Hopkins Landing Renovation Project

Construction & Environmental Management Plan

Prepared for

Sunshine Coast Regional District
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Prepared by

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1 Introduction

The Hopkins Landing Port Facility (the Wharf) is a timber dock structure constructed in the 1920s located in Hopkins Landing, BC, a named community in Area F of the Sunshine Coast Regional District (SCRD). The structure is a timber wharf structure situated in Howe Sound (an extension of the Strait of Georgia) that extends approximately 140 m into tidal waters; including a ramp to a dropped float structure (not currently in place).

The original use for the structure was a residential, commercial, and industrial wharf that serviced the once independent community of Hopkins Landing. Since its construction, the Sunshine Coast has been interconnected with a public ferry service, roads, and other infrastructure, reducing the key services for the Wharf to boat-to-land access, public assembly, leisure, and tourism. In recent years, the Wharf has been reviewed by the SCRD and found to be of insufficient structural integrity to maintain access. The Wharf was closed to public access in 2023 following this review and has remained closed until repair work could be completed.

The Hopkins Landing Renovation Project aims to restore the facility so that it can be reopened to the public. Boundary Consulting Services Ltd. (BCS) was retained by the SCRD be the engineer of record and to complete design, specifications, permitting, tendering services, contract administration, construction management services, and post-construction closeout, including completion of record drawings for the major structural repairs and upgrades to the Wharf.

1.1 Purpose of this Document

BCS presents the following Construction and Environmental Management Plan (CEMP) to promote construction activities that are organized, efficient, safe, and responsible. There are five plans that make up this CEMP:

- Construction Management Plan
- Environmental Control Plan
- Waste Management Plan
- Traffic Control Plan
- Emergency / Safety Plan

This document has been prepared for the SCRD with the understanding that it will be provided to the Contractors performing the repair and to the regulators associated with environmental review of foreshore and nearshore work (BC Ministry of Environment and the Federal Department of Fisheries and Oceans, respectively). This document will also be incorporated into the tender documents for quotation of the work itself.

2 Project Description

The Project focuses on replacing deteriorated, damaged, or otherwise compromised components of the Hopkins Landing Port facility, as detailed in the design documents included in Appendix A.

A public consultation open house for this project took place in the Gibsons & Area Community Centre on May 1st, 2024, where BCS and the SCRD presented three concepts for consideration. The

results of consultation indicated that the community desires to maintain the structure in its current layout.

The Project will be conducted at the Hopkins Landing Port facility, shown in Figure 1.

Figure 1 - General Location Map

A computer rendering of the wharf is shown below in Figure 2.

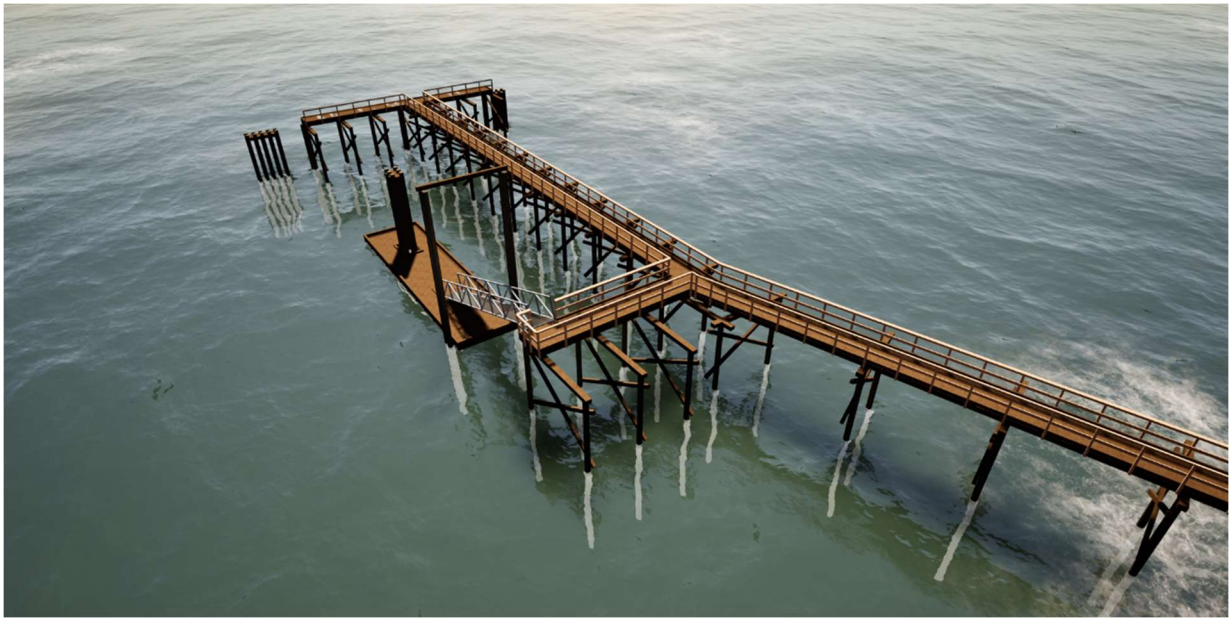

Figure 2 - Computer render of the wharf.

2.1 Key Activities

The repair activities on site will generally follow the following key activities:

- **Barge Mobilization/Demobilization/Spudding:** Transportation of materials to site, spudding of a barge in the nearshore in the project area, and reversal on completion of the Project.
- **Removal of Decommissioned Components:** Full removal and disposal of non replacement decommissioned components (such as unused fender dolphins), as itemized in Appendix A.
- **Replacement Compromised Components:** Removal and disposal of worn or damaged wharf components, as itemized in Appendix A, and replacement of those components with new structural components.
- **Float Installation:** Placement and connection of the landing float to the primary structure, and connection of the ramp to the float.

2.2 Environmental Considerations

This project can potentially have environmental impacts that need to be addressed formally in the direction and completion of the work before, during, and after the project. This includes physical habitat displacement, water quality impacts, noise and vibration impacts, sediment bed impacts, and the potential introduction of invasive species. These environmental considerations will be addressed in the environmental control plan later in Section 4 of this document.

2.3 Waste Management Considerations

The project will produce special hazardous waste (creosote timber, specifically) that has specific requirements for handling and disposal. These waste disposal considerations will be addressed in Section 5 of this document.

2.4 Traffic and Access Considerations

The project needs to be completed in a manner that does not cause significant disturbances to the nearby residents and users of the area. Increased traffic and parking requirements for the project need to be managed in a safe, clear, and coordinated manner. These traffic and access considerations will be addressed in Section 6 of this document.

2.5 Safety Considerations

This project involves several safety hazards that need to be managed to ensure the well-being of all personnel involved. This includes the introduction of both new potential hazards to the nearby public, and the introduction of new workers engaged in complex work to the existing structure. This spans everything from tripping hazards, drowning hazards, falling hazards, noise hazards, marine traffic hazards, chemical hazards, fire hazards, weather hazards, and general emergency preparedness. These safety considerations will be addressed in Section 7 of this document.

3 Construction Management Plan

This Construction Management Plan outlines the framework for managing the construction phase of the Hopkins Landing Renovation Project, ensuring efficient execution, adherence to specifications, environmental protection, and a safe working environment.

3.1 Roles and Responsibilities

- Sunshine Coast Regional District (SCRD)
  - Project owner, tenure owner, and paying client.
  - Responsible for awarding the construction contract based on the bid process.
  - Provides overall project direction and approves major changes.
- Boundary Consulting Services Ltd. (BCS)
  - Engineer of record and lead consultant.
  - Contract administrator.
  - Prepared bidding documents including Issued for Construction (IFC) drawings, specifications, and contract documents.
  - Evaluates bids in conjunction with the SCRD.
  - Conducts regular site inspections to perform quality assurance (QA) checks.
  - Owner's representative onsite regarding cost and schedule items.
  - Prepares record drawings and final sign-off upon project completion.
  - Responds to inquiries during tendering.
  - Prepare for and conducts monthly progress meetings and reports
  - Review and prepare monthly pay estimates
- Contractor:
  - Party awarded the construction contract through the bidding process.
  - Responsible for executing all construction activities in accordance with the contract documents, including the IFC drawings, this CEMP, and all applicable codes and regulations.
  - Safety is the responsibility of the Contractor.
  - Provides all labour, materials, equipment, and supervision necessary for the work.
  - Conducts regular quality control (QC) checks.
  - Implements safety measures and environmental controls.
  - Maintains daily logs and records of work performed.

3.2 Key Project Contacts

Organization	Name	Role	Phone Number
SCRD	Jesse Waldorf	Capital Projects Manager	TBD
BCS	Micah Smith	Project Manager & EOR	TBD
TBD	TBD	Contractor's Project Manager	TBD

3.3 Bid Process

- BCS is providing technical and administrative support to the SCRD for this project.
- BCS is responsible for the preparation of the bid package, including:
    - Issued for tender documents.
    - Confirm contract documents
    - Detailed specifications.
    - Bill of Quantities (BOQ) for pricing.
    - General Supplementary Conditions of Contract.
- SCRD is responsible for selecting form of bid and bringing the project to bid.
- Contractors will submit their bids in accordance with the bid package.
- BCS and the SCRD will jointly review bids, evaluate, and approve a Contractor accordingly.
- The SCRD awards the bid to the preferred Contractor.

3.4 Summary of Work

When construction materials arrive on site BCS will be provided access to inspect the materials to verify dimensions, wood treatment and quality.

The works to be constructed for this project generally include, but is not limited to, the following (measurements are provided in mm and distances are from beginning of the structure at the shoreline, see drawing for more details):

Handrail Work

- **Handrail Posts:** Remove and replace six handrail posts. Each post is to be secured to the structure with two 19mmØ bolts complete with nut and washer as shown in the drawings. The posts to be replaced are located:
    - Along gridline E at 37.2m, 110.3m and at bent 27; and,
    - Along gridline D at 37.2m, 107.9m, and 119.8m.
- **Handrail Mid-rails:** Remove and replace four sections of mid-rails. Each mid-rail is to be secured to the structure with hot-dipped galvanized nails in the layout shown in the drawings. The mid-rails to be replaced are located:
    - Along gridline E at 43.6m, between bents 8.5 to 10, and between bents 11.3 to 12; and,
    - Along gridline D at 107.9m.
- **Handrail Top-rails:** Remove and replace two sections of top-rails. Each top-rail is to be secured to the structure with hot-dipped galvanized nails in the layout shown in the drawings. The top-rails to be replaced are located:
    - Along gridline D at 100.6m and 107.9m.
- **Handrails:** Remove and replace three sections of handrails. Each handrail is to be secured to the structure with hot-dipped galvanized nails in the configuration shown in the drawings. The handrails to be replaced are located:
    - Along gridline D at 107.9m;
    - Along gridline E at 132.0m; and,
    - Along bent 27 from gridline A to D and E to G.

Guardrail Work

- **Guardrails:** Remove and replace 15 sections of guardrails. Each guardrail is to be secured to the structure with 19mmØ bolts complete with nut and washer as shown in the drawings. Each guardrail to receive at least four bolts. Bolts are to be installed through pre-drilled holes through the guardrail, guardrail riser, decking, stringer and pile cap (if present below). The guardrails to be replaced are located:
  - Along gridline D at 2.4 m, 7.9 m, 31.1 m, 37.2 m, and 59.4 m;
  - Along gridline E at 10.7 m, 25.6 m, 37.2 m, 47.5 m, 132 m, 138.4 m, bent 24,and bent 26; and
  - At bents 16 and 17 along gridlines A, B and C.
- **Guardrail Risers:** Remove existing guardrails above missing risers. Remove and/or replace approximately 14 risers. To be secured to the structure as described above, between the guardrail and decking. The guardrails to be replaced are located:
  - At bent 26E; and
  - At bents 16 and 17 along gridlines A, B and C.

Stringer Work

- Replacement of missing stringer splice connection between bents 1 and 2.

Pile Cap Work

- **Pile Cap Connection:** Ensure pile cap is connected to the pile with a drift pin, metal strapping or through bolt at bent 12 gridline D and E.
- **Pile Cap:** Remove and replace pile cap at bent 1 and reestablish connections to piles.

Bearing Pile Work

- **Bearing Piles:** Remove and replace 23 bearing piles. Each pile to be replaced must be pulled from the substrate prior to being replaced. If corbels are present, remove and do not replace the corbel. Connections to pile caps and cross braces must be reestablished as shown in the drawings. Bearing piles to be made of creosote treated timber with a minimum diameter of 305mm (Ensure the BC Ministry of Transportation and Infrastructure's "*Guide for Use of Treated Wood In and Around Aquatic Environments and Disposal of Treated Wood*" is adhered to). Removal of piles should be done in a manner that minimizes disturbance of the substrate and contaminated sediments. If removal is unsuccessful, the pile should be cut at the lowest practicable extent possible. The bearing piles to be replaced are located:
  - Along gridline D at bents 6, 13, 14, 15, 16, 17, 20, and 22;
  - Along gridline E at bents 5, 10, 12, 16, 18, 19, 20, 22, 23, and 24;
  - At bent 27 along gridlines B, F and G; and,
  - At bent 28 along gridline A.
- **Bearing Pile Strapping:** Place stainless steel strapping around the following bearing piles:
  - Along gridline D at bents 12; and,
  - Along gridline E at bents 6, 9, 13, 14, 15 and 17.
- **Bearing Pile patches:** Plug and patch holes using PileMedic by QuakeWrap or approved alternative in bearing piles at the following locations:
  - Along gridline E at bents 7 and 8.

- **Removal of Abandoned Piles:** Remove abandoned piles at the following locations:
    - Along gridline D at bent 5; and,
    - Along gridline E at bents 4, 3 and south of 10.
- **Repair connections:** Repair connection between piles and pile caps at the following locations:
    - Along gridline E at bents 8, 9 and 14.

Cross-Brace Work

- **Repair connections:** Reestablish a connection between the bearing pile and cross braces at the following locations:
    - Along gridline D at bents 3, 5, and 18; and,
    - Along gridline E at bent 24.
- **Replace cross braces:** Remove and replace cross braces and hardware at the following locations:
    - Along gridline D at bent 20; and,
    - Along gridline E at bent 5.
- Cross Brace strapping: Install stainless steel strapping on cross braces at the following locations:
    - Along gridline D at bent 6; and,
    - Along gridline E at bents 8, 9 and 14.
- Cross Brace hardware: Remove and reinstall hardware for cross brace at 8E.

Safety Work

- Relocating the ladder's top grab rail to the top of the guardrail between bents 28C and 28D.
- Provide ladder signage on both seaward and shoreward faces of the guard at the ladder location between bents 28C and 28D.
- Provide signage indicating dolphins are not to be climbed on.

Gangway Work

- Replacement of two sections of grating
- Reinstallation of gangway which has been removed including the provision of chain guarding to posts.

Float Work

- Replacement of the float's floatation components.
- Reinstallation of float including reconstructing elements around the mooring well.

Electrical Work

- Replace the support connection for the light pole on bent 18 D (strapped to a concrete pile).
- The reestablish electrical connections to the two light posts on bents 3D and 18D conforming to NFPA 303.

3.5 Work Requirements

- **Existing Conditions**
  - Ensure that all elements damaged during construction are repaired or replaced to match the pre-construction conditions, including materials, finishes, and functionality.
- **Demolition**
  - Ensure demolition activities adhere to the waste management plan.
- **Metals**
  - Steel strapping to be made of stainless steel.
  - All bolts shall be minimum 19mm (0.75") diameter, unless noted otherwise.
  - Washers to be provided at both nut and head, unless noted otherwise. Plate washers shall be 76x6 (Dia mm x T mm).
  - Welded Connections shall be made by CWB qualified welders.
  - Hot-dip galvanize all miscellaneous metals and fasteners in accordance with CSA G164 unless noted otherwise. Minimum thickness of zinc to be 0.11mm unless noted otherwise.
  - At completion of installation, touch up connections, welds and burned or damaged surfaces with approved compatible zinc-rich primer.
- **Wood, Plastics and Composite**
  - Ensure all timber work is plumb, square and true in accordance with the design and confirmed by BCS.
  - All sawn lumber shall be properly air-dried and seasoned, containing not more than 20% moisture.
  - All timber piles shall be unused, clean peeled, uniformly tapered, one piece from butt to tip. Checks shall be limited to 100mm (4 inches) in length and 1.5mm (1/16th inch) in width.
  - All timber at or above deck level such as deck planks, guardrails, handrails or posts shall be pressure-treated. All timber below deck level, except rub boards, shall be creosote treated.
  - All timbers to be treated to Canadian Institute of Treated Wood's Best Management Practices for use of wood in aquatic environments.
  - All bolts to be placed in pre-drilled holes. Not to exceed 1/16" or 1.5mm larger than bolt diameter without approval of Engineer of Record (BCS).
  - End distance (parallel to grain): Minimum 12 times the bolt diameter.
  - Edge distance (perpendicular to grain): Minimum 1.5 times the bolt diameter.
- Nails and screws
  - End distance (parallel to grain): Minimum 10 times the diameter of the nail or screw.
  - Edge distance (perpendicular to grain): Minimum five times the diameter of the nail or screw.
  - Treated Timber that will be in contact with seawater shall be allowed to air-dry for 45 days prior to contact with seawater.
    - Creosote-treated materials:
      - All creosote treated materials to be treated in accordance with CSA Standard 080 to a net retention of 320 kg/m3.
      - Cut pile tops shall be treated with 2 coats of creosote, mastic and aluminium caps.

        - Pressure-treated materials:
            - All timber above the deck level must be pressure treated.
            - All pressure-treated members that are modified (cut or drilled) shall be field treated with two coats of copper naphthenate or pentachlorophenol. When field treating by brushing, spraying, dipping or soaking do so in such a manner that the preservative does not drip into the water or ground.

- **Finishes**
    - Nails for timber greater than 51mm shall be galvanized ardox nails and for timber less than 51mm to be stainless steel annular ring nails conforming to CSA-B111. Bots, nuts and washers through timber shall conform to ASTM A307.
    - Drift pins shall conform to CSA G40.21 Grade 260W.
    - All spikes, nails and staples to conform to CSA B111.
    - All lag screws to conform to CSA B34.
    - Unless noted otherwise, use plate washers under heads and nuts of all bolts bearing on timber; plate washers against piles shall be curved.
- **Pile installation**
    - For all piling work, Contractor to comply with the "Best Management Practices for Pile Driving and Related Operations – BC Marine and Pile Driving Contractors Associated – March, 2003".
    - The pile must be driven until an allowable bearing capacity of 220 kN is achieved. BCS will provide the required blow count to the Contractor based on the Contractor's equipment. The Contractor is responsible for maintaining a record of each pile installation, which should include:
        - the original length of the pile,
        - the exposed length after driving (before cutting to the correct height),
        - and the number of blows the pile received.
    - BCS will observe the first day of driving work and will conduct spot checks on subsequent days based on the observed quality.
    - Submit details of proposed pile driving equipment, methods and schedules to BCS for review a minimum of ten days prior to mobilization of pile driving equipment. Provide copies od driving records with survey data to check vertical alignment.
    - Take all necessary precautions, including the provision of suitable screening fences or barriers to protect the public, existing structures, facilities, and services from damage due to the pile installation and associated works.
    - Ensure the leads of the pile driving equipment do not exert lateral forces on the piles during driving. No adjustment of a possible misalignment will be permitted during driving, except at the very initial stages.
    - Installation of each pile will be subject to the approval of BCS.
    - Do not remove the pile installation equipment rig from the site until the BCS has approved the installation of all piles.

3.6 Construction Schedule

- The contract duration will be for approximately six months.
- The detailed construction schedule will be developed by the Contractor upon award of the contract and submitted to BCS for review and approval.

- The schedule will identify key milestones, critical path activities, and long lead items. It will include expected task durations and include closeout activities.
- BCS (as the owner's agent) and the Contractor will hold regular progress meetings to monitor adherence to the schedule and address any delays or conflicts. The progress meetings will occur monthly, at a minimum.

3.7 Quality Assurance and Quality Control

Quality Assurance and Quality Control activities are covered in Section 9 of this document.

3.8 Safety

- There is an emergency/safety plan in Section 7 of this document.
- The Contractor is responsible to provide supplementary safety plans to address their specific equipment and processes as required by WorkSafeBC regulations and is required to have them posed and accessible at the construction site.
- An initial hazard assessment will be required by the Contractor covering the site and the integration of the Contractor's safety standards and guidelines into site specific requirements.

4 Construction Environmental Control Plan (CECP)

The SCRD is committed to conducting its operations in a safe and environmentally responsible manner. The potential environmental impacts that could results from project activities can be mitigated by following environmental standards, guidelines and Best Management Practices (BMPs). The Contractor is required to develop the CECP. The following sections provide mitigation measures and stand best practices relevant to this project. The CECP is required to contain the components in the following subsections. Additionally, the Contractor is required to have a qualified environmental professional (QEP) sign-off on the developed CECP to ensure that best practices and guidelines are adhered to (See Appendix D), namely:

- Guidelines to Protect Fish and Fish Habitat from Treated wood used in Aquatic Environments in the Pacific Region. Habitat and Enhancement Branch of Fisheries and Oceans Canada, 2000.
- Best Management Practices for Pile Driving and Related Operations – BC Marine and Pile Driving Contractors Association, March 2003.
- British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture.

