Davis, CA.

NHC (2021). *Updated Cowichan-Koksilah Flood Mapping Project Final Report*. Prepared for Cowichan Valley Regional District.

NHC (2022). *Cowichan Estuary Marsh Restoration Project - Assessment of Physical Processes and Restoration Opportunities* (Final, Rev. 0). The Nature Trust of British Columbia.

APPENDIX C

THURBER ENGINEERING LTD. GEOTECHNICAL REPORT

THURBER

February 13, 2025 File No.: 34156

Nature Trust of British Columbia
c/o Northwest Hydraulic Consultants
#405 – 495 Dunsmuir Street
Nanaimo, BC V9R 6B9

Attention: Wil Hilsen, P.Geo., Principal

COWICHAN ESTUARY RESTORATION PROJECT
GEOTECHNICAL DESIGN RECOMMENDATIONS

Dear Wil,

As requested, this design memorandum presents geotechnical recommendations for the construction of mitigation measures developed by Northwest Hydraulics Consultants Ltd. (NHC) for the Cowichan Estuary restoration project.

It is a condition of this memorandum that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

1. PROJECT UNDERSTANDING

We understand, based on our discussions with NHC during the meeting on July 25 and September 26, 2024 and our review of the Issued for Review Dinsdale Field Mitigation drawings provided by NHC, that the design approach will focus on the use of Wave Attenuation Features (WAFs) to mitigate coastal influences and to control flooding within the marsh.

As modelled by NHC, four WAFs are proposed to be constructed within Dinsdale Field. These features would be constructed using imported general fill (Type 1) at the WAF 1 and 2 road tie-in, and inorganic (Type 2) fills excavated from the marsh channels in Dinsdale Field. Type 6 material (imported cobble-sized rounded material) would be used on the side slopes near the ends of the WAFs to provide erosion protection from wave action. Typical crest width would be 4 m with sides slopes of 20H:1V on the outward side and 10H:1V on the inward side. WAFs 1 and 2 tie into the elevation tie-in feature (ETIF) which ties into Cowichan Bay Road. The ETIF has a 6:1 slope on the side facing the road, and the WAFs tie into the ETIF's seaward facing 20:1 slope.

The ETIF will be about 290 m long, 4 m wide at the crest and will transition from WAF 1 and 2 to tie into Cowichan Bay Road northwest of WAF 2 as shown on NHC Drawing Sheet 102. A flood control box is to be constructed at the south end of the ETIF where it transitions to Cowichan Bay

Road. The flood box will incorporate an approximately 12.4 m long, 600 mm diameter concrete pipe with the gradient flowing to the southwest that will spill into a swale lined with Type 5 (25 kg) riprap material. The pipe surrounds will be backfilled using Type 3 (pipe haunching) material as shown on Detail F on NHC Drawing Sheet 500. We understand that Dike 49 located along the southeast perimeter near WAF 1 and 4 is to be decommissioned during a later phase of the project.

2. GEOTECHNICAL COMMENTARY AND RECOMMENDATIONS

We understand that NHC requires geotechnical design input on the Elevation Tie-In Feature (ETIF) and associated floodbox pipe installation including subgrade preparation requirements, placement and compaction requirements and gradation specifications for Type 1 general fill, Type 2 local re-used inorganic material, and Type 3 pipe surround fill. Geotechnical input will also be required for the Wave Attenuation Features (WAFs) that are to be constructed as shown on NHC Drawing Sheet No. 101.

Our geotechnical comments and recommendations for these features are provided below.

2.1 Elevation Tie-In Feature and Floodbox

Based on our review of the ETIF profile on Drawing Sheet 102 and Detail C on Drawing Sheet 300, the existing ground is to be stripped to a depth of 0.3 m below the design base for the ETIF. Backfill will consist of Type 1 material (see Section 2.3.1). Depending on the ground conditions encountered at the design subgrade elevation, as well as the timing of the work, it is possible the subgrade soils could consist of softened wet silty soils. In this case, additional sub-excavation (up to about 0.3 m) may be required and this can be evaluated in the field at the time of excavation. To aid in compaction and potentially reduce sub-excavation requirements, a medium weight non-woven geotextile fabric could be placed over the subgrade in selected areas prior to backfilling. Alternatively, a granular filter could be used if the use of synthetic materials in the field is prohibited. The side slopes are to be trimmed to 2H:1V prior to placement of Type 2 material for WAF 1 and 2 (see Drawing Sheet No. 300 – Detail C).

The subgrade for the floodbox should be stripped at least 0.3 m below the base of the concrete support curbing below the headwalls and evaluated for acceptance prior to backfilling. Depending on the conditions encountered at the subgrade elevation, a non-woven geotextile fabric or a granular filter could be placed on the subgrade to aid in compaction of Type 3 (pipe haunching) material.

A geotextile fabric or granular filter should also be used along the length of the outlet swale as a separator layer between the heavier cobble material (Type 6) that could settle into the finer marsh silts causing performance issues (ie. settlement along the alignment could cause disruption in the outflow and possibly localized erosion). The granular filter layer would likely need to be thick enough to bridge over the underlying sensitive soils and may need to be placed over a large work area to be effective compared to a geotextile fabric.