4.1 General Practices

- The Contractor must complete daily safety and environmental tailgate meetings to identify and communicate changes to risk related hazards to BCS; discuss project status and daily working procedures.
- The Contractor must confirm all subcontractors, and their site managers review this CECP and the applicable guidelines.
- The Contractor must confirm all subcontractors understand BMPs and know how to properly install any protection measures recommended on the project.

- The Contractor must be prepared to change existing measures and BMPs should they fail, or additional measures be required. BCS must be notified of any changes to ensure they are adequate.
- The Contractor will review work procedures with their staff and enforce compliance throughout the project. Up-to-date copies of this CECP will be kept on the project site, where they must remain available to workers and visitors.
- Any damage to the existing structure shall be the liability of the Contractor.

4.2 Marine Works

The following is recommended to avoid or minimize the potential impacts to fish and fish habitat that may result from in-water construction activities:

- All project personnel shall avoid activities that may, directly or indirectly:
    - deposit deleterious substances of any type in water frequented by fish, in a manner contrary to Section 36(3) of the Fisheries Act; or
    - adversely affect fish or fish habitat in a manner contrary to Section 35(1) of the Fisheries Act.
- Unless otherwise approved in writing by BCS, all construction activities occurring below the high-water mark (HWM) that may impact fish or fish habitat should be scheduled during the fisheries work window of least risk: August 16, 2024 to January 31, 2025.
- Equipment (e.g., heavy machinery) used in and around water will be kept clean and in good working condition (i.e., free of leaks, excess oil, and grease).
- Where possible, any hydraulic machinery used in water should use environmentally friendly hydraulic fluids (i.e., non-toxic to aquatic life, and biodegradable).
- All materials to be used in and around water, should be certified clean (i.e. they will not present any risk of leaching contaminants or affecting water/sediment chemistry).
- Measures should be taken to provide 100% containment of all potentially deleterious materials including: fuel/ oil/ grease, chlorinated water, paint chips, cleaning products, coatings, or any other potentially deleterious materials.
- Barges or other vessels will not ground on the foreshore or seabed, or otherwise disturb the foreshore or seabed (including disturbance as a result of vessel propeller wash), with the exception of such disturbance as is reasonably required resulting from the use of barge spuds.
- No equipment will operate on the intertidal foreshore and/or disturb the seabed outside the project site.
- Appropriate measures must be implemented to prevent sediment, sediment-laden waters, or other deleterious substances entering the water during the project.
- All physical activities should be carried out in a manner that prevents induced sedimentation of foreshore and near shore areas, and induced turbidity of local waters. Water quality should be managed in compliance with the British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture, November 2023.
- Work shall immediately cease, and the BCS and the SCRD be notified, should there be reasonable grounds to believe that the project has harmed fish or fish habitat, including observation of distressed, injured, or dead fish or marine mammals. The work shall not resume until authorized by BCS.
- Vegetable oil shall be used instead of hydraulic oil for all working machinery.

4.3 Pile Removal and Placement

- Prior to the commencement of any work, BCS will complete and forward a "Notice of Project" to the Department of Fisheries and Oceans (DFO).
- Should pile removal/driving occur during closure periods (as described in section above), there will be no restriction of work (the only exception being when spawning is present) provided the Contractors employ an exclusion device (i.e., protective netting or geotextile material suspended in the water column around pile driving area) around the work area to prevent fish access or when required, an effective method of mitigating shock waves (e.g., bubble curtain) (BC Marine and Pile Driving Contractors Association, 2003).
- All applicable BMPs suggested in the Best Management Practices for Pile Driving and Related Operations (BC Marine and Pile Driving Contractors Association, 2003) should be implemented during pile removal/ driving works to maximize environmental protection and avoid contravention to the Fisheries Act.
- Pile removal and pile driving works should not be conducted during unfavourable conditions (e.g., periods of high winds and/or rough waters).
- Piles should be removed by vibratory extraction (preferred method) or direct pull. Piles should be removed slowly to minimize turbidity in the water column, as well as sediment disturbance. Crane operator shall be experienced in pile removal.
- A floating surface boom should be installed, prior to creosote-treated pile removal, to capture floating surface debris. The floating boom should be equipped with absorbent pads to contain any oil sheens.
- Pulled piles shall be immediately placed in a containment basin to capture any adhering sediment.
- Piles removed from the water shall be transferred to the containment basin without leaving the boomed area to prevent creosote from dripping outside of the boom.
- Piles should be removed completely by extracting the entire length of pile from the seabed. If physical conditions result in the breakage of timber piles, the remaining pile stubs should be removed with the least amount of disturbance of the seabed as possible. Particular effort shall be made to extract or reduce the height of pile stubs, which may pose a hazard to navigation. If pile stubs are left in place, the location shall be surveyed, and the coordinates provided to BCS within five calendar days of project completion.
- Removed creosote piles, and any associated waste materials (e.g., sediment, absorbent pads/boom, etc.) will be disposed of at an approved hazardous waste landfill. Creosote piles shall not be re-used. Contractors shall provide and track via chain of custody paperwork for all hazardous waste removal.
- During pile removal and pile driving, in situ water quality should be monitored in accordance with the BC Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. If necessary, floating silt/debris curtains should be deployed around the work area to minimize mobilization of potentially contaminated sediment and to further reduce turbidity to adjacent areas.
- Piles shall be driven with a vibratory or drop hammer. Piles shall not be installed using a diesel or hydraulic hammer or other technology such as drilling without review and authorization by BCS.
- Sediments contained within piles after driving shall be left in place. If it is determined that they must be removed for engineering reasons, BCS will be consulted for review and authorization prior to initiating the proposed physical activities.

- Because of the small diameter of the piles to be driven, it is assumed that the energy required to drive the pile to the final point of installation will not result in shock waves more than 30 kPa, therefore, protective measures to reduce shock waves are not expected to be required (BC Marine and Pile Driving Contractors Association, 2003).
- If distressed, injured or dead fish or marine mammals are observed following the initiation of pile driving, work will be halted immediately and measures to reduce the sound pressure waves will be implemented before the work is resumed. Appropriate mitigating measures would include the deployment a bubble curtain over the full length of the wetted pile. This technique should reduce the shock waves to an acceptable level (BC Marine and Pile Driving Contractors Association, 2003).
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately, and the methods will be reviewed and corrected.
- Visual monitoring for marine mammals should be maintained by the Contractor during pile removal/driving and when operating work vessels to avoid potential disturbance/ injury to marine mammals in the project area.

4.4 Spill Response

Spill kits and containment booms must be on-site in case of spills. The following procedures should be implemented if a spill occurs:

- Assess safety – ensure unnecessary people are kept clear of the area and that people with proper training and equipment deal with the spill. Put on any required personal protective equipment and consult MSDS.
- Stop the source – if required, and when it is safe to do so, stop the spill at its source. This may simply be righting an overturned container or sealing a hole.
- Contain and control the spill – the spill should be prevented from entering the water. If the spill occurs on water, booms should be immediately deployed to prevent its spread.
- Clean up the spill – utilize appropriate absorbent pads or other materials based on the type of substance spilled. The method of disposing of the waste is dependent on the amount and type of deleterious substance that was spilled.
- Notify appropriate authority – spills must be reported in accordance with the Spill Reporting document in Appendix D. Additionally, all spills should be reported to BCS.
- Record the incident – make a note of what, how and where the incident happened as well as what was done to clean it up. Depending on the spill, further assessment of the impact to land and water and/or additional cleanup may be required.

4.5 Air Quality Management

The following are recommended to avoid or minimize impacts to air quality:

- All equipment, vehicles and stationary emission sources will be well-maintained and used at optimal loads to minimize emissions.
- Stationary emission sources (e.g., portable diesel generators, compressors, etc.) will be used only as necessary and turned off when not in use.
- Equipment and vehicles will be turned off when not in active use.

- Any generators used must be “whisper quite” type.
- Vehicles or equipment producing excessive exhaust will be repaired or replaced prior to being used on the project.
- Dust-generating activities will be minimized as much as possible, especially during windy periods.
- Material loads entering or exiting the site will be covered as appropriate.
- No burning of oils, rubber, tires and any other material will take place at the site.

4.6 Noise and Vibration

The following are recommended to avoid or minimize potential project effects resulting from noise:

- Construction activities must adhere to SCRD Bylaw No. 597 which, in part, restricts potentially noise disrupting construction activity to 7:00 a.m. to 9:00 p.m. on any day that is not a holiday and between 9:00 a.m. and 6:00 p.m. on any holiday.
- All equipment will be properly maintained to limit noise emissions and fitted with functioning exhaust and muffler systems. Machinery covers, and equipment panels will be well fitted and remain in place to muffle noise. Bolts and fasteners will be tight to avoid rattling.
- Engines will be turned off when not in use or reduced to limited idle (or as appropriate to reduce air emissions).

4.7 Fuel Management

Fuel management best practices include:

- Fuel storage tanks/ containers will be clearly labelled, and their locations will be made know to all on-site personnel.
- Refueling equipment and tanks will be clean and in good working order. Fuel tanks will be situated within appropriate secondary containment (an impermeable containment facility capable of holding 110% of the storage tank contents). This may be achieved using double walled storage tanks or sit-in containers constructed out of impermeable material, such as aluminum or plastic.
- Where practical, all fuels, oils, lubricants and other petrochemical products will not be stored within 30 m of any waterbody.
- Where practical, equipment will not be fuelled within 30 m of a waterbody. If possible, one area will be designated for fuel transfer. Refueling will occur on a flat surface to minimize potential offsite runoff. A spill kit should be on-hand at the refueling site.
- Any fuel spilled will be immediately cleaned up and reported to BCS.

5 Waste Management Plan (WMP)

All materials resulting from demolition, and all products and materials brought to the construction site (e.g., fuels and lubricants and their empty containers, oily rags and used spill kit products, wood, cigarette butts, coffee cups, water bottles, etc.) must be adequately disposed of. A WMP must be generated by the Contractor and submitted to BCS for review no later than ten days prior to construction commencement. The following items are required to be addressed within the WMP:

- Contractors are expected to adhere to all applicable legislation with respect to the handling, transportation, and/or disposal of all materials related to this project (waste or otherwise). These regulations may include (but not be limited to) the BC Hazardous Waste Regulations, the Environmental Management Act, Spill Reporting Regulations, Workers Compensation Board Regulations, Transportation of Dangerous Goods Regulations, etc.
- Contractor is required to use Hazardous Waste Manifests for transportation of any hazardous material such as pressure treated timber.
- Contractors will provide labelled separate container(s) for potentially hazardous waste, such as oily rags and hydrocarbon absorbent pads. Hazardous wastes generated could include pressure treated timber, waste petroleum products (engine oils, lubricants) from machinery and equipment, spent batteries, solvents and cleaning agents, etc.
- All hydrocarbon products and other hazardous wastes potentially present during project activities will be identified and the associated Workplace Hazardous Materials Information System (WHMIS) and Material Safety Data Sheets (MSDS) made available to all construction team members.
- Removed creosote piles must be disposed of at a facility approved to accept hazardous waste.
- All recyclable or compostable materials will be collected separately from general waste. All project personnel will be made aware of this practice and of the associated disposal locations (i.e., on-site waste/recycle bins).
- The Contractor shall contain and collect debris and waste material in the immediate working area within the project site.
- The Contractor shall dispose of waste material at suitable locations and maintain records of off-site disposal through chain of custody documentation.
- Proof of waste disposal for all products not reused must be provided to BCS for record.
- The Contractor is responsible for repairing, replacing or reconstructing any part of the property or structure that is not explicitly marked for demolition and incurs damage during the work execution.
- The Contractor is required to submit all chain of custody documentation prior to project completion.

6 Traffic Control Plan

6.1 Traffic Flow Patterns

- Hopkins Road will be blocked off to local traffic at the intersection of Hopkins Road at Burns Road and Point Road (Point Road turns into Burns Road at Hopkins Road).
- The Contractor will provide appropriate signage to indicate the road closure, duration of closure and Contractor contact information.

- The closed section of Hopkins Road will allow for approximately six vehicle parking spaces and a turn around spot at the end of the road.
- No residences require this portion of Hopkins Road to access their dwellings.
- There is an alternative access point to the beach located approximately 600 m to the south along Point Road where some roadside parking is available.
- Contractor shall provide a traffic control plan to the SCRD and the BC Ministry of Transportation for approval in advance of road restrictions.
- All traffic control signs must conform to the Manual of Uniform Traffic Control Devices for Canada.
- All traffic signs are to be sheeted with high intensity prismatic sheeting.
- Sheeting by 3M or approved alternative.

6.2 Pedestrian Safety

- The public is to be excluded from the construction zone including the construction parking area situated at the end of Hopkins Road.
- The Contractor will provide adequate signage and barriers to ensure pedestrian safety.

6.3 Parking Restrictions

- Clear signage indicating parking restrictions and enforcement including tow away services.

6.4 Emergency Vehicle Access

- Ensure clear and unobstructed access for emergency vehicles at all times.
- Inform emergency medical services of any and all road restrictions.

7 Emergency / Safety Plan

BCS has completed a preliminary First Aid Assessment for this Project as described by the WorkSafeBC OHS Guidelines for Part 3: Occupational First Aid. The results of this assessment indicate that the minimum first aid requirements include the following:

- Advanced first aid kit.
- Basic first aid attendant (transport).
- Advanced first aid attendant.

The Contractor must conduct their own First Aid Assessment to confirm first aid requirements for this project. The Contractor should also note that new first aid requirements will come into effect November 1, 2024. The Contractor is responsible to ensure they are following the latest amendments to the Occupations Health and Safety Regulation.

7.1 Project Location

- Address: 160 Hopkins Road, Gibsons, BC
- Latitude / Longitude: 49.4283795, -123.4790828

7.2 Emergency Contact Information

Fire / Police / Ambulance	911
Canadian Coast Guard	VHF Ch 16 (156.8 MHz) Or *16 on a cellphone
Nearest hospital	Sechelt Hospital 5544 Sunshine Coast Hwy 604-885-2224
RCMP (non-emergency)	604-885-2266
Gibsons Fire Department (non-emergency)	604-885-6870

7.3 Emergency Response Procedures

- The Contractor must establish clear communication protocols for emergencies.
- The Contractor must develop evacuation plan for workers.
- The Contractor must provide first aid training for designated personnel.

7.4 Safety Training and Equipment

- The Contractor must conduct mandatory safety orientations for all workers.
- The Contractor must provide appropriate personal protective equipment (PPE) and ensure its use.
- The Contractor must regularly inspect work areas for potential hazards and address them promptly.
- The Contractor is responsible for their construction safety.
- The Contractor is designated as the Prime Contractor under the WCA of BC for the duration of the project until total completion is achieved.

7.5 Incident Reporting and Investigation

- The Contractor must establish a clear process for reporting accidents, injuries, and near misses.
- The Contractor must conduct thorough investigations to determine root causes and prevent recurrence.
- The Contractor must implement corrective actions based on investigation findings.
- The Contractor must retain safety records including documentation of safety orientations, and reports on accidents, injuries and near misses for the duration of the project.

8 Archeological Monitoring & Inadvertent Discovery Plan

The BC Heritage and Conservation Act stipulates that all archeological sites and objects are protected, whether they are known or discovered inadvertently. It is illegal to alter, damage or remove archeological sites or objects without a permit. An Archeological Monitoring & Inadvertent Discovery Plan needs to be created by the Contractor. The plan shall consider the following subsections.

8.1 Purpose and Scope

- Define the purpose of archeological monitoring during the project.
- Specify the areas of the project site where monitoring is required.
- Outline the scope of activities that will be covered by archeological monitoring.

8.2 Regulatory Framework

- Reference relevant federal, provincial, and local regulations and guidelines (e.g., British Columbia Heritage Conservation Act).
- Include any permits or approvals required for archeological monitoring.

8.3 Roles and Responsibilities

- **Contractor:** Overall responsibility for ensuring compliance with archeological monitoring requirements.
- **Archeologist:** A qualified professional responsible for on-site monitoring and reporting.
- **Construction Team:** Immediate reporting of any inadvertent discoveries to the Archeologist.
- **Regulatory Agencies:** Agencies to be notified in the event of a discovery.

8.4 Pre-Construction Planning

- SCRD to consult with local indigenous groups, discussing the requirement for an Archeological Impact Assessment.
- Develop an Archeological Monitoring & Inadvertent Discovery Plan (AMIDP) detailing monitoring strategies, areas of focus, and reporting procedures.
- Provide training for construction personnel on recognizing and protecting archeological resources.

8.5 Monitoring Procedures

- **On-Site Monitoring:**
  - In accordance with results of consultation with local indigenous groups.
- **Documentation:**
  - Maintain detailed records of monitoring activities, including dates, locations, and findings.
  - Use standardized forms and/or digital tools for documentation.

8.6 Inadvertent Discovery Protocol

- **Stop-Work Order:**
  - Immediately halt construction activities in the area of the discovery.
  - Establish a buffer zone around the discovery site.
- **Notification:**
  - Notify the Archeologist immediately.
  - Contact regulatory agencies as required (e.g., BC Archaeology Branch).
- **Assessment and Documentation:**
  - Conduct a preliminary assessment to determine the significance of the find.

    - Document the discovery with photographs, sketches, and detailed notes.
- **Consultation:**
    - Consult with regulatory agencies and Indigenous groups, if applicable, to determine appropriate actions.
- **Resumption of Work:**
    - Obtain clearance from the Archeologist and regulatory agencies before resuming construction in the affected area.

8.7 Reporting and Communication

- **Regular Reports:**
    - Provide regular reports to the project management team and regulatory agencies summarizing monitoring activities and findings.
- **Incident Reports:**
    - Submit detailed incident reports for any inadvertent discoveries, including actions taken and outcomes.
- **Stakeholder Communication:**
    - Maintain open communication with Indigenous groups and other stakeholders regarding archeological monitoring and discoveries.

9 Monitoring and Reporting

9.1 Submittals

The Contractor is required to provide the following submittals:

- Description of proposed driving equipment, a minimum of ten days prior to construction.
- Detailed construction schedule, a maximum of tendays after project commencement.
- A QC plan, a maximum of ten days after project commencement.
- A CECP with QEP signoff, a maximum of ten days after project commencement.
- An Evacuation plan, a minimum of ten days prior to construction.
- A Traffic Control Plan must be submitted, a minimum of ten days prior to construction.
- An Archeological Monitoring & Inadvertent Discovery Plan.
- A Wate Management Plan, a minimum of ten days prior to construction.

Submittals are to be provided to BCS is electronic format, over email with the subject line reflecting the project and submittal item.

9.2 Quality Assurance (QA)

BCS shall conduct QA checks to ensure QC measures are effective.

- Prior to the commencement of construction activities BCS shall review the Contractor QC processes to ensure effectiveness and adherence to project requirements.
- Upon arrival of construction materials, BCS will check samples to confirm correct dimensions, material and treatments.

- Weekly checks to ensure components are installed as per design drawings and as specified in this document. A short weekly report will summarize completed repair items which conform to the design and any items that are non-conforming along with the requirements to meet conformance.
- All items identified as non-conforming will require addressing requirements as specified in the weekly QA report, prior to approval of repair item.

9.3 Quality Control (QC)

The Contractor shall conduct regular QC checks to ensure quality standards and project specifications are met. The Contractor is responsible for developing a QC plan outlining inspection and testing procedures.

- Define QC processes and provide to BCS prior to construction activities. QC processes should include:
    - inspections and tests at various stages of construction to ensure compliance with specifications,
    - use of standardized testing methods,
    - detailed records of all inspections, tests, and quality-related activities,
    - regular reporting highlighting any issues requiring further discussion,
    - a mechanism to identify and document non-conformances, and
    - documentation of corrective actions.
- Shop drawings for fabricated elements such as electrical pole brackets to be supplied to BCS in electronic format prior to fabrication. BCS to approve shop drawing prior to fabrication.
- Material data sheets for all construction materials to be provided to BCS in electronic format prior to the commencement of construction.
- Certificates of compliance, such as timber treatment certificates, to be supplied to BCS in electronic format prior to the commencement of construction.
- Conduct a final quality review before project completion to ensure all work meets specified standards.
- Contractor to provide warranties:
    - General Warranty: The Contractor shall provide a warranty for a period of two years from the date of substantial completion, covering defects in workmanship and materials. The Contractor shall repair or replace any defective work at no additional cost.
    - Material Warranty: The Contractor shall provide copies of manufacturer's warranties for all materials used in the project, including treated timber and fasteners, detailing coverage periods.
    - Warranty Claim Process: The Owner shall notify the Contractor in writing of any defects or issues within the warranty period. The Contractor shall respond within ten business days and provide a resolution plan.

9.4 Project Closeout

When the project is nearing completion BSC shall work with the Contractor to ensure the following:

- All repair items must be completed to the satisfaction of BCS prior to the Contractor demobilizing.
- Contractor must supply documentation specifying the original length of pile, the exposed length of pile after driving (before cutting) and the number of blows the pile received. This list must be reviewed and approved by BCS prior to the Contractor demobilizing pile driving equipment.
- Demobilizing efforts must include site cleanup, ensuring the site is restored to a condition that is at least as good as, if not better than, its original state, to the satisfaction of BCS.
- Contractor must supply all completed chain of custody forms to BCS prior to project completion.
- Contractor to supply lien waivers upon receipt of final invoice.
- BCS shall provide as-built drawings to the SCRD upon project completion.
- BCS shall provide a final closeout document for the SCRD which shall include:
    - a summary of the project work,
    - as-built drawings,
    - all chain of custody documents,
    - warranty documentation from the Contractor, and
    - any manuals which may be provided by manufacturers.

10 References

BC Marine and Pile Driving Contractors Association. (2003, March). *Best Management Practices for Pile Driving and Related Operations*. Retrieved from https://projects.eao.gov.bc.ca/api/document/5887e34fad20ac134d916367/fetch

Fisheries and Oceans Canada (DFO). (2024, 06 20). *British Columbia Marine/Estuarine Timing Windows for the Protection of Fish and Fish Habitat - South Coast and Lower Fraser Areas*. Retrieved from Government of Canada: https://www.dfo-mpo.gc.ca/pnw-ppe/timing-periodes/bc-s-eng.html#area-28

Washington Department of Natural Resources. (2017, January 25). *Derelict Creosote Piling Removal Best Management Practices For Pile Removal & Disposal*. Retrieved from https://www.dnr.wa.gov/publications/aqr_rest_pileremoval_bmp_2017.pdf

Appendix A
Design Drawings

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SUNSHINE COAST REGIONAL DISTRICT

HOPKINS LANDING RENOVATION PROJECT

SHEET INDEX

ABBREVIATIONS:

CL. – CLEAR
C – CENTRELINE
CP. – COMPLETE PENETRATION
C/W – COMPLETE WITH
DWG. – DRAWING
EL. – ELEVATION
I.D. – INSIDE DIAMETER
LLH – LONG LEG HORIZONTAL
LLV – LONG LEG VERTICAL
MAX. – MAXIMUM
MIN. – MINIMUM
NTS – NOT TO SCALE
OPP. – OPPOSITE
PL – PLATE
R – RADIUS
SIM. – SIMILAR
S.S. – STAINLESS STEEL
T.O. – TOP OF
TYP. – TYPICAL
U/S – UNDERSIDE
WP – WORK POINT

CONTACT INFORMATION

ENGINEER: MICAH SMITH P.ENG – 604-671-6518 – BOUNDARY CONSULTING SERVICES Ltd.
ENGINEER: BEN SMALE P.ENG –604-671-6518 – BOUNDARY CONSULTING SERVICES Ltd.
RPBio: JASON BARSANTI – 778-908-9711 – BARSANTI ENVIRONMENTAL SERVICES Ltd.

SCRD PROJECT INFORMATION

PO 3005177

SITE LOCATION

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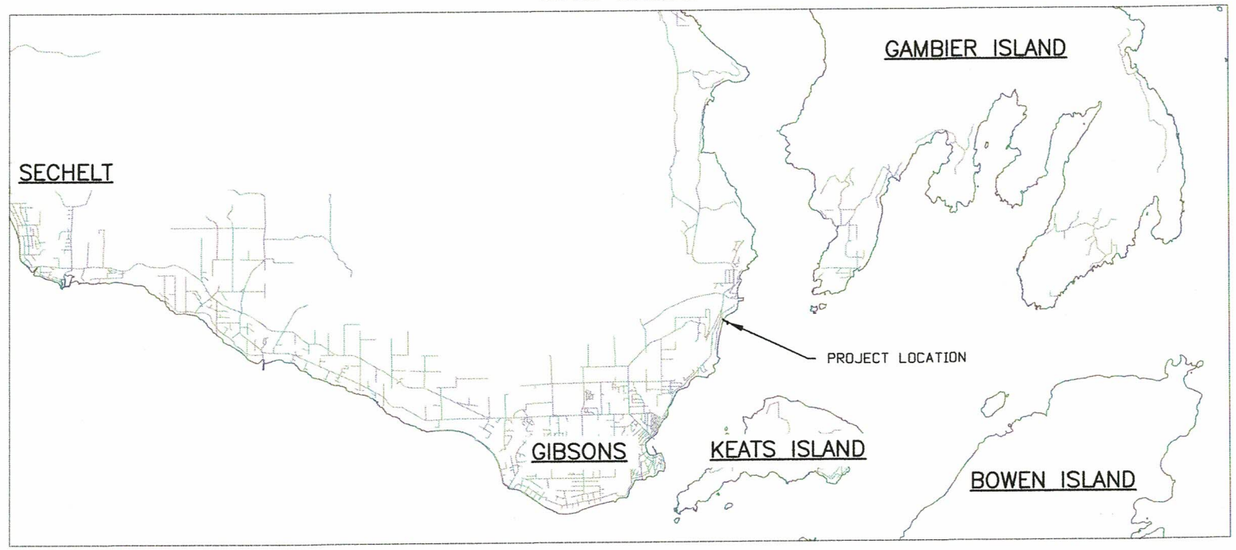

SITE PLAN

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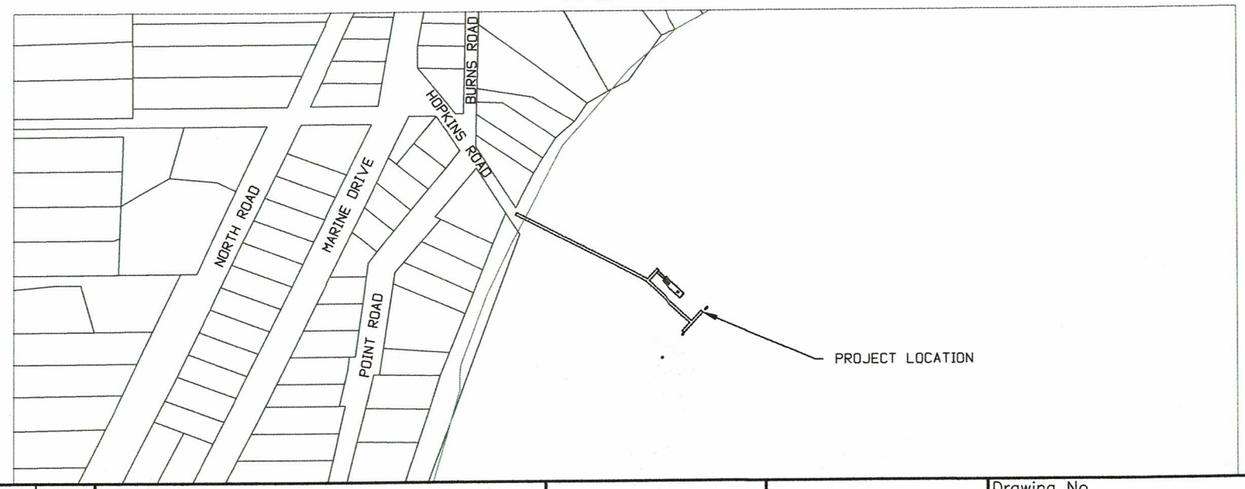

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PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
M. N. SMITH
44057
2024/10/09

No	Date	Revisions	By	Chk'd	App'd
1.3	2024/10/09	ISSUED FOR TENDER	MNS	BAS	BAS
1.2	2024/10/07	FOR CLIENT REVIEW	MNS	BAS	BAS
1.1	2024/09/18	FOR CLIENT REVIEW	MNS	BAS	BAS
1.0	2024/06/19	FOR CLIENT REVIEW	MNS	BAS	BAS

DRAWING IS IN UTM-NAD83 UNLESS DESCRIBED OTHERWISE

ORIGINAL SCALE ON 11"x17" OR ANSI B

BOUNDARY CONSULTING SERVICES PERMIT TO PRACTICE #: 1002593

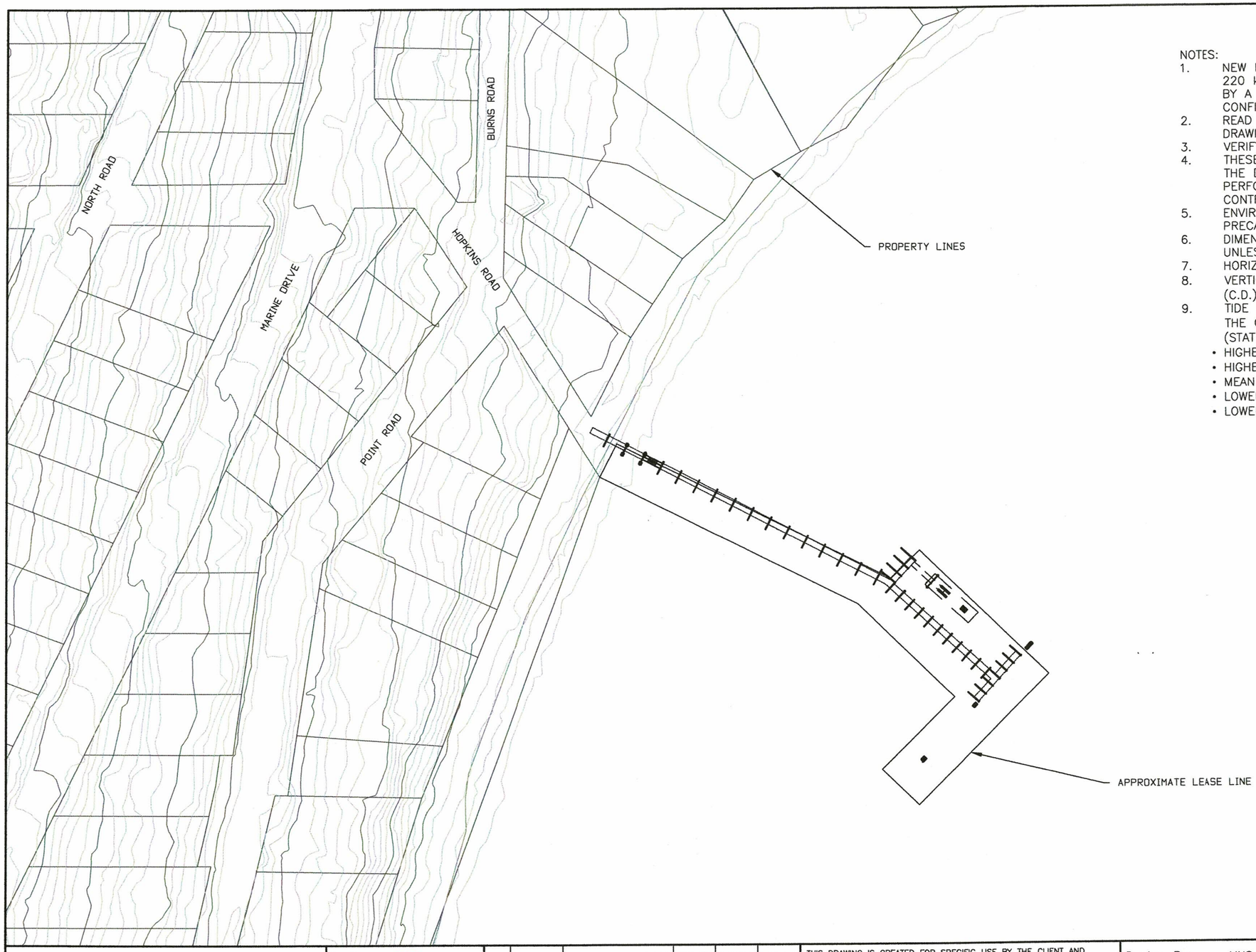
Design By:	MNS	Project:	BCS-0209
Drawn By:	MNS	Date:	2024-09-18
Checked By:	BAS	H. Scale:	AS SHOWN
Approved By:	BAS	V. Scale:	NTS

ALL DRAWING DIMENSIONS ARE IN MILLIMETERS UNLESS SHOWN OTHERWISE

Drawing No.
BCS-0209-01

Project
HOPKINS LANDING RENEWAL PROJECT

Drawing Title
GENERAL LOCATION



NOTES:

1. NEW PILES REQUIRE A MINIMUM ALLOWABLE BEARING CAPACITY OF 220 kN. CONTRACTOR TO PROVIDE A LETTER, SIGNED AND SEALED BY A PROFESSIONAL ENGINEER IN GOOD STANDING WITH EGBC, CONFIRMING THE BEARING CAPACITY AND SAFETY FACTOR.
2. READ DRAWING IN CONJUNCTION WITH ALL OTHER CONTRACT DRAWINGS AND DOCUMENTS.
3. VERIFY ALL DIMENSIONS AND ELEVATIONS PRIOR TO CONSTRUCTION.
4. THESE DRAWINGS SHOW COMPLETED STRUCTURAL COMPONENTS OF THE DOCK. THE REQUIRED TEMPORARY BRACING AND SHORING TO PERFORM THE WORK SAFELY IS THE RESPONSIBILITY OF THE CONTRACTOR.
5. ENVIRONMENTAL WORK PROCEDURES, TIMING AND SPECIAL PRECAUTIONS SHALL BE IN ACCORDANCE WITH THE PROJECT CEMP.
6. DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METRES, UNLESS OTHERWISE NOTED.
7. HORIZONTAL DATUM U.T.M. NAD 83.
8. VERTICAL DATUM (ELEVATIONS AND CONTOURS) TO CHART DATUM (C.D.)
9. TIDE ELEVATIONS AT THE SITE ARE BASED ON VALUES PUBLISHED BY THE CANADIAN HYDROGRAPHIC SERVICE (chs) FOR THE GIBSONS (STATION 07820) AS FOLLOWS:
   - HIGHER HIGH WATER, LARGE TIDE (H.H.W.L.T.) 5.1 METRES
   - HIGHER HIGH WATER, MEAN TIDE (H.H.W.M.T.) 4.6 METRES
   - MEAN WATER LEVEL (M.W.L.) 3.2 METRES
   - LOWER LOW WATER, MEAN TIDE (L.L.W.M.T.) 1.3 METRES
   - LOWER LOW WATER, LARGE TIDE (L.L.W.L.T.) 0.1 METRES

N

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44057
21 OCT 2024

No	Date	Revisions	By	Chk'd	App'd
1.3	2024/10/09	ISSUED FOR TENDER	MNS	BAS	BAS
1.2	2024/10/07	FOR CLIENT REVIEW	MNS	BAS	BAS
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1.0	2024/06/19	FOR CLIENT REVIEW	MNS	BAS	BAS

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Checked By:	BAS	H. Scale:	1:1250
Approved By:	BAS	V. Scale:	NTS

ALL DRAWING DIMENSIONS ARE IN MILLIMETERS UNLESS SHOWN OTHERWISE

Drawing No.
BCS-0209-02

Project
HOPKINS LANDING RENEWAL PROJECT

Drawing Title
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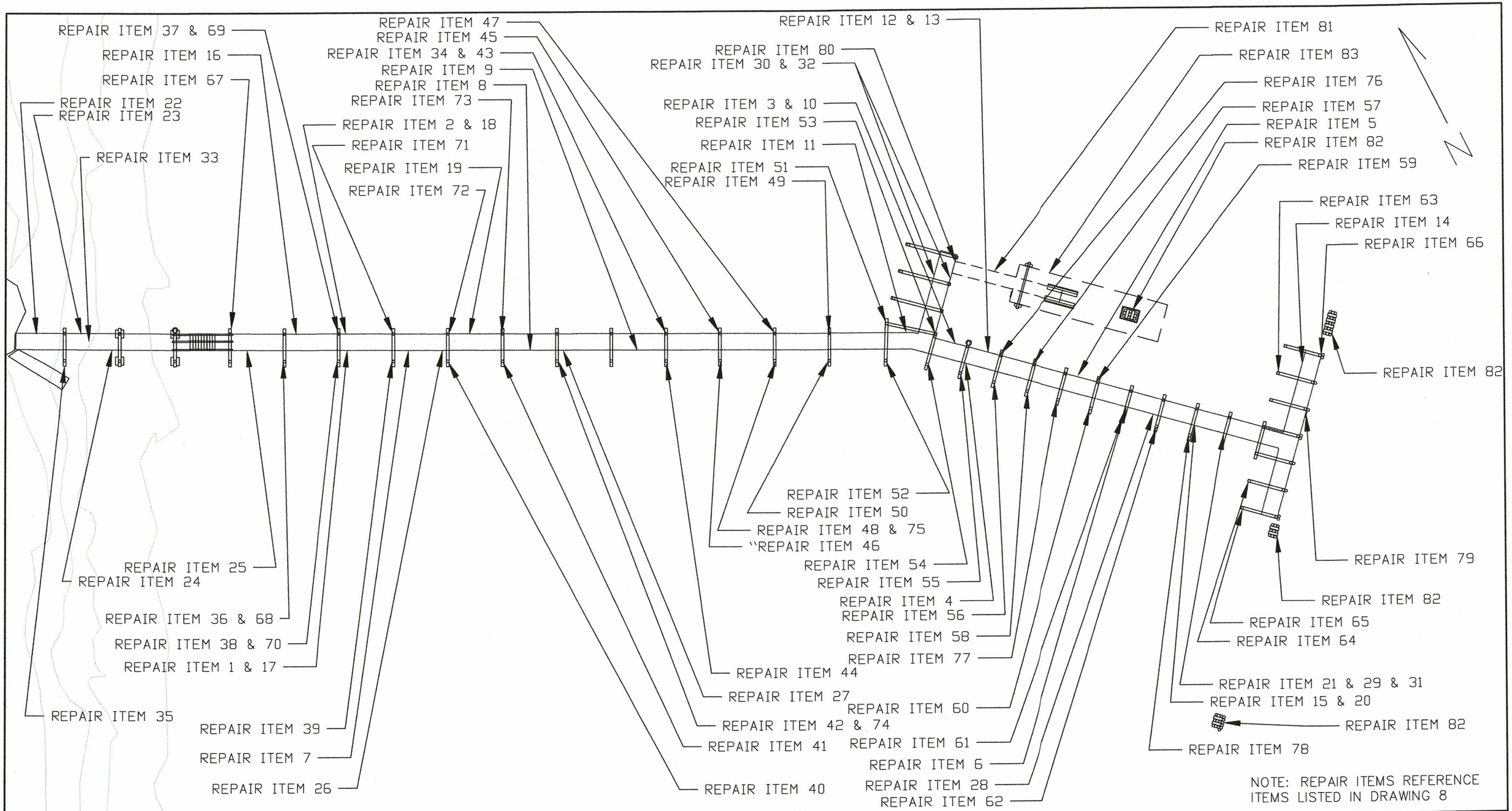

NOTE: REPAIR ITEMS REFERENCE ITEMS LISTED IN DRAWING 8

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1.1	2024/09/18	FOR CLIENT REVIEW	MNS	BAS	BAS
1.0	2024/06/19	FOR CLIENT REVIEW	MNS	BAS	BAS

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Approved By:	BAS	V. Scale:	NTS

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Project
HOPKINS LANDING RENEWAL PROJECT

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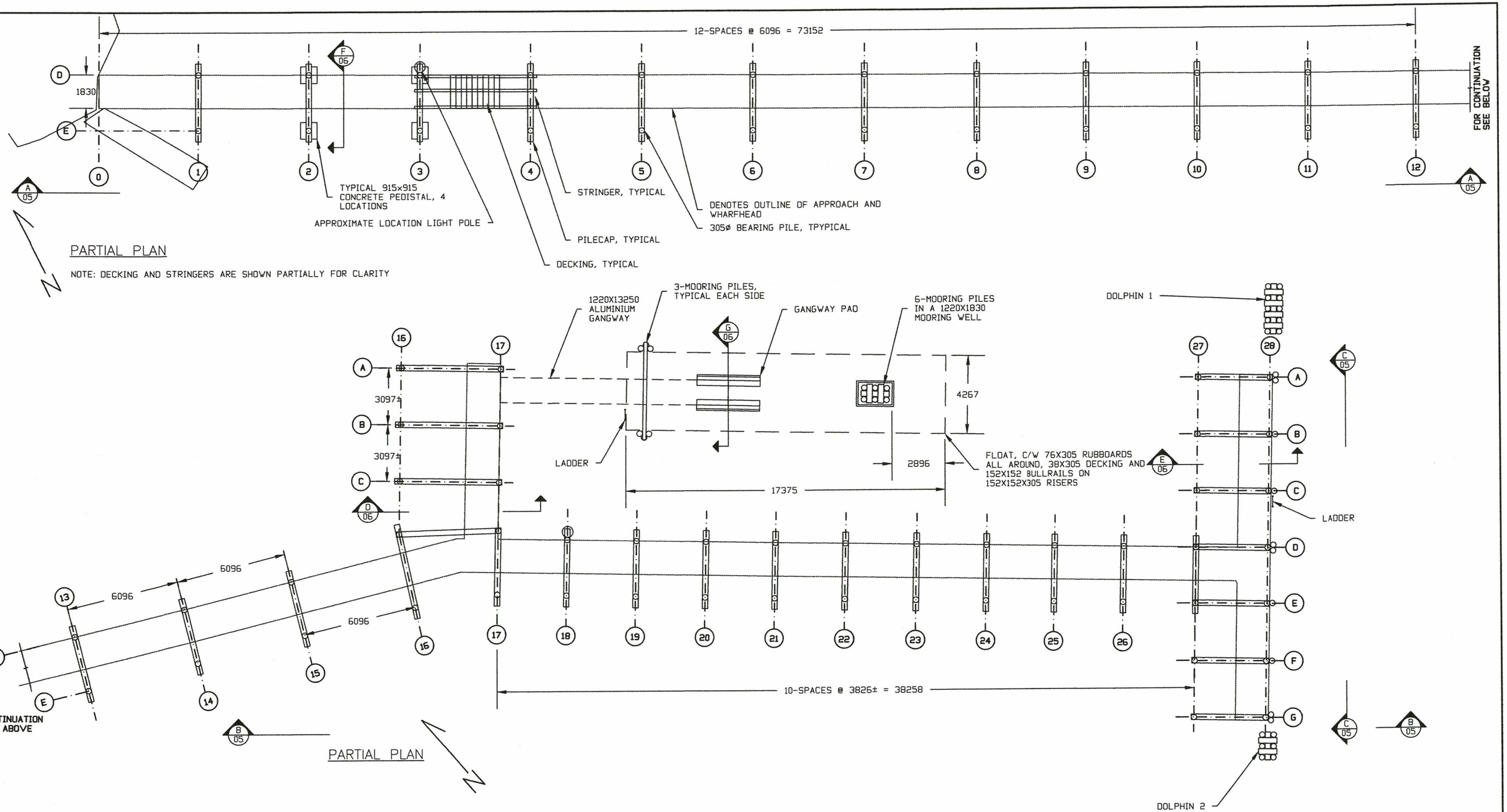