Type 1 and Type 3 backfill should be placed in maximum 250 mm thick lifts and compacted to at least 95% of the modified Proctor maximum dry density value. Thinner lifts (i.e. down to 150 mm) may be required depending on the consistency and moisture content of the material at the time of placement. Where there is sufficient width to permit use, compaction should be undertaken using a sheepsfoot roller or similar equipment. A heavy diesel plate tamper (or equivalent) should be used to compact Type 3 material below and around the culvert. Hand tamping will be required in addition to plate tamping to ensure adequate compaction of pipe haunching fill placed below pipe springline.

We understand from NHC that the preference would be to use the specified Type 1 fill. Depending on logistics, this fill will be obtained from the deconstruction of Dike 49. If the timing of deconstruction does not line up with the construction of the ETIF, then an alternative fill (ie. pit-run gravel material) will likely need to be sourced. Section 2.3.1 provides an alternative gradation for Type 1 fill for use in constructing the ETIF if Dike 49 material is not available.

2.2 Wave Attenuation Features

Four WAFs are planned to be constructed to control coastal fluctuations and flooding within Dinsdale Field. The WAFs will generally be constructed using Type 2 inorganic soils (silts and gravels) excavated from the marsh channels in Dinsdale Field. Imported Type 1 material (as noted above in Section 2.1) will be used for the core of the ETIF. WAF 1 and 2 tie into the ETIF. The east ends of WAF 1 and 2 and the west ends of WAF 3 and 4 will be capped with Type 6 (cobble sized) material to mitigate erosion from wave action. Consideration could be given to applying a layer of non-woven geotextile fabric or granular filter on the Type 2 fill prior to placing the Type 6 cobble material to mitigate the migration of fines from wave action and settlement of cobble material into the finer silt material.

WAFs are to be constructed on the existing field grade within a crest elevation tolerance of 0 m to +0.15 m. It is understood that the WAF's have been designed to tolerate some minor settlement; therefore, no special ground preparation (ie. granular filter or geotextile fabric) will be used in these areas.

2.3 Material Types

Below is a summary of the geotechnical material types to be used in the construction of the coastal mitigation features outlined above. Samples of the imported Type 1 and 3 fill materials should be provided to Thurber for laboratory sieve and Proctor testing prior to being imported to site. It is noted that gradations for the Type 5 (riprap) and Type 6 (cobble) fill materials are not included as we understand that NHC will specify the gradations for these materials. Additionally, we assume that NHC will be responsible for determining the requirement for, and specifying the gradations of, any filter layers below Type 1, Type 3 and Type 5 and Type 6 fill materials.

2.3.1 Type 1 (General Fill)

Type 1 material will be used in the construction of the ETIF at WAF 1 and 2 tie-in to Cowichan Bay Road. We recommend that if Type 1 fill does not come from the Dike 49 deconstruction, that the alternative product generally conform to Dike Fill with the following gradation limits with less than 15% fines.

TABLE 1
Type 1 Fill – Gradation Limits

Sieve Designation (mm)	Percent Passing
150	100
100	70 to 100
25	55 to 90
4.75	40 to 70
0.075	<15

2.3.2 Type 2 (Inorganic Silts)

Type 2 fill soils excavated from marsh channels in Dinsdale Field will be finer graded with a higher silt content and will be moisture sensitive. This material is to be used mainly to construct the WAFs and will be variable in consistency.

2.3.3 Type 3 (Pipe Haunch)

Type 3 material will be used as pipe surround. Type 3 fill should conform to MMCD Type 1 Granular Pipe Bedding and Surround Material. The following gradation (Drawing Sheet No. 002) was provided by NHC:

TABLE 2
Type 3 Pipe Haunch – Gradation Limits

Sieve Designation (mm)	Percent Passing
25	100
19	90 to 100
12.5	65 to 85
9.5	50 to 75
4.75	25 to 50
2.36	10 to 35
1.18	6 to 26
0.6	3 to 17
0.075	0 to 5

2.3.4 Granular Filter

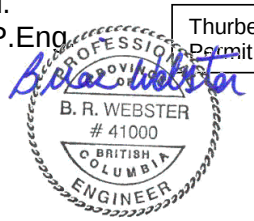
In areas where the ETIF and outlet swale will be constructed, we recommend that if a non-woven geotextile fabric is not used that NHC design a suitable granular filter for use as a separator between Type 1 and Type 2 fills and the base consisting of marsh sediments to help with material placement and compaction and to reduce potential for erosion and settlement.

3. CLOSURE

We trust this information meets your present needs. If you have any questions, please contact us at your convenience.

Yours truly,
Thurber Engineering Ltd.
Jay McIntyre, M.A.Sc., P.Eng.
Review Engineer

Thurber Engineering Ltd.
Permit to Practice #1001319



2025-02-13

Brian Webster, B.Eng., P.Eng.
Geotechnical Engineer

Attachments:

- Statement of Limitations and Conditions

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

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The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.