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1.3	2024/10/09	ISSUED FOR TENDER	MNS	BAS	BAS
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1.0	2024/06/19	FOR CLIENT REVIEW	MNS	BAS	BAS

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Approved By:	BAS	V. Scale:	NTS

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Drawing No.
BCS-0209-04

Project
HOPKINS LANDING RENEWAL PROJECT

Drawing Title
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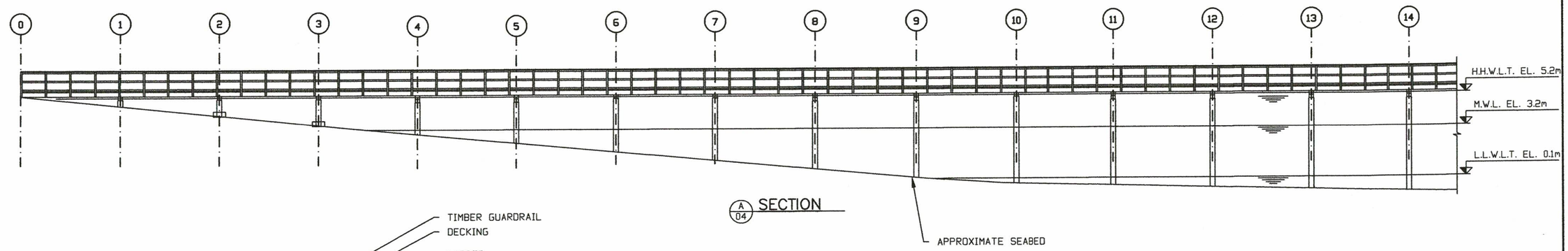

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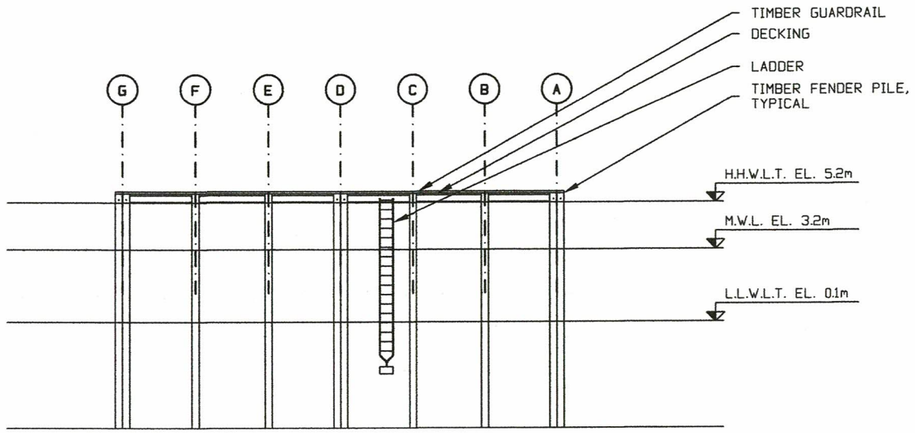

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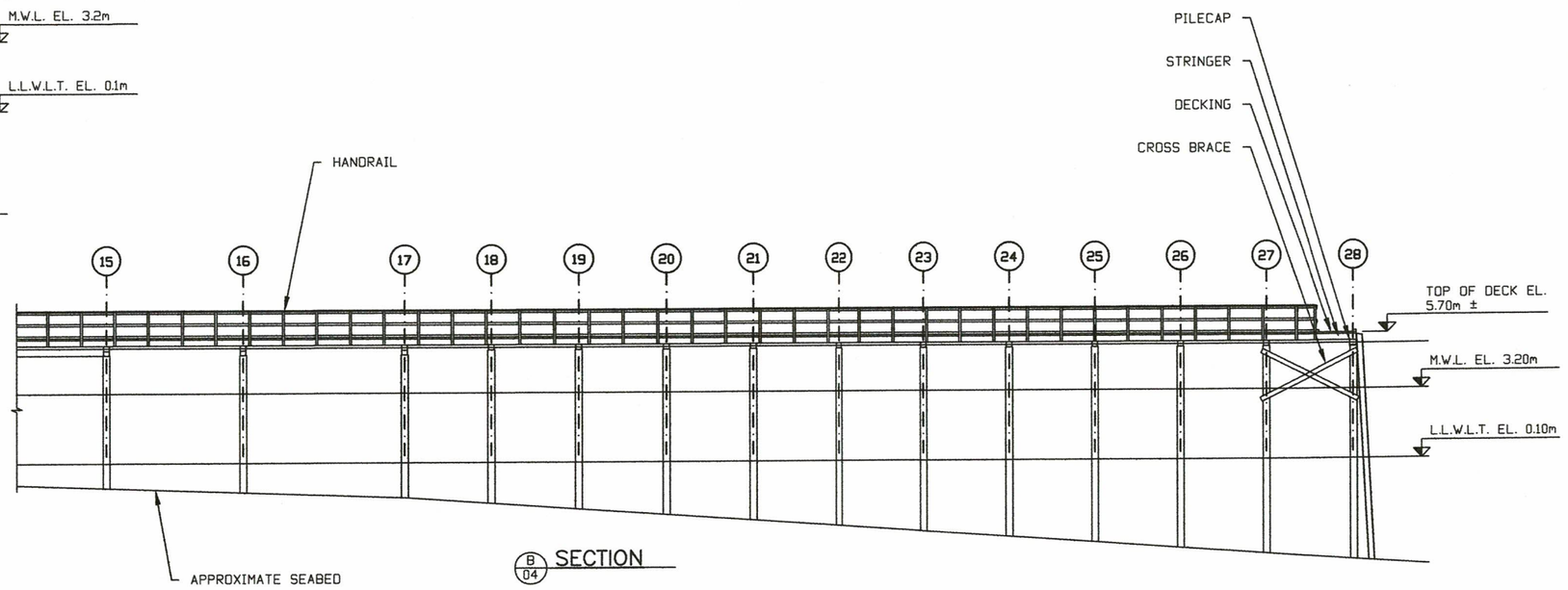

B/D4 SECTION

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PROFESSIONAL ENGINEER
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DATE OCT 04 2024

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Project
HOPKINS LANDING RENEWAL PROJECT

Drawing Title
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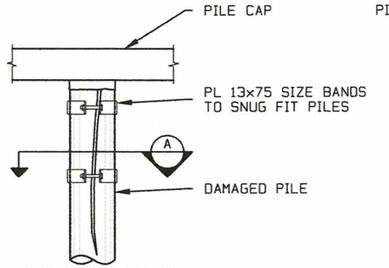

PILE BANDING DETAIL
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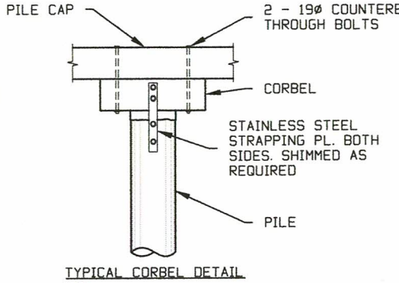
NOTE: STRINGERS, DECKING AND BRACING NOT SHOWN



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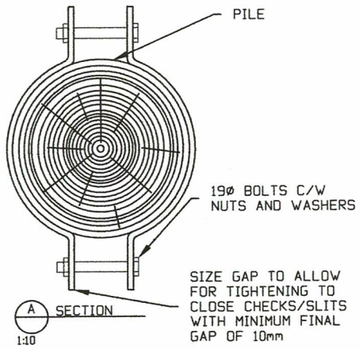

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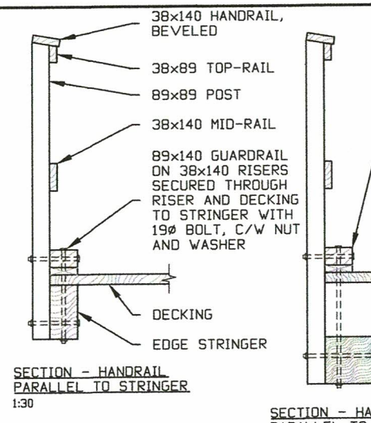

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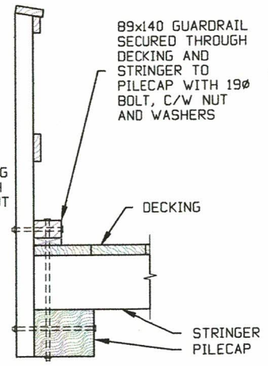
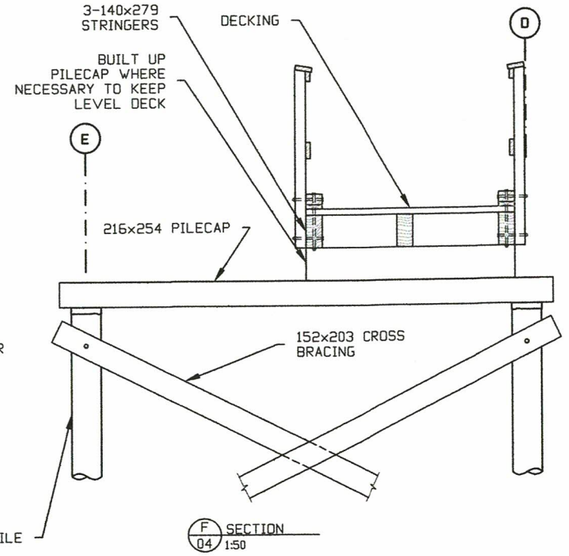
1:30



SECTION - HANDRAIL PARALLEL TO PILE CAP
1:30
NOTE: SIMILAR TO SECTION - HANDRAIL PARALLEL TO STRINGER, UNLESS NOTED OTHERWISE



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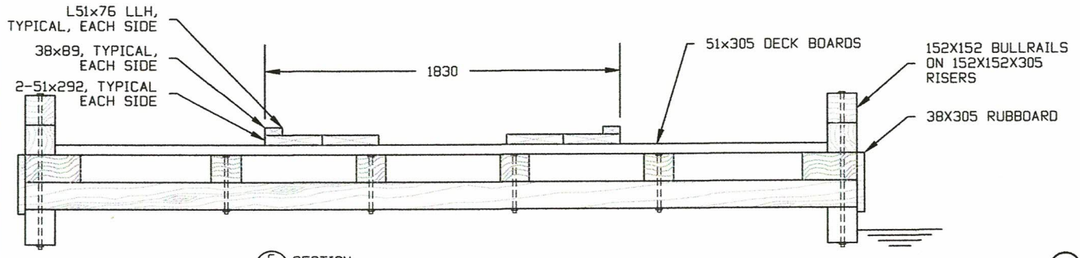
1:50



G 04 SECTION
1:30
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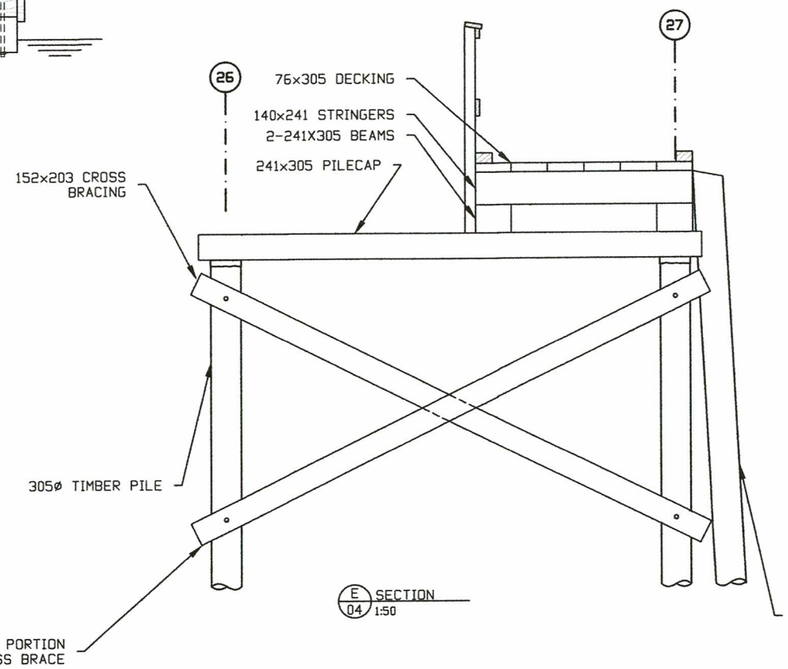

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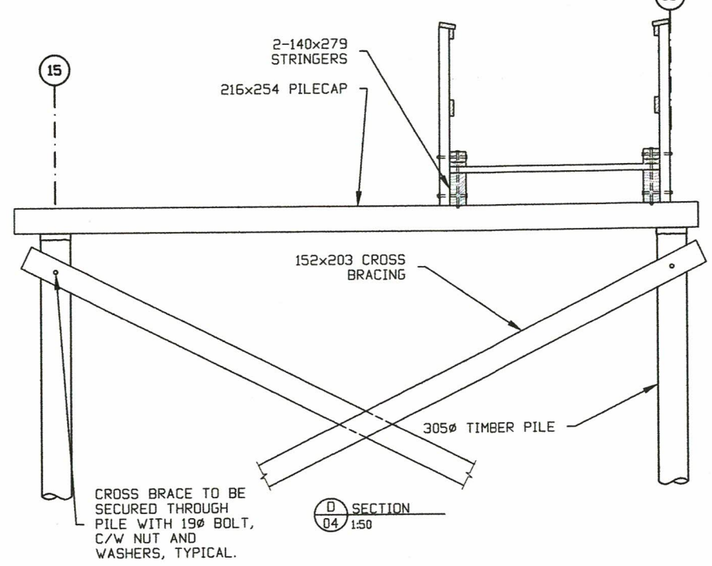
1:50



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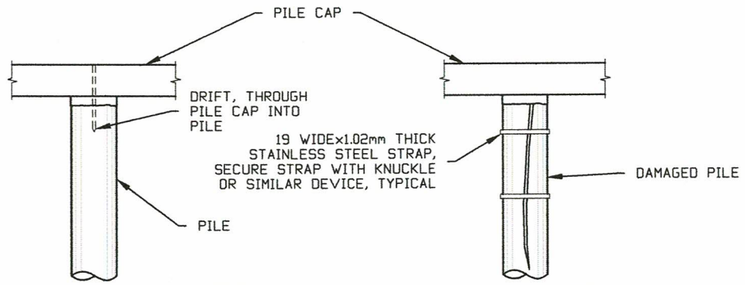

PILE TO PILE CAP CONNECTION
1:40
NOTE: STRINGERS, DECKING AND BRACING NOT SHOWN

PILE STRAPPING DETAIL
1:40
NOTE: STRINGERS, DECKING AND BRACING NOT SHOWN

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No	Date	Revisions	By	Chk'd	App'd
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Drawn By:	MNS	Date:	2024-09-18
Checked By:	BAS	H. Scale:	AS SHOWN
Approved By:	BAS	V. Scale:	NTS

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Drawing No.
BCS-0209-06

Project
HOPKINS LANDING RENEWAL PROJECT

Drawing Title
DETAILS

REPAIR ITEM #	ITEM	LOCATION	REPAIR DESCRIPTION	REPAIR MATERIALS (TIMBER UNLESS NOTED OTHERWISE)
1	HANDRAIL - POST	GRIDLINE E @ 37.2m	REPLACE HANDRAIL POST	89X89X1524
2	HANDRAIL - POST	GRIDLINE D @ 37.2m	REPLACE HANDRAIL POST	89X89X1524
3	HANDRAIL - POST	GRIDLINE D @ 107.9m	REPLACE HANDRAIL POST	89X89X1524
4	HANDRAIL - POST	GRIDLINE E @ 110.3m	REPLACE HANDRAIL POST	89X89X1524
5	HANDRAIL - POST	GRIDLINE D @ 119.8m	REPLACE HANDRAIL POST	89X89X1524
6	HANDRAIL - POST	POST @23E	REPLACE HANDRAIL POST	89X89X1524
7	HANDRAIL - MID-RAIL	GRIDLINE E @ 43.6m	REPLACE MID-RAIL	38X140X1500
8	HANDRAIL - MID-RAIL	APX BENTS 8.5 TO 10 E	REPLACE MID-RAIL	38X140X10500
9	HANDRAIL - MID-RAIL	APX BENTS 11.3-12 E	REPLACE MID-RAIL	38X140X3000
10	HANDRAIL - MID-RAIL	GRIDLINE D @ 107.9m	REPLACE MID-RAIL	38x89x4877
11	HANDRAIL - TOP-RAIL	GRIDLINE D @ 100.6m	REPLACE TOP-RAIL	38X89X4877
12	HANDRAIL - TOP-RAIL	GRIDLINE D @ 107.9m	REPLACE TOP-RAIL	38X89X4877
13	HANDRAIL	GRIDLINE D @ 107.9m	REPLACE HANDRAIL	38X140X4877
14	HANDRAIL	BENT 27	REPLACE HANDRAIL	38X140X17000
15	HANDRAIL	GRIDLINE E @ 132.0m	REPLACE HANDRAIL	38X140X4877
16	GUARDRAIL	GRIDLINE D @ 31.1m	REPLACE GUARD	89X140X6200
17	GUARDRAIL	GRIDLINE E @ 37.2m	REPLACE GUARD	89X140X12400
18	GUARDRAIL	GRIDLINE D @ 37.2m	REPLACE GUARD	89X140X12400
19	GUARDRAIL	GRIDLINE D @ 59.4m	REPLACE GUARD	89X140X6200
20	GUARDRAIL	GRIDLINE E @ 132m	REPLACE GUARD	89X140X6200
21	GUARDRAIL	GRIDLINE E @ 138.4m	REPLACE GUARD	89X140X6200
22	GUARDRAIL	GRIDLINE D @2.4m	REPLACE GUARD	89X140X6200
23	GUARDRAIL	GRIDLINE D @ 7.9m	REPLACE GUARD	89X140X6200
24	GUARDRAIL	GRIDLINE E @10.7m	REPLACE GUARD	89X140X6200
25	GUARDRAIL	GRIDLINE E @ 25.6m	REPLACE GUARD	89X140X6200
26	GUARDRAIL	GRIDLINE E @ 47.5m	REPLACE GUARD	89X140X6200
27	GUARDRAIL	GRIDLINE E @ 61m	REPLACE GUARD	89X140X6200
28	GUARDRAIL	24E	REPLACE GUARD	89X140X6200
29	GUARDRAIL	26E	REPLACE GUARD	89X140X6200
30	GUARDRAIL	BENT 16 AND 17 (GRIDLINES A, B,	REPLACE GUARDS	89X140X19200
31	GUARD RISER	26E	REPLACE GUARD RISER	38X140X305
32	GUARD RISER	BENT 16 AND 17 (GRIDLINES A, B, C)	REPLACE GUARD RISERS EVERY 1524 mm OR LESS	38X140X305 X 13
33	STRINGERS	BENT 1 & 2	REPLACE SPLICE BLOCK	140x279x600
34	PILE CAP - CONNECTION	BENT 12, UPPER CAP	ADD CONNECTION	METAL STRAPPING
35	PILE CAP	BENT 1	REPLACE PILE CAP	216X254X4300
36	BEARING PILE	5E	REPLACE BEARING PILE	305Ø
37	BEARING PILE	6D	REPLACE BEARING PILE	305Ø
38	BEARING PILE	6E	INSTALL STAINLESS STEEL STRAPPING FIRST 1.5M OF THE	METAL STRAPPING
39	BEARING PILE	7E	PLUG AND PATCH HOLE	PATCH
40	BEARING PILE	8E	PLUG AND PATCH HOLE	PATCH
41	BEARING PILE	9E	COLLAR CONNECTION TO PILE CAP COMPLETE WITH SHIMS TO ENSURE FULL BEARING	METAL STRAPPING
42	BEARING PILE	10E	REPLACE BEARING PILE	305Ø
43	BEARING PILE	12D	INSTALL STAINLESS STEEL STRAPPING FIRST 1.5M OF THE PILE	METAL STRAPPING
44	BEARING PILE	12E	REPLACE BEARING PILE	305Ø
45	BEARING PILE	13D	REPLACE BEARING PILE	305Ø
46	BEARING PILE	13E	BANDING ALONG PILE LENGTH. INSTALL SHIMS AND CONNECT PILE TO PILE CAP TO ENSURE LOAD TRANSFER AND ADEQUATE BEARING	METAL STRAPPING & ADD CONNECTION
47	BEARING PILE	14D	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
48	BEARING PILE	14E	PROVIDE STEEL STRAP OR COLLAR CONNECTION TO PILE CAP COMPLETE WITH SHIMS TO ENSURE FULL BEARING	METAL STRAPPING & ADD CONNECTION
49	BEARING PILE	15D	REPLACE BEARING PILE	305Ø
50	BEARING PILE	15E	INSTALL STAINLESS STEEL BANDING	METAL STRAPPING
51	BEARING PILE	16D	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
52	BEARING PILE	16E	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
53	BEARING PILE	17D	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
54	BEARING PILE	17E	INSTALL STAINLESS STEEL BANDING ON PILE	METAL STRAPPING
55	BEARING PILE	18E	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
56	BEARING PILE	19E	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
57	BEARING PILE	20D	REPLACE BEARING PILE	305Ø
58	BEARING PILE	20E	REPLACE BEARING PILE	305Ø
59	BEARING PILE	22D	REPLACE BEARING PILE	305Ø
60	BEARING PILE	22E	REPLACE BEARING PILE	305Ø
61	BEARING PILE	23E	REPLACE BEARING PILE	305Ø
62	BEARING PILE	24E	REPLACE BEARING PILE	305Ø
63	BEARING PILE	27B	REPLACE BEARING PILE	305Ø
64	BEARING PILE	27F	REPLACE BEARING PILE	305Ø
65	BEARING PILE	27G	REMOVE CORBELS AND REPLACE BEARING PILE	305Ø
66	BEARING PILE	28A	REPLACE BEARING PILE	305Ø
67	CROSS BRACE	4D	RE-SECURE BRACE CONNECTION	METAL HARDWARE
68	CROSS BRACE	5E	REPLACE HARDWARE	METAL HARDWARE
69	CROSS BRACE	6D	REPLACE HARDWARE	METAL HARDWARE
70	CROSS BRACE	6E	REPLACE CROSS BRACE AND MOUNTING HARDWARE	152X203 & METAL HARDWARE
71	CROSS BRACE	7D	INSTALL STAINLESS STEEL STRAPPING ON BRACE	METAL STRAPPING
72	CROSS BRACE	8D	REPLACE HARDWARE	METAL HARDWARE
73	CROSS BRACE	9D	INSTALL STAINLESS STEEL STRAPPING ON BRACE	METAL STRAPPING
74	CROSS BRACE	10E	INSTALL STAINLESS STEEL STRAPPING ON BRACE	METAL STRAPPING
75	CROSS BRACE	14E	INSTALL STAINLESS STEEL STRAPPING ON BRACE	METAL STRAPPING
76	CROSS BRACE	19D	RE-INSTATE CONNECTION	METAL HARDWARE
77	CROSS BRACE	21E	REPLACE CROSS BRACE	152X203 & METAL HARDWARE
78	CROSS BRACE	25E	REPLACE HARDWARE	METAL HARDWARE
79	SAFETY LADDER	28C-28D	MOVE GRAB RAIL TO THE TOP OF THE GUARD TIMBER	MOVE HARDWARE
80	GANGWAY - CHAIN GUARDING	SHOREWARD END	RE-INSTATE CHAIN GUARDING	CHAIN GUARDING
81	GANGWAY - SERRATED ALUMINUM GRATING	TWO SECTIONS	REPLACE TWO SECTIONS OF GRATING	GANGWAY GRATING
82	DOLPHIN	ALL 4 DOLPHINS	ADD SIGNAGE INDICATING DOPHINS ARE NOT TO BE CLIMBED ON FOR SAFETY REASONS	METAL SIGNAGE x 4
83	FLOAT	END OF GANGWAY	REBUILD AROUND DOLPHIN	NEW FLOATATION, REPLACE DETERIORATED TIMBER

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Seal

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
M. N. SMITH
44057
2024

No	Date	Revisions	By	Chk'd	App'd
1.2	2024/10/09	ISSUED FOR TENDER	MNS	BAS	BAS
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BOUNDARY CONSULTING SERVICES PERMIT TO PRACTICE #: 1002593

Design By:	MNS	Project:	BCS-0209
Drawn By:	MNS	Date:	2024-09-18
Checked By:	BAS	H. Scale:	NTS
Approved By:	BAS	V. Scale:	NTS

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Drawing No.
BCS-0209-07

Project
HOPKINS LANDING RENEWAL PROJECT

Drawing Title
LIST OF REPAIR ITEMS

Appendix B
Bill of Quantities

Bill of Quantities

Project: Hopkins Landing Renovation Project – Construction & Environmental Management Plan

Project Number: BCS-0209

Date of Tender: _____

BID SUMMARY

Contractors are required to provide unit pricing, total prices, excluding applicable taxes for each of the following line items. Provide total taxes at the bottom of the form. All work is to be completed per the specifications and drawings attached to this tender package.

1. General Construction Activities

Item No.	Description	Unit	Quantity	Unit Price	Total
1	Mobilization/Demobilization	LS	1	_____	_____
2	Barge Spudding & Setup	LS	1	_____	_____
3	Removal and Disposal of Decommissioned Components	LS	1	_____	_____
4	Disposal of Creosote Treated Timber (Hazardous Waste)	LS	1	_____	_____
5	Safety, First Aid, Traffic Control Plan.	LS	1	_____	_____
6	Environmental Protection Measures (CECP, Silt Curtain, Spill Kits, ETC.)	LS	1	_____	_____

2. Repair and Replacement of Structural Components (Repair Items 1-35)

2.1 Handrails (Repair Items 1-15)

Item No.	Description	Unit	Quantity	Unit Price	Total
7	Remove and Replace Handrail Posts	EA	6		
8	Remove and Replace Mid-Rails	EA	4		
9	Remove and Replace Top-Rails	EA	2		
10	Remove and Replace Handrails	EA	3		

2.2 Guardrails (Repair Items 16-30)

Item No.	Description	Unit	Quantity	Unit Price	Total
11	Remove and Replace Guardrails	EA	15		

2.3 Guard Risers (Repair Items 31-32)

Item No.	Description	Unit	Quantity	Unit Price	Total
12	Remove and Replace Guard Risers	LS	1		

2.4 Stringers (Item 33)

Item No.	Description	Unit	Quantity	Unit Price	Total
13	Replace Stringer Splice Connection	EA	1		

2.5 Pile Caps (Repair Items 34-35)

Item No.	Description	Unit	Quantity	Unit Price	Total
14	Repair/Connect Pile Caps	EA	2		

3. Bearing Pile Works (Repair Items 36-67)

Item No.	Description	Unit	Quantity	Unit Price	Total
15	Remove and Replace Bearing Piles	EA	16		
16	Stainless Steel Strapping for Bearing Piles	EA	7		
17	Plug and Patch Holes in Bearing Piles	EA	2		
18	Remove Abandoned Piles *not on the list	EA	4		
19	Repair Pile to Pile Cap Connections	EA	3		

4. Cross-Bracing Work (Repair Items 68-79)

Item No.	Description	Unit	Quantity	Unit Price	Total
20	Reestablish Cross Brace Connections	EA	12		
21	Remove and Replace Cross Braces	EA	12		
22	Install Stainless Steel Strapping on Cross Braces	EA	3		
23	Reinstall Cross Brace Hardware	EA	1		

5. Safety, Gangway, and Miscellaneous Work (Repair Items 80-84)

Item No.	Description	Unit	Quantity	Unit Price	Total
24	Install Safety Ladder	EA	1		
25	Gangway Chain Guarding	LS	1		
26	Install Serrated Aluminum Grating on Gangway	EA	2		
27	Dolphin Installation	LS	1		
28	Reinstall Float	LS	1		

6. Close Out

Item No.	Description	Unit	Quantity	Unit Price	Total
29	Record Drawings	LS	1		
30	Manuals and Warranty Documents	LS	1		
31	Final Schedules for all Engineered Shopdrawings and Submittals	LS			
32	TBD	LS			
33	TBD	LS			

Total Bid Price : _____

Tax: _____

Total Bid Price including tax : _____

Notes:

1 - All prices are to be exclusive of GST.
2 - Contractors are to include all overhead, profit, insurance, bonds, permits, and contingencies within their unit rates.
3 - Mobilization and demobilization shall cover all equipment, materials, and labor
4 - Contractors must adhere to the Environmental Control Plan and provide disposal

Contractor Declaration:

I/We the undersigned, having carefully examined the specifications, tender documents, and drawings, hereby offer to execute the work described for the prices entered in this form.

Company Name: _____

Authorized Signature: _____

Date: _____

Contact Information: _____

Appendix C
Best Management Practices and Guidelines

Guidelines to Protect Fish and Fish Habitat From Treated Wood Used in Aquatic Environments in the Pacific Region

Hutton, K.E. and S.C. Samis

Habitat and Enhancement Branch
Fisheries and Oceans Canada
555 West Hastings Street
Vancouver, BC V6B 5G3

2000

Canadian Technical Report of Fisheries and Aquatic Sciences 2314

Fisheries and Oceans Canada Pêches et Océans Canada

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of Fisheries and Oceans Canada, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Number 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715-924 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des science halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelle, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'ya aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques de Pêches et Océans Canada, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dan l'index annual des publications scientifiques et techniques du Ministère.

Les numéros l à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcherie du Canada. Les numéro 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demands de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of Fisheries and Aquatic Sciences 2314

2000

GUIDELINES TO PROTECT FISH AND FISH HABITAT FROM TREATED WOOD USED IN AQUATIC ENVIRONMENTS IN THE PACIFIC REGION

By

K. E. Hutton and S. C. Samis

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Fisheries and Oceans Canada
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Cat. No. Fs 975/9999E ISSN 0706-6457

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Hutton, K. E. and S. C. Samis. 2000. Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. 2314: vi + 34 p.

TABLE OF CONTENTS

ABSTRACT

Hutton, K. E. and S. C. Samis. 2000. Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. 2314: vi + 34 p.

This report outlines potential impacts to fish and fish habitat when treated-wood products are installed in aquatic environments. Commonly used heavy-duty preserved-wood structures are reviewed, in conjunction with alternatives to treated wood. All treated and untreated-wood structures have the potential to cause impacts in the aquatic environment. If treated wood is used, reducing these impacts requires choosing the appropriate wood treatment for the environmental conditions at the site, ensuring wood is factory treated to meet current industry standards, and imposing site-specific conditions such as restricting the timing of installation. In some cases, the potential for impacts may preclude the use of treated wood. These guidelines are designed to ensure the protection of aquatic life from installation through to decommissioning of the treated-wood structure.

RÉSUMÉ

Hutton, K. E. and S. C. Samis. 2000. Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. 2314: vi + 34 p.

Le présent rapport décrit les impacts potentiels de l’installation dans les milieux aquatiques de produits en bois traité sur le poisson et son habitat. On traite des structures résistantes en bois traité communément utilisées de même que des solutions de rechange au bois traité. Toutes les structures en bois traité ou non traité peuvent avoir des impacts sur les milieux aquatiques. Si on utilise du bois traité, on doit pour réduire ces impacts choisir un type de traitement du bois adapté aux conditions environnementales du site considéré en veillant à ce que le bois soit traité en usine de façon à respecter les normes courantes de l’industrie, et en imposant des conditions propres au site ayant trait, par exemple, au moment de l’installation. Dans certains cas, le bois traité aurait des impacts potentiels trop importants pour qu’on puisse l’utiliser. Ces lignes directrices visent à protéger la vie aquatique depuis l’installation jusqu’au démantèlement des structures en bois traité.

ACKNOWLEDGMENTS

Dr. K. Brooks, Aquatic Environmental Sciences, provided an extensive and insightful critique of the draft document based on his considerable research into the aquatic environmental effects of treated wood products. His comments were fundamental to the successful completion of this document.

D. Goyette provided comment on the many drafts of these Guidelines, and offered hypotheses to explain the changes in the physical and chemical conditions surrounding the Sooke study test piling four years after installation.

The authors thank T. Appleton, Senior Project Engineer, Small Craft Harbours Branch, Fisheries and Oceans Canada for his advice on the practical applications of treated wood in aquatic environments.

H. Walthert, Executive Director, Canadian Institute of Treated Wood (CITW), offered constructive comments on initial drafts of this document and, in collaboration with his colleagues in the treated-wood industry, provided valuable technical input into the development of these guidelines.

Fisheries and Oceans Canada Area Habitat and Enhancement Branch staff assisted the writers in ensuring that these guidelines can be practically applied.

The Creosote Evaluation Steering Committee comprised of: D. Goyette, Environment Canada; Dr. K. Brooks, Aquatic Environmental Sciences; H. Walthert, CITW; Dr. N. Nagpal, B.C. Ministry of Environment, Lands and Parks (MELP); T. Appleton and K. Hutton, Fisheries and Oceans Canada, supported the development of these guidelines.

The conclusions reached and recommendations presented may not necessarily reflect the opinions of these reviewers.

1.0. INTRODUCTION

Treated wood has a long history of use in Canada for the construction of shoreline facilities in marine and freshwater fish habitats. Chemical preservation is designed to make wood toxic to organisms that would otherwise use it as food. There are 6 heavy duty wood preservatives (listed below) registered under the *Pest Control Products Act (PCPA)* of Canada which is administered by Health Canada's Pest Management Regulatory Agency.

- Creosote;
- Pentachlorophenol (PCP);
- Copper naphthenate;
- Ammoniacal copper arsenate (ACA);
- Ammoniacal copper zinc arsenate (ACZA); and
- Chromated copper arsenate (CCA).

A brief description of ammoniacal copper quat (ACQ) is included in the document although this pesticide is not registered for use in Canada. Notwithstanding, wood products preserved with ACQ can be imported into Canada.

Environmental risk due to pesticide use is a function of both chemical toxicity and environmental exposure. The *PCPA* sets out the requirements for product labels, which outline the legal use of a pesticide and impose constraints to protect human health and the environment.

1.1. PURPOSE

The present Guidelines are intended for use by Fisheries and Oceans Canada staff to assist in the review of shoreline projects involving treated wood. Best Management Practices (BMPs) for the in-plant preservation of wood, including a rudimentary guide to the use of treated wood in aquatic environments, are contained in a 1997 document published jointly by the Canadian Institute of Treated Wood (CITW) and the U.S.-based Western Wood Preservers Institute (WWPI). These industry-developed BMPs have been recognized by Environment Canada as a useful tool for staff in the Pacific Region, with the provisos that the BMPs must be updated as knowledge improves, and that even wood treated according to BMPs can have impacts on aquatic life under certain conditions. The authors of the BMPs encourage the Canadian Standards Association (CSA) to continually explore the potential for reducing the retention standards for wood-treatment pesticides. Users of the present Guidelines should become familiar with key aspects of industry's BMPs. The BMP mark (see Figure 1) is registered under the U.S. Federal *Trademark Act* but it is not registered in Canada. However, in British Columbia the Canadian Softwood Inspection Agency is using the BMP mark to certify wood products treated with preservatives according to BMP specifications. Accordingly, Pacific Region staff need to specify that all treated wood used in water is so designated.

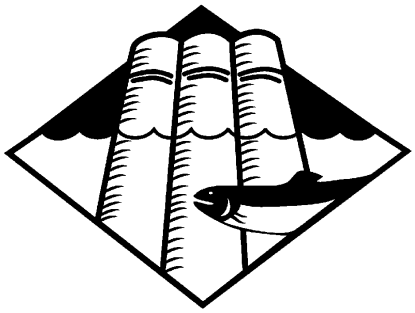

Fig. 1. BMP mark. This insignia is used by manufacturers of factory-preserved wood treated according to specifications set out in Best Management Practices for the Use of Treated Wood in Aquatic Environments (CITW and WWPI 1997).

Any project involving the aquatic use of treated wood may have adverse environmental effects, even if proponents ensure that manufacturers follow the treatment recommendations in the BMPs. Consultation with the appropriate regulatory agencies is required when such projects are proposed. Fisheries and Oceans Canada administers s. 35 of the *Fisheries Act* which prohibits the harmful alteration, disruption or destruction of fish habitat without authorization. Foreshore dock placement or the installation of piling can harmfully alter fish habitat. Consequently, Fisheries and Oceans Canada must be notified in advance of any such proposals so that an assessment can be conducted and the acceptability of the project and any mitigation and compensation determined according to the Policy for the Management of Fish Habitat (DFO 1986). Readers are referred to the 1995 Fisheries and Oceans Canada (DFO)-Ministry of Environment, Lands and Parks (MELP) Marina Development Guidelines for the Protection of Fish and Fish Habitat for further information on the biophysical impacts of building and maintaining dock structures. Part of the assessment for any such construction will be evaluation of the suitability of construction materials, including treated wood in the context of the specific site proposed for the development. Wood treatment products have the potential to be toxic to fish and thereby the potential to be deleterious under s. 36 of the Act. Environment Canada has the lead administrative authority for s. 36 of the *Fisheries Act* which prohibits the deposit of a deleterious substance into waters frequented by fish. Fisheries and Oceans Canada's Minister is legally responsible to Parliament for all sections of the *Fisheries Act*.

2.0. OIL-BORNE TREATMENTS, ENVIRONMENTAL CONCERNS AND ASSOCIATED MITIGATION STRATEGIES

2.1. CREOSOTE

Creosote, a distillate of coal tar, is a complex chemical mixture, up to 80% of which is comprised of polycyclic aromatic hydrocarbons (PAHs). High molecular weight PAHs can be carcinogenic, whereas the more volatile, low molecular weight PAHs are more likely to be acutely toxic to aquatic life. Creosote is applied to wood under pressure at specialized treatment facilities. Using methods recommended in the above-referenced Best Management Practices, operators apply

creosote employing techniques to minimize residual pesticide on the surface of the treated product. This can result in significantly less surface residue of creosote on the newly treated wood than was the case with historical treatment methods (see Figure 2). The BMPs recommend treatment to CSA requirements which are linked to the minimum amount of pesticide required to preserve the wood, based on the intended use or exposure (i.e., ground contact, marine use). A number of new in-plant treatment processes including surface residue recovery of creosote are now routinely being used in B.C.

Fig. 2. A new pile treated with creosote to BMP standards, prior to weathering, compared to a pile treated to traditional standards. Note the obvious residual surface creosote on the pile receiving the traditional treatment. (Photo courtesy of R. D. Hayward.)

In recent years it was recognized that the borer hazard in marine waters north of San Francisco on the west coast and north of New Jersey on the east coast were such that lower retention levels could be used for creosote than were earlier required. The American Wood Preservers Association (AWPA) recommended changes to the U.S. standard after its Creosote Council identified the ability to properly preserve wood at lower retention levels. The CSA adopted the AWPA standard. The creosote retention standard was reduced from 20 to 16 pounds per cubic foot (pcf) for temperate marine waters such as in British Columbia.

Creosote is particularly effective in repelling marine borers. Creosote escapes from treated wood at a faster rate in freshwater than in salt water, although in both cases the loss of the preservative is small. In sensitive freshwater areas, particularly where there are low current velocities, and in anaerobic sediments, the use of alternatives to creosote-treated wood is recommended (see Section 4.0.). In estuarine areas, the proponent should be prepared to justify the need for creosote-treated wood by demonstrating the historic presence of marine borers in the area, and the lack of viable alternatives to creosote. Part of this justification can be as simple as gathering local information on the historic evidence of marine borer infestation. Fisheries and Oceans Canada's Small Craft Harbours (SCH) Branch, Pacific Region has been mapping the occurrence of *Limnoria* and *Bankia*, the 2 most common local marine borers. In sensitive estuarine environments, treated wood may not be acceptable.

Sheet-pile walls or other installations involving large volumes of creosote-treated wood could theoretically be the source of enough PAH dissolved in surrounding waters to be expected to cause toxic impacts to aquatic life. Such elevated concentrations of PAH in water are not common with most projects involving the installation of small numbers of dolphins or piles. Wood treated with creosote to BMP specifications typically releases only low amounts of PAH into the water column during the life of the structure. The initial release is seen as a hydrocarbon sheen on the water surface. Goyette and Brooks (1998) have shown that pile-sourced PAHs in the water column are of low concentration, and their occurrence is intermittent and of short duration. Of much greater concern for aquatic ecosystems is the accumulation of PAHs in the sediments surrounding piles. A summary of the Goyette and Brooks study is included in Appendix A.

Goyette and Brooks (1998) have hypothesized that PAHs are transported through the water column in particulate form. This hypothesis suggests that microlitre-sized particles of creosote fall through the water column and slowly work their way downward through interstices in sediments. These creosote particles may be formed when treated wood is subjected to intense solar exposure associated with elevated air temperatures. Therefore, care must be exercised when authorizing overhead structures treated with creosote where wood will be directly exposed to the sun. The loss of creosote from overhead structures can be ameliorated by artificial shading or by providing collectors to intercept the creosote before it drips into the aquatic environment. For example, sleeves, wrapping and coatings are options that may reduce the release of preservative from all types of treated wood. Creosote movement from unwrapped piling will eventually achieve equilibrium with microbial degradation in aerobic sediments (Brooks 1997a; Goyette and Brooks 1998). A wrapped pile may allow creosote to accumulate under the covering and move into the aquatic environment in a significant pulse if it is breached (Brooks 1999a).

Protective caps are being assessed for efficacy in mitigating creosote expulsion (Appleton 1998). Floating docks and boats can rub against creosote-treated piling resulting in the loss of significant amounts of treated-wood splinters. This compromises the integrity of the treated wood and results in unnecessary environmental risk associated with the loss of treated-wood fibres. In some cases, shifting bottom materials abrade the pile at the sediment-water interface. Losses due to abrasion can be minimized by armouring the wood with protective high-density polyethylene wear strips.

In the DFO-MELP 1995 Marina Guidelines use of creosote-treated wood was precluded in freshwater. As a result of further examination of this question, there may be limited circumstances where creosote-treated wood is acceptable in freshwater. The characteristics of an oil-borne preservative such as creosote are often preferred by industry for decking on industrial docks or in flooring, given that many users find that the wood remains softer and more resistant to wear from heavy use, compared to wood treated with water-borne preservatives. Notwithstanding, because creosote leaches relatively rapidly in freshwater and throughout the life of the structure, Fisheries and Oceans Canada is likely to significantly limit the freshwater use of creosote-treated wood, given that alternatives are readily available. In the case of utility poles, it has been reported that poles treated with water-borne preservatives are more difficult for repair crews to climb using spurs than poles treated with creosote (Walthert 1999). However, most utility poles now are treated with water-borne preservatives due to human health concerns associated with exposing repair crews to creosote. Creosote-treated wood is preferred by industry in the construction of laminated decks. This involves the use of creosote-treated lumber (e.g., 2x4 inches or 2x6 inches) placed on edge to create a surface which is covered with asphalt. The asphalt cover caps the tops of the lumber, leaving only the bottoms and the outer edge of the deck exposed to weathering, including solar radiation. Creosote should not be used in above-water or overhead structures where solar heating can result in the expulsion of creosote from the treated wood and its deposition into the aquatic environment. For example, creosote-treated wood used in a laminated deck may be acceptable, but the outer lumber and the ends of stringers, which will be exposed to solar radiation, should be protected from the sun. This may involve the use of protective polyethylene wraps, or a construction design to provide shading to the potentially exposed treated wood. A cautious approach should be used when reviewing proposals for dock and decking structures employing large volumes of creosote-treated wood. In some cases, the potential for adverse environmental impact will preclude this use of creosote-treated wood and alternative products will be required.

> **Note: Railway Ties**. The BMPs referenced above were designed for treated wood used in construction in aquatic environments. Railway ties are generally treated using a different process than piling or lumber. Creosote-treated ties are often preferred by the railroad industry for high-use areas because they have greater shock-absorbing capacity and are less likely to crack than concrete ties. Brooks is currently studying the loss of PAHs from creosote-treated railway ties. Results from the first year of study indicate that PAHs are migrating from the treated ties into the railway ballast, but have not been detected in stormwater, groundwater or a nearby wetland (Brooks 1999a). Further study is required to assess the potential impacts that treated railway ties may represent to the aquatic environment. Wan (1991) found dioxins and furans in drainage water from railway ballasts

on the B.C. Lower Mainland adjacent to ties which had been treated with a combination of creosote and PCP.

Apart from railway ties, all newly-treated wood should bear the BMP certification mark, ensuring that appropriate treatment and post-treatment measures have been employed in producing the preserved wood. The proponent should be prepared to produce documentation verifying that the treated wood to be used in a specific project has been certified. The supplier or installer should guarantee that all treated wood will be visually inspected before installation to ensure that there are no excessive preservative deposits or signs of bleeding of creosote. If deposits are present, the installer or supplier should reject the materials.

Piling are often brought to a site in rafts and remain alongside the pile-driver barge until installation. This practice can result in a release of creosote into the water at the surface which may subsequently deposit onto benthic sediments. The surface sheen contains the light, volatile and comparatively-toxic PAH fraction. Deployment of absorbent booms or pads during pile installation is advisable to capture this initial surface contamination. In-water storage of treated wood for any extended period should be avoided.

Splintering during pile driving can deposit PAHs on the bottom sediment through loss of creosote-impregnated wood debris. Over-water construction of bulkheads, stringers and other structures should be managed in such a way as to minimize any release of wood debris and sawdust into aquatic habitats. Efforts must be made to eliminate the release of such treated material (i.e., cut ends, borings, sawdust, splinters) during over-water construction. All construction debris must be contained and recovered.

When wharves or other structures are to be decommissioned, a reasonable attempt should be made to remove the entire creosote-treated pile. Piles should be removed by a slow, steady pull to minimize disturbance of surface habitats and to avoid bringing creosote-contaminated sediments to the surface. If the pile breaks off below the biologically-active zone in the sediment, it may not be advisable to dredge the remainder out, depending on the sensitivity of the habitat at the site. Appropriate disposal of used piles on land or reuse is also important to consider during the planning stages of the decommissioning.

When dredging and ocean disposal of sediments adjacent to docks or other structures built of creosote-treated wood is likely, proponents need to be aware of *Canadian Environmental Protection Act (CEPA)*-regulated requirements regarding maximum PAH levels in material designated for ocean disposal. The Environment Canada, Pacific and Yukon Region Interim Contaminant Testing Guidelines for Ocean Disposal (1997), prepared pursuant to *CEPA*, restrict total PAH levels to 2.5 $\mu g \cdot g^{-1}$ in sediments destined for designated ocean disposal sites. Sediments with PAH concentrations exceeding that limit would be rejected for ocean disposal.

If creosote-treated wood is proposed for upland construction projects, consideration should be given to the potential for contamination of surface-water runoff and groundwater.

2.1.1. Weathered or Reused Creosote-treated Wood

The crustacean *Limnoria* tends to bore tunnels through a pile, going progressively deeper into the pile as the surface of the wood flakes off, causing extensive structural damage. Piles infested with *Limnoria* are not usually suitable for reuse. *Bankia* is a mollusc which tends to drill tunnels that follow the grain of the wood; it is not known to cross other *Bankia* tunnels. This characteristic may result in less structural damage to the pile than would be the case with *Limnoria.* The type of marine borer causing the damage is therefore important in cases where the replacement or reuse of piling is being considered. In the case of piling infested with *Bankia*, the structural integrity of the wood may make it acceptable for selected uses. Industry is cautious about the reuse of piling for many reasons, including legal liability. The proponent is responsible for assessing whether used material is structurally suitable for the proposed installation. If a structure is being decommissioned, infested piling may be suitable for reuse in other, primarily non-structural applications, such as fender piles on a dock or upland, as landscape ties and fence posts.

- Reused, weathered piles will indefinitely lose creosote but the rate is reduced from that of new piles. The loss rate is thought to be proportional to the age of the wood and the amount of the original creosote charge. Creosote-treated piles can maintain their structural integrity for 20 to 90 years depending on use and location. Piles in Vancouver Harbour after 40 years of service have retained 75% of the original creosote charge.
- If creosote-treated wood is to be used/deposited on land, placement must be in accordance with Provincial and Municipal legislation.
- When a large volume of creosote-treated wood is taken out of service from in-water or on-land prior use, the proponent and regulator need to fully consider all reuse and disposal options to maximize protection of the aquatic environment.
- Used, treated wood should be inspected to ensure that the wood is in a condition that is suitable for the intended new use. Inappropriate reuse of treated wood could result in structural failure and lead to repeated habitat disturbance through decommissioning and reconstruction of a facility.
- Weathered or reused wood should be inspected to ensure there are no excessive deposits of creosote on the surface of the wood. Such deposits indicate there may be continuing, significant PAH loss from the wood. Such wood is unlikely to be suitable for use in fish habitat.

2.2. PENTACHLOROPHENOL

Pentachlorophenol is commonly used for utility pole and fence post preservation and is specified in the BMPs for use on lumber to be placed in freshwater areas, including timbers and piling; in laminated beams; and above the splash zone in saltwater environments. Pentachlorophenol is not recommended in the CSA standards for use in salt water environments (WWPI 1998). Researchers in one recent study (Brooks 1999b) of pentachlorophenol-treated bridges sampled for PCP in water and sediment in U.S. west coast streams. In this study, the PCP-treated wood was not immersed in the streams; its use was limited to the overhead structures. PCP was not detected in the water column at a detection limit of 0.25 $\mu g \cdot L^{-1}$. Sediment samples exceeded the detection limits of 7.2 to 11.0 $\mu g \cdot kg^{-1}$ in 5 of 16 samples with PCP levels up to 20.0 $\mu g \cdot kg^{-1} \pm 7.9$

$\mu g \cdot kg^{-1}$. No adverse effects were observed. Invertebrate abundance appeared to be more influenced by sediment composition than by pentachlorophenol levels (Brooks 1999b). Historic concerns with the use of pentachlorophenol due in part to contamination with dioxins, furans and hexachlorobenzene, and the potential for chronic impacts at low pentachlorophenol levels, has limited its use in aquatic environments. The more recent data do not preclude consideration of its use in treated wood for overhead structures. There is a risk assessment model that has been developed for pentachlorophenol (Brooks 1998b).

2.3. COPPER NAPHTHENATE

Copper naphthenate is an oil-borne preservative that is the reaction product of copper oxide and naphthenic acids. It is used primarily for above-water components and for hand dressing of end cuts. All end cuts should be treated in an upland contained area. Health Canada's Pest Management Regulatory Agency sets out use restrictions on pesticide product labels. However, label constraints have not historically been detailed with respect to ensuring fish habitats are protected. Following a 1992 label improvement initiative, copper naphthenate labels are now required to identify that this product is toxic to fish.

Copper naphthenate is occasionally proposed for freshwater structures such as timbers for bridges. Copper naphthenate is not listed in the CSA standards for lumber used in salt water or for any piling. Materials should only be used for listed applications (WWPI 1998). CSA standards are in effect for wood treatment with copper naphthenate in both ground contact and freshwater applications. There is no risk assessment model for the use of copper naphthenate.

For wood treated with copper naphthenate, as is the case with other heavy duty wood preservatives, compliance with the above-mentioned BMPs, including post-treatment steps involving the use of an expansion bath and vacuum recovery, is required. The treated wood should be visually inspected and rejected if there are excessive solids or grease-like deposits which can be scraped off the surface. Treated wood should be rejected where liquid preservative bleeds from the surface.

Copper naphthenate-treated wood is often used for utility poles, and is commonly available in retail lumber yards for use in fencing and decking.

3.0. METAL-OXIDE TREATMENTS, ENVIRONMENTAL CONCERNS AND ASSOCIATED MITIGATION STRATEGIES

Treatment using metal oxide involves forcing dissolved copper, chromium, arsenic and/or zinc under pressure into wood. As noted above, (see Section 2.1.) recent information shows that the borer hazard in marine waters north of San Francisco on the west coast and north of New Jersey on the east coast is lower than earlier believed. Accordingly, lower retention is appropriate and effective for CCA and ACA/ACZA, compared with that which was required earlier. Recently the AWPA recommended changes to the U.S. standard, and the CSA has adopted the revised U.S. standard. As a result, ACA/ACZA and CCA retention in treated wood was reduced from 2.5 to

1.5 pcf for structures in temperate marine waters such as in coastal British Columbia and further north.

According to the industry, the key aquatic environmental concern with wood treated with metal oxides is the initial copper loss (CITW and WWPI 1997). Use of the above-referenced BMPs by treatment plant operators involves ensuring that the metal oxides are properly fixed within the wood and therefore are significantly more resistant to leaching when the structure is installed in water. Industry recommends that wood treated with metal oxides not be painted immediately, but be allowed to dry thoroughly to improve paint adhesion to the surface.

3.1. AMMONIACAL COPPER ZINC ARSENATE (ACZA) AND AMMONIACAL COPPER ARSENATE (ACA)

ACZA was registered for use in Canada in 1999, but has been in common usage in the United States for a number of years as an alternative to creosote. With ACZA, half the arsenic in ACA is replaced with zinc, therefore losses of arsenic from ACZA are expected to be lower than losses from ACA. ACZA and ACA are somewhat similar in chemical behaviour and are discussed together in the BMPs. Industry expects ACZA will rapidly replace ACA (Walthert 1999).

Successful metal-oxide fixation with ACZA is dependent on the evaporation of the ammonia-based solvent. The BMPs establish post-treatment procedures to ensure adequate fixation. If there is an obvious ammonia odour present, the chemical is not properly fixed in the wood and it should not be accepted for use. Brooks (1997c) contains a computer model to predict ACZA leaching rates under different environmental conditions. The metal-loss algorithm in Brooks (1997c) predicts loss rates from ACZA-treated wood that decline exponentially with time and reach background levels within one week after installation. The model predicts that copper is the contaminant of concern with ACZA. Adjacent to an ACZA-treated pile, if copper in water and sediment does not exceed water quality objectives or guideline levels, it is unlikely that chromium, zinc or arsenic will reach levels of concern. Industrial washing of the treated wood prior to installation may remove some of the metals that leach out during initial immersion. This is not a routine procedure. If required, washing must be carried out at the manufacturing site to ensure there is proper collection and reuse of the wash water.

ACZA is more effective than CCA in treatment of Douglas-fir and should be considered as an alternative to creosote for marine borer protection. ACZA is more likely to be used in piling and other industrial applications than is CCA.

3.2. CHROMATED COPPER ARSENATE (CCA)

CCA is used both for above-water components and a full range of aquatic installations, including piling. Industry does not recommend CCA for marine piling using Douglas-fir, which is favoured locally for strength. CCA is effective on many other western softwood species, including western hemlock and ponderosa pine. CCA fixation to wood cells is a function of time and temperature. According to the BMPs and the CSA, wood properly treated with CCA must pass the chromotropic acid test to verify the absence of chromium VI. Presence of chromium VI

indicates that the fixation process is incomplete. Passing the test ensures that for aquatic applications 99.5% – 99.95% of the preservative is fixed to the wood (CITW and WWPI 1997). There are three common formulations of CCA, with minor differences in the forms of the metals. The most commonly used formulation is CCA-C. With in-water installations, most metal leaching from CCA-treated wood occurs in the first 90 days (CITW and WWPI 1997). In above-water structures most CCA leaching is thought to occur in the first year (Brooks 1997b). This weathering period is based on rain water flowing over the wood surface, thus intensity and duration of rain events is of significance in the weathering process.

Brooks (1996) used a model to predict environmental levels of copper following the installation of a bulkhead. The model predicted significant elevations of copper in the water column immediately following the installation of a bulkhead using CCA-treated wood where proper fixation of the chemical has occurred. In one example of a 500-metre-long bulkhead installed in freshwater where currents were flowing at a speed of 2.5 $cm \cdot sec^{-1}$ with a water hardness of 50 $mg \cdot L^{-1}$ $CaCO_3$, the model predicted a copper concentration immediately adjacent to the bulkhead of 2.13 $\mu g\ Cu \cdot L^{-1}$ on the first day of immersion. These levels declined exponentially and the copper concentrations were predicted to be 1.8 $\mu g\ Cu \cdot L^{-1}$ on the second day. The Canadian Council of Ministers of Environment (CCME 1999) identified the upper limit of 2 $\mu g \cdot L^{-1}$ copper as protective of freshwater aquatic life in waters where hardness is 120 $mg \cdot L^{-1}$ $CaCO_3$ or less.

The Brooks model further predicted that if copper concentrations in water remained below the regulatory standard, sediment copper concentrations should also be in adherence. It is important to note that the model is designed to be conservative, thus it will likely overestimate the amount of metal leached from the wood.

In laboratory flow-through and field in situ bioassays using CCA-C-treated southern yellow pine in sea water, blue mussels attached to or immediately adjacent to the treated wood did not accumulate copper, chromium or arsenic after up to 9 months of exposure (Adler-Ivanbrook and Breslin 1999). These authors concluded that although copper, chromium and arsenic were continually released from the treated wood, the concentrations measured in the water were not high enough to result in elevations in mussel tissue.

Weis et al. (1998) studied 5 CCA-treated-wood bulkheads of different ages in estuaries from New York to South Carolina. These authors concluded that metals leached from the treated wood and accumulated in the fine-grain fractions of nearby sediments. Benthic community species richness, diversity and biomass were reduced at sample stations 1 metre from the bulkheads, generally returning to background characteristics at a distance of 10 metres from the bulkheads. This was correlated with both the highest concentrations of copper and arsenic, and percent fines in sediments. Benthic response was thought to reflect sediment characteristics, not contaminant concentration. Factors influencing leaching and accumulation included the age of the treated wood (i.e., weathering time), sediment characteristics and the energy level of the aquatic environment. Weis et al. (1998) considered copper to be the metal most likely responsible for the effects documented in the benthic community. These authors referred to a previous study wherein sediment contamination was assessed adjacent to CCA-treated pilings. In that study, there was no significant sediment metal contamination or apparent changes to the benthic

community near the piling in relatively well-flushed areas. Weis et al. (1998) also noted that while there was no marked accumulation of metals in well-flushed areas near the piling, metals that did leach from the wood were likely accumulating at downstream depositional sites.

CCA-treated wood is commonly available at retail lumber yards. In British Columbia, CCA is unlikely to be used for treating marine piling. CCA-treated wood can be stained green or brown, and is more likely than ACZA to be incised to permit penetration of the preservative into the wood.

3.3 AMMONIACAL COPPER QUAT (ACQ)

The active ingredients in ammoniacal copper quat are 62% to 71% copper oxide, and 29% to 38% quat (didecyldimethylammonium chloride or DDAC). ACQ is not registered for use in Canada, but ACQ-treated wood may be imported into Canada. It is generally used for dimension lumber, not usually exceeding 2x8 inches in size, and the wood is generally used in above-water installations such as decking. ACQ is not listed in the AWPA standards for wood placed in salt water or for any piling applications (WWPI 1998). Materials should only be used for those applications for which they are listed (Hayward 1999).

ACQ is considered to be an effective preservative for many western softwoods such as hemlock and Douglas-fir. Wood imported from the U.S. should have been treated according to BMP requirements. As with all treated-wood products, ACQ-treated wood should be visually inspected to ensure that there are no excessive pesticide residues on the finished product.

Brooks (1998a) included a risk assessment model for ACQ-B, the common formulation of this preservative. Following a recent study of treated wood in a wetland environment, Brooks (1999a) advised that ACQ-B appeared to lose more copper to the aquatic environment than CCA-C or ACZA. However, ACQ-B does not contain arsenic, chromium or zinc, which are present in CCA-C and/or ACZA.

4.0. WATER QUALITY ASSESSMENT OF A PROPOSAL FOR A TREATED-WOOD STRUCTURE

1. Consider the environmental risks associated with all types of construction materials, including treated wood and alternatives, particularly in sensitive shoreline areas. There are significant differences in the cost of various products. Alternatives to treated wood are generally more costly, but may be warranted.

    - Precast concrete structures may be advisable in areas with low current velocities and where there are anoxic, fine-textured sediments because such benthic areas exhibit relatively slow microbial degradation rates for creosote/PAHs. However, cast-in-place concrete operations may initially release water that is highly toxic because of elevated pH, and the work may increase water turbidity. In addition, use of alternatives to treated wood will dictate different construction techniques and machinery which could pose greater physical impacts on fish habitat.

- Steel structures are stronger than wooden ones, thus steel facilities can be built with fewer supporting members and with less associated environmental disruption, provided that the underwater substrate is suitable. Steel can require periodic repainting which sometimes involves repeated use of toxic paints, rust inhibitors and blasting abrasives. Often steel will require cathodic protection, usually in the form of sacrificial zinc anodes. In certain areas, such as shellfish growing waters, elevation of zinc levels may be of concern.
- Structural challenges for various foreshore projects can dictate development of innovative solutions. Damage to docking ships has been a growing concern to industry where steel and concrete are used, given that these materials lack the energy-absorption capacity of wooden structures.
- Untreated wood may be suitable for temporary use, or for structures with a relatively short lifespan, particularly in freshwater. However in salt water, structural integrity can be compromised by marine borer damage in a few years, thus dictating early structure replacement and associated habitat disruption.
- Full-pile polyurethane wraps can be used on treated or untreated wooden structures to ensure protection of particularly-sensitive habitats from wood leachates and from releases of creosote droplets. Other locations where wraps should be considered include areas having constricted water access, or those proximal to large volumes of treated wood. Some means of ensuring the integrity of the wrapping over time is required.
- Top caps are being examined for creosote-treated wood (Appleton 1998). It is hoped that such caps will effectively shield the supratidal portion of piles from solar heating and the possible blistering and spattering of creosote.
- New technology under development includes:
    - Plastic piling (pilot project was conducted at the CN terminal in Nanaimo in spring 1998);
    - Use of anchors rather than piling to hold floating structures in place (SCH is experimenting with durable Hardlast™ nylon rope);
    - Superwood, a plastic timber; and
    - TREX, a wood fibre and plastic composite used for decking.

Note: In some regions of the U.S. bans are being implemented on the use of plastics such as styrofoam in docks because of the litter produced as the material disintegrates.

2. When an unacceptable risk to the environment is expected, SCH engineers can assist HEB field staff in evaluating the potential for using alternatives to treated wood for specific projects.

3. If the proponent can demonstrate the need for preserved wood in a project, the proponent should then identify the most appropriate type of treated wood for the use required, considering existing environmental conditions at the site. For example, in an area with already-elevated PAHs in sediments, creosote-treated wood may not be acceptable and metal oxide-treated wood or non-wooden structures may be required.

4. In areas of low water hardness (i.e., 15-25 $mg \cdot L^{-1}$ $CaCO_3$), pH 5.5 or less and elevated background metals levels or metals-sensitive biota, the use of metal oxide-treated wood is not recommended.

5. In areas with anaerobic sediment, low total organic carbon in the sediment, or elevated background PAHs, the use of creosote-treated wood should be discouraged.

6. The proponent should make every effort to minimize or eliminate in-water or over-water (i.e., in situ) treatment. All end cuts and field boring should occur in an upland containment area where practicable. Over-water boring of treated wood should be minimized and all debris must be collected and deposited at an approved upland facility. Care should be taken to ensure there is no loss of wood-treatment chemicals into the aquatic environment. This may dictate the use of draping in treatment areas.

7. Losses of treated wood into the aquatic environment through abrasion can be minimized by armouring the wood with protective wear strips.

8. Timing restrictions may be required to protect sensitive aquatic species from physical impacts during construction, or to reduce the risk of exposing sensitive aquatic life stages to chemical contamination during initial submersion of the treated wood.

9. For all preserved wood, Fisheries and Oceans Canada staff should specify that the product is to be treated according to the above-referenced BMPs, and that the related post-treatment procedures (i.e., employment of vacuum recovery, expansion bath and steaming) are strictly followed. The installer and/or the supplier should guarantee provision of these measures, and be prepared to produce documentation to verify compliance.

5.0. RISK EVALUATION

To assist in risk assessment the industry has sponsored the development of risk assessment models that may be obtained through CITW. There are models available for creosote, CCA, ACZA (which may be used for ACA), ACQ-B and pentachlorophenol. Separate models are provided for bulkheads (BRISK) and piling (PRISK) projects. The models incorporate such variables as current velocity, sediment oxygen levels, sediment total organic carbon and the amount of treated wood involved in a project. The models allow input for background levels of metals, PAH or pentachlorophenol as appropriate, and so can be used in the assessment of cumulative effects.

Comparing the model predictions to actual values obtained through sampling indicates that the models are conservative (i.e., the models predict higher levels of contamination than have actually been measured). These models are currently being updated and will be made easier to use.

In conducting a site-specific risk evaluation, it is expected that the following factors will be considered:

- Average annual water temperature;
- Hardness and pH for water-borne preservatives, pH for pentachlorophenol;
- Salinity and related supporting information on marine borer prevalence;
- Background water chemistry, particularly concentrations of the metals and organic compounds found in the wood preservative;
- Current velocity and direction;
- Proximity to sensitive fish habitat (e.g., herring spawning habitat, eelgrass beds, kelp beds, juvenile rearing areas, shellfish areas);
- Timing of proposed construction;
- Size of proposed structure/number of treated piles;
- Chemical used in treatment and the application methods to be employed;
- Proximity of other preserved-wood structures;
- Other sources of contamination which may contribute to cumulative effects;
- Existing sediment chemistry (PAH, metals – Cu, As, Zn, Cr);
- Sediment characteristics (i.e., grain size);
- Sediment total organic carbon and redox potential when oil-borne preservatives (e.g., creosote) are proposed;
- Expertise of proponent and construction crew;
- Precedent-setting aspects of decisions; and
- Regional consistency.

6.0. SUMMARY

- Installation of any kind of piling can cause physical and chemical impacts on benthic habitats and fisheries resources.
- Treated-wood piles lose preservative chemicals into water and sediment; the rate and duration of leaching are governed by the pre-treatment condition of the wood, its species, the chemical, the treatment process used, the initial chemical charge, post-treatment steps and the nature of the environment into which it is placed.
- There should be no in situ or residential treatment of wood used in the aquatic environment. Creosote oil and copper naphthenate are wood-treatment products commonly sold at lumber yards for homeowner application. Only factory-treated wood bearing the BMP mark should be considered for aquatic use.
- In-water storage of treated wood for extended periods is not acceptable.
- For most estuarine and all freshwater installations the use of alternatives to creosote is recommended. In those few instances where the flexibility and durability of an oil-borne treatment is critical to the project, or where there is particularly low water pH and hardness, or high background metals levels (e.g., copper), the use of creosote-treated wood may be acceptable.
- Based on the recent Sooke Basin study, which was designed to reflect worst-case marine conditions, in the first year of the study sediment contamination by PAHs was restricted to within 7.5 metres of a six-piling creosoted dolphin treated to BMP standards.

- A single six-piling creosote-treated dolphin in a low current marine area would be expected to have localized, short-term impacts on benthic infauna. Part of this impact would be due to the physical disturbance during installation and the on-going physical presence of the structure. After the microbial flora have built up to break down PAHs following installation of the treated-wood structure (at Sooke Basin it took as much as 1000 days), the rate of microbial degradation of PAHs should exceed the deposition rate.
- ACZA when properly fixed in piling is expected to leach for the first week when submerged in water then decline to very low levels.
- CCA leaching from BMP-treated wood occurs mostly in the first 3 weeks after the treated wood is submerged, after which time leaching declines to very low levels. Elevated levels of copper in fine-grained sediments can be expected near the treated wood which could result in localized impacts to benthic communities.
- For all installations of treated-wood products, timing restrictions are recommended to protect aquatic resources from the initial release of wood-treatment chemicals following installation.
- Railway ties are treated by a different process than piling and should not be assessed using the present Guidelines, nor should ties be placed in aquatic habitat.

Further information is required concerning the impacts of creosote-treated wood, as follows:

- Phototoxicity of PAHs released from creosote-treated wood has not been fully studied in relation to aquatic life;
- Four years after installation, the BMP piling at Sooke Basin continued to show visible tar-like surface deposits of creosote. This experiment has shown that even though BMP piling lose less creosote than more heavily-treated piling, there continues to be some loss of PAH to the aquatic environment. The effects of this continuing exposure of local biota to PAHs have not been addressed;
- More work on endocrine disruption in aquatic life and PAHs is warranted;
- Data on the freshwater effects of creosote are limited, although the recent work reported in Brooks (1999b) showed that impacts at many sites appear to be insignificant. More information is required to fully evaluate the impact of creosote in freshwater;
- Tainting of aquatic organisms from exposure to creosote has not been fully addressed and may have implications for human use of fish; and
- More research is required on impacts to aquatic organisms of long-term exposure to low levels of mixtures of contaminants such as wood-treatment chemicals.

7.0. CONCLUSIONS

The use of treated wood in the aquatic environment is a controversial topic. The installation of treated-wood structures has both a physical and a chemical impact on the immediate aquatic environment. Many studies have been conducted to determine effects of treated wood in freshwater and marine installations. The use of Best Management Practices (CITW and WWPI 1997) for the in-plant application of wood-treatment pesticides and implementation of post-treatment recovery procedures reduces problems caused by the excessive use/improper fixation of treatment chemicals which are lost into the aquatic environment. Creosote-treated wood will lose PAHs to the water as long as the wood is in service. Metal oxide-treated wood will leach primarily in the first few weeks after installation, although some metals will continue to be lost at

very low levels for months. Low levels of PAHs are biodegradable in aerobic sediments once appropriate microbial flora have become established. In anerobic sediments, PAHs may not be broken down appreciably.

There may be some freshwater installations where the flexibility and softness of creosote-treated wood are critical to a project. In such cases, and in freshwater areas where there is very low pH and hardness, or high background metals levels (e.g., copper), creosote-treated wood structures will be considered. In the review of such projects, consideration will be given to the biological sensitivity of the site and its sediment characteristics in terms of whether they would be conducive to the aerobic break down of PAHs. Metals leaching from treated wood are not degraded in the environment and as stated above, this may be a concern in low pH, low hardness waters where elevated copper already is in evidence. In such areas, the use of metal oxide-treated wood may be unacceptable.

In light of the lack of conclusive data on the long-term impacts of treated wood on the aquatic environment, a precautionary approach is required.

The following 15 points should always be considered in the review of proposals to use treated wood in water.

1. There will be an impact on fish habitat from the presence of a structure, whatever the construction material;
2. Alternatives to treated wood should be used wherever practicable;
3. Only wood treated to BMP specifications will be acceptable in or adjacent to aquatic areas;
4. The volume of treated wood used in water should be minimized by utilizing alternative materials and designs;
5. For most projects, creosote-treated wood is not required or recommended for use in freshwater;
6. Proposals to use exposed creosote-treated wood for above-water structures should be carefully evaluated, and only accepted when there is no alternative. Every effort must be made to shield the creosote-treated wood from exposure to solar heating and to prevent entry of the pesticide into the aquatic environment;
7. In areas where the water pH is less than 5.5, or where high background copper levels are present, the use of metal-oxide or waterborne preservatives may not be appropriate;
8. In areas with anaerobic sediments and low organic content, creosote-treated wood should not be used;
9. Timing restrictions on projects are generally required to ensure that particularly-sensitive biota are not exposed to the first flush of chemical released after installation of treated-wood products. In addition, the non-routine prewashing of metal oxide-treated wood at the treatment plant may be necessary;
10. Absorbent booms must be deployed and maintained during installation of all structures using oil-borne wood treatments. These booms should remain in place and operational until such time as visible evidence of wood-treatment chemicals on the water surface is no longer apparent;

11. All cutting and boring of treated wood should take place in upland areas; all waste materials must be kept out of the aquatic environment and be properly disposed of upland. Such work that must be done in situ is to be fully contained so that no waste materials are deposited into water or onto aquatic sediments;
12. Any cut wood, chips or sawdust that enters the aquatic environment is to be promptly collected and later disposed of at an acceptable upland site;
13. In situ application of wood-treatment chemicals is generally not acceptable. In the event that minor application of wood-treatment chemicals is required after construction of a treated-wood structure, all application areas must be contained or tarped so that no chemicals are deposited into the water or onto aquatic sediments;
14. Due to the availability of alternate chemicals, pentachlorophenol-treated wood should be discouraged for use in water; and
15. Railway ties are not covered by these Guidelines, nor should they be used in aquatic structures.

8.0. REFERENCES

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APPENDIX A

RECENT REPORTS

A.1. BEST MANAGEMENT PRACTICES FOR THE USE OF TREATED WOOD IN AQUATIC ENVIRONMENTS (CITW and WWPI 1997)

The BMPs outline treatment and post-treatment procedures to be followed to reduce the potential for chemicals to be lost from treated wood. Reference is made to computer models which were developed to predict concentrations of contaminants released from treated wood under various environmental conditions. The CREORISK model calculates probable sediment PAH degradation rates based on factors such as sediment particle size, oxidation/reduction potential and organic content. Field testing has shown the model is conservative, that is, the model predicts somewhat higher PAH concentrations in sediment, and significantly higher concentrations of dissolved PAH in water than what has actually been observed.

The BMPs are designed so that an environmentally-sensitive product is manufactured. Some information is included on environmental considerations for use of treated wood in aquatic environments. Further information is provided in the Risk Assessment Documents (Brooks 1997a, b, c; Brooks 1998a, b) upon which the BMP recommendations are largely based. Environment Canada advised Fisheries and Oceans Canada that its regional staff will adopt these BMPs as recommended guidelines, while recognizing that site-specific conditions will affect the advice provided.

A.2. CREOSOTE EVALUATION PROJECT (EVS Consultants Ltd. 1994)

A study was undertaken in the early 1990s to identify PAH concentrations and the toxicity of sediments from two Lower Mainland sites near creosote-treated piles. One site was at Westham Island in the Fraser River estuary where piles were more than 8 years old and there was significant water exchange and sediment transport. The second site was at Belcarra Bay, Indian Arm, where piles were newer (i.e., less than 5 years old), the sediment carbon content was higher and there was a lower rate of water exchange (i.e., the current velocity was less than 5 $cm \cdot s^{-1}$) compared with that of the Westham Island site.

Results showed that sediment PAH concentrations at the Westham Island site were low. Amphipod survival was greater than 90%, and Microtox™ tests showed marginal impacts from the sediments collected near the piles. At the Belcarra Bay site, sediment PAH levels exceeded background levels within a 10-metre radius of the treated piles. Amphipod survival was lower than at the Westham Island site and Microtox™ inhibition was significant. A factor at the Belcarra Bay site was the elevated background levels of PAH which contributed to the toxicity observed.

The study showed that the cumulative effects of dense aggregations of creosote-treated piling in an industrial area with significant levels of background PAH and slow currents, resulted in biological stress in laboratory bioassays. No loss of biological integrity was documented in a

moderately well-flushed freshwater site with significant numbers of older piling. The severity of the effects is dependent on factors such as:

- Age of the piling;
- Current velocity; and
- Sediment grain size and total organic content.

A.3 CREOSOTE EVALUATION: PHASE II. SOOKE BASIN STUDY – BASELINE TO 535 DAYS POST CONSTRUCTION. 1995-1996 (Goyette and Brooks 1998)

Environment Canada, Fisheries and Oceans Canada (Habitat and Enhancement Branch, HEB and SCH), MELP and CITW have been conducting a study in Sooke Basin on Vancouver Island to further examine the research questions posed for the 1994 EVS project (Goyette and Brooks 1998). The Sooke study was designed to assess in situ environmental effects on marine organisms and associated habitats from newly installed, BMP creosote-treated, and weathered, non-BMP creosote-treated piles. The monitoring program included sampling of wood cores from the piles, water column chemistry, sediment chemistry, benthic infaunal community analysis, liquid and solid phase Microtox™, echinoderm fertilization, and mussel (*Mytilus edulis edulis*) spawning and larval development tests. The study was designed to be a worst-case scenario and to be completed in 12 months, but initial results indicated that more extensive monitoring of sediments and biota was warranted, thus some limited additional sampling was conducted 18 months into the project.

Results showed that sediment PAH concentrations were highly variable. Comparison to values generated by the model developed by Brooks (1997a) showed that it tended to be conservative (i.e., it predicted higher concentrations of preservative chemicals in the aquatic environment than have been measured in verification studies). This conservative tendency has been apparent in five field trials, and the model appeared to be a useful tool for evaluating the environmental risks associated with creosote-treated wood.

Interestingly, no adverse effects were observed in the benthic community at any distance from the creosote-treated dolphins when compared to either the untreated Douglas-fir dolphin or the open control containing no structure. Amphipod survival and Microtox™ luminescence were lower in sediments collected immediately adjacent to both the untreated and treated dolphins when compared to the local reference station. These bioassay tests suggested greater adverse effects at the creosote-treated dolphin when compared to the untreated Douglas-fir structure. Significant adverse effects were restricted to distances less than 0.65 metre from the creosote-treated dolphins in this study under low current conditions. Sediment chemistry results indicated that PAHs were elevated at 7.5 metres downcurrent from the treated dolphin but declined to near background levels at 10.0 metres. In the first year after installation, creosote losses from the BMP-treated dolphin were similar to those from the dolphin constructed of weathered (i.e., used) creosote-treated piling. After 18 months, the PAH levels in sediments had not yet reached their peak and were projected to increase another 18% to their predicted maximum at 1,000 days post-installation.

Benthic toxicity tests showed some effects using sediment collected within 0.5 metre of the BMP-treated piles, the weathered, treated piles, and the untreated Douglas-fir piles. Accumulation studies with mussels showed some uptake of PAHs up to 2 metres from all creosote-treated piles. Levels of PAHs in tissues of caged mussels increased immediately after installation of the piling, and returned to pre-exposure levels by the next sampling event on Day 185. Mussel growth increased with distance from the creosote-treated piling. No adverse effects were observed on mussel survival, condition factor, spawning success or development of juveniles from any of the test sites at the treated or untreated dolphins.

It appeared that creosote was being deposited in sediments as small particles. The manner in which creosote was being lost from the piling was not investigated in this study. An initial surface sheen was noted during installation, but not quantified. However, dissolved PAH in the water column was measured on Day 250 and found to be only slightly elevated over background, and only in close proximity to the treated wood. The measured water column concentrations of PAH were not considered to be a significant concern for aquatic life protection, and sediment contamination was expected to be highly localized.

Goyette and Brooks (In Prep.) found that four years after installation, the appearance of tar-like deposits on bottom sediments near the piles was less common, and surface sediment PAH concentrations had declined from levels noted in Year 1 of the study (Goyette and Brooks 1998). Creosote losses from the BMP piling declined from Year 1 levels, due in part to extensive biological growth encasing the pile. The heavy marine growth also resulted in the deposition of large amounts of biological debris around the piles. This caused the formation of anaerobic conditions in the sediments, with levels of hydrogen sulphide that were toxic in benthic bioassays. This occurred at the untreated, weathered and BMP piling sites.

These authors have hypothesized that a significant amount of the localized sediment PAH contamination may originate from that portion of the piling exposed to sunlight, and that solar heating may draw the creosote to the surface of the piling. On the submerged portion of the piling, algal and mussel growth, and the limited exposure to solar heating in this zone, may restrict this route of creosote loss. Further study of this hypothesis could lead to a better understanding of the transport routes of creosote, and possible mitigation strategies to reduce the potential for impacts on the aquatic environment.

APPENDIX B

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITY SUBSTANCES LIST, STRATEGIC OPTIONS PROCESS

Environment Canada and partners are currently reviewing chemicals on the *CEPA* Priority Substances List (PSL). The management of toxic substances is guided by the CCME Policy for the Management of Toxic Substances (PMTS). Under PMTS, substances are managed in two ways: Track 1 substances are targeted for virtual elimination and include largely persistent, bioaccumulative substances; Track 2 substances are managed through a life-cycle approach with management options developed through a Strategic Options Process (SOP). The SOP is a consultative mechanism that provides the basis for recommendations to ministers, and includes a cradle-to-grave management approach for toxic substances, emphasizing technical controls at each phase of production, use and disposal, as appropriate. The SOP Issue Table includes representatives from Federal and Provincial regulatory agencies, consultants, ENGOs and industry. Fisheries and Oceans Canada has provided some input to the process and continues to seek opportunities to participate as an observer.

Recommendations to ministers may include the development of BMPs for the lifecycle management of creosote-treated wood products and wastes. To ensure national consistency, the provinces are consulted on SOP recommendations through existing federal/provincial consultative mechanisms. The Wood Preservation Issue Table could recommend amendments to the registration of creosote under the *Pest Control Products Act* to facilitate further controls on creosote-treated materials and wastes, but that or any other regulatory initiative under the SOP consultative process will not result in immediate changes to the use of treated wood in aquatic environments.

Of more immediate interest is the SOP Report for creosote-treated materials and wastes which was made available late in 1999. This document included a recommendation that BMPs be developed for the use of creosote-treated wood, including use in aquatic and terrestrial environments. It is anticipated that these BMPs will address in very general terms the ecological significance of creosote-treated wood in aquatic use and will support the present, more detailed and specific Fisheries and Oceans Canada Guidelines by increasing the awareness in industry and the public of the potential implications of using treated wood in aquatic environments.

Also included on the SOP list are arsenic and chromium which are constituents of CCA and ACA/ACZA, and dioxins and furans which occur as impurities in pentachlorophenol. The review of these chemicals by government and industry may result in management decisions that have implications for wood treatment and the aquatic use of treated wood.

APPENDIX C

WATER AND SEDIMENT QUALITY GUIDELINES

Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 1999)

WATER

Metals ($\mu g \cdot L^{-1}$)	**Freshwater**	**Marine**
Arsenic	5.0	12.5 [a]
Chromium VI	1.0	1.5
Chromium III	8.9 [a]	56 [a]
Copper at various water hardnesses:		
$CaCO_3$ <120 $mg \cdot L^{-1}$	2	
$CaCO_3$ 120-180 $mg \cdot L^{-1}$	3	No recommendation
$CaCO_3$ >180 $mg \cdot L^{-1}$	4	
Zinc	30	No recommendation

[a]Interim Guide

Polycyclic Aromatic Hydrocarbons (PAH, interim guidelines) ($\mu g \cdot L^{-1}$)	**Freshwater**	**Marine**
Acenaphthene	5.8	Insufficient data
Anthracene	0.012	Insufficient data
Benz(a)anthracene	0.018	Insufficient data
Benzo(a)pyrene	0.015	Insufficient data
Fluoranthene	0.04	Insufficient data
Fluorene	3.0	Insufficient data
Naphthalene	1.1	1.4
Phenanthrene	0.4	Insufficient data
Pyrene	0.025	Insufficient data

Freshwater Sediments

Metals ($mg \cdot kg^{-1}$ dry weight)	**ISQG**	**PEL**	**AEL[b]**
Arsenic	5.9	17.0	11
Chromium	37.3	90.0	64
Copper	35.7	197	120
Zinc	123	315	220

Low Molecular Weight Polycyclic Aromatic Hydrocarbons ($\mu g \cdot kg^{-1}$ dry weight)	**ISQG**	**PEL**	**AEL[b]**
Acenaphthene	6.71 [a]	88.9 [a]	48
Acenaphthylene	5.87 [a]	128 [a]	67
Anthracene	46.9 [a]	245 [a]	150
Fluorene	21.2 [a]	144 [a]	83
Naphthalene	34.6 [a]	391 [a]	210
Phenanthrene	41.9	515	280

High Molecular Weight Polycyclic Aromatic Hydrocarbons ($\mu g \cdot kg^{-1}$ dry weight)	**ISQG**	**PEL**	**AEL[b]**
Benz(a)anthracene	31.7	385	210
Benzo(a)pyrene	31.9	782	410
Chrysene	57.1	862	460
Dibenz(a,h)anthracene	6.22 [a]	135 [a]	71
Fluoranthene	111	2355	1200
Pyrene	53.0	875	460

Source: CCME (1999)

Notes:
ISQGInterim sediment quality guideline
PEL Probable effects level
AEL Average effects level ((PEL + ISQG)/2 = AEL). Suggested remediation target for contaminated sediments
[a] Provisional Guideline
[b] British Columbia Ministry of Environment, Lands and Parks (1998)

Marine Sediments

Metals ($mg \cdot kg^{-1}$ dry weight)	**ISQG**	**PEL**	**AEL[b]**
Arsenic	7.24	41.6	24
Chromium	52.3	160	110
Copper	18.7	108	63
Zinc	124	271	200

Low Molecular Weight Polycyclic Aromatic Hydrocarbons ($\mu g \cdot kg^{-1}$ dry weight)	**ISQG**	**PEL**	**AEL[b]**
Acenaphthene	6.71	88.9	48
Acenaphthylene	5.87	128	67
Anthracene	46.9	245	150
Fluorene	21.2	144	83
Naphthalene	34.6	391	210
Phenanthrene	86.7	544	320

High Molecular Weight Polycyclic Aromatic Hydrocarbons ($\mu g \cdot kg^{-1}$ dry weight)	**ISQG**	**PEL**	**AEL[b]**
Benz(a)anthracene	74.8	693	380
Benzo(a)pyrene	88.8	763	430
Chrysene	108	846	480
Dibenz(a,h)anthracene	6.22	135	71
Fluoranthene	113	1494	800
Pyrene	153	1398	780

Source: CCME (1999)

Notes:
ISQG Interim sediment quality guideline
PEL Probable effects level
AEL Average effects level ((PEL + ISQG)/2 = AEL). Suggested remediation target for contaminated sediments
[b] British Columbia Ministry of Environment, Lands and Parks (1998)

APPENDIX D

CHECKLIST FOR PROJECT REVIEWERS

Construction of Treated-Wood Structures

Site Considerations:

- Determine the type (freshwater, estuarine, marine) and sensitivity of the aquatic environment and the overall acceptability of the proposed project.
- Determine timing windows for sensitive life stages of biota.
- Consult the Marina Development Guidelines (1995) in terms of minimizing biophysical impacts of structures.

Selecting the Most Appropriate Materials:

- Consider the use of alternative construction materials such as pre-cast concrete, steel and plastic wherever practicable.
- Encourage the use of anchors rather than pilings for floating structures.
- Request pre-cast concrete in areas with low current velocity and anoxic, fine-textured sediments (see Table 1, below).
- Railway ties are not acceptable for use in aquatic environments.
- Specify that all treated wood used in or over water must have a BMP certification mark.
- PCP-treated wood should only be considered for use where it will not be immersed in water (e.g., overhead construction).
- Douglas-fir is the most common wood used locally for marine piling. Most marine piling is treated with creosote. Considering the metal-oxide pesticides, Douglas-fir is most appropriately treated with ACZA. CCA is effective on other softwood species, including western hemlock and ponderosa pine.
- ACQ-treated wood is not appropriate for marine use. In marine areas, the use of ACQ-treated wood should be limited to above-water applications such as decking.
- Creosote-treated wood should only be used in situations where marine borers are a risk, or where there is a demonstrated need for the flexible and durable qualities imparted to the wood by creosote.
- Creosote-treated wood should not be used in locations with anaerobic sediments with low total organic carbon (see Table 2, below), or elevated PAH levels (see Appendix C).
- Metal-salt treated wood should not be used in conditions of low water hardness (15-25 $mg \cdot L^{-1}$ $CaCO_3$), low pH (≤5.5), elevated background metals levels (see Appendix C) or where metals-sensitive biota (e.g., shellfish) are prevalent.
- Where ambient levels of heavy metals are already high and CCA-, ACZA- or ACA-treated wood is proposed for use, consider having the wood pre-washed at the manufacturing site.

Design Details to Consider:

- Avoid approving the use of large volumes of treated wood in structures in aquatic environments.
- Request artificial shading, collectors, protective caps, wrapping or coatings for creosote-treated structures in conditions of intense solar exposure and/or elevated temperatures.
- Request that treated-wood surfaces subject to abrasion be armoured with protective wear strips (e.g., high-density polyethelene).

Best Construction Practices:

- Specify that all treated wood used in or near water must have a BMP certification mark.
- Direct the proponent to visually inspect and reject any wood that has obvious surface residues or bleeding of preservative.
- Require the inspection and rejection of any ACA or ACZA-treated wood that has an obvious ammonia odour.
- Require that all CCA-treated wood pass a chromotropic acid test before it is used.
- Minimize the in-water storage of treated wood during construction of the structure.
- Minimize the introduction of treated-wood debris into the aquatic environment by promoting prefabrication on land, containment of cuttings with draping, and the disposal of debris on land in accordance with Provincial and Municipal laws and policies.
- Specify containment and recovery techniques for any debris that enters the water.
- Request the deployment of absorbent booms during the installation of oil-based treated-wood pilings.
- Avoid the hand dressing of end cuts over water; wherever possible treat in a contained upland area. Where this is not possible, prevent pesticide entry into the water with the use of draping.

Decommissioning of Treated-wood Structures

- Remove the entire pile using a slow steady pull to minimize the disturbance of the substrate and avoid bringing contaminated sediments to the surface.
- If the pile breaks off below the biologically-active sediment zone, the impacts from dredging out the remainder may outweigh any benefit of removing a minor PAH source.
- The recovered wood must be disposed of or reused in an appropriate manner and in accordance with applicable Provincial and Municipal laws and policies.

Other Considerations

- Advise proponents of the *CEPA* maximum PAH level (2.5 $\mu g \cdot g^{-1}$) in sediments proposed for ocean disposal.
- Consider the potential for additional contamination of surface water and groundwater where the use of treated wood is proposed for adjacent upland construction projects.

Maximum current speed ($cm \cdot sec^{-1}$)	Depth of the reduction-oxidation potential discontinuity (cm)						
	0.0	0.5	1.0	1.5	2.0	3.0	4.0
0.5	262.96	120.25	66.79	43.83	33.05	25.50	24.57
1	131.48	60.13	33.4	21.91	16.52	12.75	12.29
2	65.74	30.06	16.7	10.96	8.26	6.37	6.14
3	43.83	20.04	11.13	7.30	5.51	4.25	4.10
4	32.87	15.03	8.35	5.48	4.13	3.19	3.07
5	26.30	12.03	6.68	4.38	3.30	2.55	2.46
6	21.91	10.02	5.57	3.65	2.75	2.12	2.05
7	18.78	8.59	4.77	3.13	2.36	1.82	1.76
8	16.43	7.52	4.17	2.74	2.07	1.59	1.54
9	14.61	6.68	3.71	2.43	1.84	1.42	1.37
10	13.15	6.01	3.34	2.19	1.65	1.27	1.23
11	11.95	5.47	3.04	1.99	1.50	1.16	1.12
12	10.96	5.01	2.78	1.83	1.38	1.06	1.02
13	10.11	4.63	2.57	1.69	1.27	0.98	0.95
14	9.39	4.29	2.39	1.57	1.18	0.91	0.88
15	8.77	4.01	2.23	1.46	1.10	0.85	0.82
16	8.22	3.76	2.09	1.37	1.03	0.80	0.77
17	7.73	3.54	1.96	1.29	0.97	0.75	0.72
18	7.30	3.34	1.86	1.22	0.92	0.71	0.68
19	6.92	3.16	1.76	1.15	0.87	0.67	0.65
20	6.57	3.01	1.67	1.10	0.83	0.64	0.61

Table 1. Summary of least-risk (unshaded), moderate risk (lightly shaded) requiring additional risk assessment, and unsuitable (darkly shaded) environments with respect to the use of creosote-treated wood in marine environments. Table values are predicted maximum total sediment PAH in $\mu g \cdot g^{-1}$ (ppm) dry sediment weight, based on sediments containing 1.0% total organic carbon, located 0.33 metres from any of 4 newly-treated BMP piles installed in a row parallel to the currents and spaced 6 feet apart. (Goyette and Brooks 1998).

Puget Sound reference values for total organic carbon	
Silt-clay particles (percent dry weight)	**Total organic carbon (percent dry weight)**
0-20	0.5
20-50	1.7
50-80	3.2
80-100	2.6

Table 2. Total organic carbon in sediments. (Washington Department of Ecology 1991). Total organic carbon values less than those indicated in this table are be considered to be low values and may indicate areas unsuitable for the use of creosote-treated wood.

Best Management Practices for Pile Driving and Related Operations – BC Marine and Pile Driving Contractors Association - March, 2003

The BC Marine and Pile Driving Contractors Association and Fisheries and Oceans Canada (DFO) have developed a Best Management Practices Policy for pile driving operations and related activities when working on the water within the province of British Columbia.

The Pile Driving Industry utilizes many different construction methods, equipment and materials in order to complete the contractual obligations for its client. Hammers; including drop, diesel, air, vibratory and hydraulic, vibroflot, and rotary, air and churn drills are the primary instruments in a pile driving operation. These hammers and drills are supported by a wide variety of heavy equipment, including a range of conventional cranes (truck mounted, crawler and pedestal mounted), spud scows, support barges and other water borne equipment. The piling types include treated timber (primarily creosote), concrete and steel (pipe, h-beam and sheet). Construction projects have the potential to utilize a number of different combinations of equipment and materials. It is the purpose of this document to examine the characteristics of each potential combination and develop a Best Management Practices Policy that will meet the following criteria:

-Maximize environmental protection
-Avoid contravention of the Fisheries Act
-Provide construction services economically

1)- Basic Rules of Operation

When in an aquatic environment, contractors will employ the following BASIC Best Management Practices:

- All equipment will be maintained in good proper running order to prevent leaking or spilling of potentially hazardous or toxic products. This includes hydraulic fluid, diesel, gasoline and other petroleum products.
- Storage of fuels and petroleum products will comply with safe operating procedures, including containment facilities in case of a spill.
- Pile cut-offs, waste or any miscellaneous unused materials will be recovered for either disposal in a designated facility or placed in storage. Under no circumstances will materials be deliberately thrown overboard.
- Contractors will have emergency spill equipment available whenever working near or on the water.
- Contractors, where possible, will position their water borne equipment in a manner that will minimize damage to identified fish habitat (i.e. eelgrass). Where possible, alternative methods will be employed (i.e.: use of anchors instead of spuds). In the event that circumstances will not allow an alternative, contractors will minimize the

damage and where required restore habitat to its original state at the completion of the project.

- Prior to the commencement of any work, the contractor will complete and forward the attached "Notice of Project" to the Department of Fisheries and Oceans. Letters of advice or Habitat Authorizations may be required, depending on the scope of work proposed.
- If contractors are working and a herring (or other fish) spawning occurs, the work will be temporarily suspended and the appropriate DFO contact notified.
- There will be no restriction of work during closure periods (the only exception being when spawning is present), provided the contractors employ an exclusion device (protective netting or geotextile material suspended in the water column around pile driving area) around the work area to prevent fish access or when required, an effective method of mitigating shock waves (bubble curtain).
- Whenever shock wave monitoring (hydrophone) is performed at a marine construction site and the findings are available to the contractor, the data will be forwarded to the BC Marine and Pile Driving Contractors Association and Svein Vagle at the Institute of Ocean Sciences in Sidney, BC. It is hoped that a database can be built that will catalogue work procedures and reflect the safest and most economical approach to protecting the fish and their habitat.

2)-Timber Piling (creosote):

When driving timber piling, the following Best Management Practices will be employed to minimize/prevent impact to marine fish and their habitat:

- Where possible, new timber piles will comply with the best Management Practices for the use of treated wood in aquatic environments as developed by the Canadian Institute of Treated Wood and the Western Wood Preservers Institute and the DFO document "Guidelines to Protect Fish and Fish Habitat from Treated Wood Used in Aquatic Environments in the Pacific Region".
- Where the above is not possible creosote piling will stand (weather) for a minimum of 45 days prior to installation.
- These requirements are for new piling only. Reused piling will not be subject to any additional treatments, however, pilings with excessive creosote should be avoided.
- Timber piling is normally driven using a drop hammer, a diesel/air impact hammer or a small vibratory hammer. Because of the relative small diameter of the timber pile, and its excellent energy absorbing quality, there is little threat of sound pressure impacts to fish and their habitat when driving timber piles.
- Environmental monitoring of sound pressure impacts is not required.
- When demolition is required on timber pile structures, the contractor will remove the piling by mechanical means and avoid breaking the piling at the mud line or below. All demolition operations should be monitored in order to control and contain the construction debris and to determine whether there are any effects on fish.

3)-Concrete Piles

When driving concrete piles, regardless of which hammer is being used, the following Best Management Practices will be employed to minimize/prevent impacts to fish habitat:

Less than 24 inch diameter

- The physical design of 24 inch concrete pile dictates that: 1/ the energy required must be controlled in order to prevent the pile from breaking and 2/ the concrete construction of the pile will absorb the energy. These two factors are expected to result in low level shock wave emission (less than 30 kPa.) and minimal or no effects to fish and their habitat should result.
- Environmental monitoring of sound pressure levels is generally not required.

Greater than 24 inch diameter

- When driving concrete piles with a diameter greater than 24 inches using an impact or hydraulic hammer, the following Best Management Practice will be employed to minimize the impact on fish habitat:
- Visual and hydrophone monitoring of the impact on fish by the sound waves emitted will be required. If sound pressures over 30 kPa is measured or a fish kill is evident, the contractor will introduce effective means of reducing the level of the shock waves. Appropriate mitigating measures would be the deployment of a bubble curtain over the full length of the wetted pile. This should reduce the shock waves to an acceptable level.
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately and the methods will be reviewed and corrected.

4)-Steel Pipe Piles

Less than 18 inch diameter

When driving steel piles 18 inches in diameter and less, regardless of the type of hammer being used, the following Best Management Practices will be employed to minimize/prevent impacts to fish habitat:

- Because of the small diameter of the pile it is assumed that the energy required to drive the pile to the final point of installation will not result in shock waves in excess of 30 kPa, therefore, protective measures to reduce shock waves are not expected to be required.

- If, however, ground conditions during pile installation cause a fish kill, work will cease and contractors will be responsible for introducing effective means of reducing the level of shock waves or will introduce measures that will prevent fish from entering the potentially harmful shock wave area. Appropriate mitigating measures would include the deployment a bubble curtain over the full length of the wetted pile. This technique should reduce the shock waves to an acceptable level.
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately and the methods will be reviewed and corrected.

Greater than 24 inches in diameter

When driving steel pipe piles with a diameter greater than 24 inches using impact or hydraulic hammers, the following Best Management Practices will be employed to minimize/prevent impacts to fish habitat:

- Hydrophone and visual monitoring of the effects of the shock waves on fish will be required. If a fish kill occurs, the contractor will introduce effective means of reducing the level of the shockwave. Appropriate mitigating measures would be the deployment of a bubble curtain over the full length of the wetted pile.
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately and the methods will be reviewed and corrected.

5)-Steel Sheet Piles and H-piles

When driving steel sheet piles and H-piles with a drop hammer, an impact hammer or a vibratory hammer, the following Best Management Practices will be employed to minimize the impact on fish habitat:

- It is anticipated that the driving of these types of piles will not generate shock waves in excess of 30kPa, therefore, mitigating measures are not expected to be required.
- If, however, ground conditions during pile installation cause a fish kill, work will cease and contractors will be responsible for introducing effective means of reducing the level of shock waves or will introduce measures that will prevent fish from entering the potentially harmful shock wave area. Appropriate mitigating measures would include the deployment a bubble curtain over the full length of the wetted pile. This technique should reduce the shock waves to an acceptable level.
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately and the methods will be reviewed and corrected.

6)-Stone Column Construction

When installing stone column using a vibroflot, the following Best Management practices will be employed to minimize/prevent impacts to fish habitat:

- The vibrating action and air flush associated with the operation of the probe results in a high degree of turbidity. When this level exceeds the criteria as outlined in the British Columbia Approved Water Quality Guidelines, the contractor will introduce containment methods that are designed to isolate the contaminated area and to prevent fish from entering the contaminated area. Silt curtains and netting are two methods that can provide the necessary protection.
- When supplying the aggregate to the probe, the contractor will ensure that spillage is prevented, thereby providing additional protection to fish habitat.
- An independent environmental consultant will be used to monitor turbidity levels.

7)-Underwater Drilling and Blasting

When performing underwater drilling and blasting the following Best Management Practices will be employed to minimize/prevent impacts to fish habitat:

<u>Underwater Drilling</u>

- Generally, drilling underwater is a process that has very little impact on fish or fish habitat. The procedure does not generate shock waves.
- Contractors will ensure that all attachments (hydraulic connections and couplings) are in good operating order and inspected prior to the start of every day. Spill kits and containment booms must be maintained on-site in case of spills.
- Depending on soil conditions and the potential for turbidity, drill cuttings will be deposited adjacent to the operation, contained on the sea bed or pumped to the surface for deposit into containment skiffs or scows for land disposal when it is determined that the drill cuttings are unsuitable for return to the environment.

<u>Underwater Blasting</u>

Contractors required to perform blasting underwater will provide the following protection to minimize/prevent impacts to fish habitat:

- Because of the potential for harmful shock waves resulting from a blast, a protection shield will surround the immediate blast area. This would be in the form of an air-induced bubble curtain, which has the primary purpose of absorbing the shock wave and a secondary purpose of preventing fish from entering the blast area.
- In order to protect against flying rock, mats (rubber) will be placed over the blasting area. The placement of the mats may also provide protection for any fish swimming in the immediate area.

- Monitoring of fish movement and concentrations will be conducted using a sounder to determine if fish herding or scaring techniques (seal bombs) can be utilized to reduce the presence of fish in the blast area.

8)-Cleaning out Pipe Piles:

When cleaning out pipe piles (i.e.: air lifting) the following Best Management Practices will be employed to minimize/prevent impacts to fish habitat:

- Generally, sediment contained in the pipe is will be pumped to the surface and processed through an approved containment system and disposed of at an approved landfill site.
- In exceptional circumstances, if the sediment is non-toxic, fish are not present in the area, and adjacent fish habitats are not a concern (contact DFO) it may be acceptable to:

1. Pump the sediment through a discharge tube and allowed it to settle in the immediate area with or without a silt curtain to contain the sediment.
2. Pump the sediment through a discharge tube and additional flex hosing and redirect it back to the base of the pile.

9) Containment of Concrete Residue and Water Run Off

When placing concrete in form work over or in water, the following Best Management Practices will be employed to minimize/prevent the impacts to fish habitat:

<u>Pouring concrete</u>

- Spills: When pouring concrete all spills of fresh concrete must be prevented. Concrete is toxic to fish due its high pH. If concrete is discharged from the transit mixer directly to the formwork or placed by wheelbarrow, proper sealed chutes must be constructed to avoid spillage. If the concrete is being placed with a concrete pump, all hose and pipe connections must be sealed and locked properly to ensure the lines will not leak or uncouple. Crews will ensure that concrete forms are not filled to overflowing.
- Sealing forms: All concrete forms will be constructed in a manner which will prevent fresh concrete or cement-laden water from leaking into the surrounding water.

<u>Curing concrete</u>

- When fresh water is used to cure concrete, the run off must be monitored for acceptable pH levels. If the pH levels are outside the allowable limits then the run off water must be contained and neutralized.

<u>Grinding concrete</u>

- When grinding cured concrete, the dust and fines entering the water must not exceed the allowable limits for suspended solids. When grinding green or incompletely cured concrete and the dust or fines are entering the water, pH

monitoring will be conducted to ensure allowable ranges are maintained. In the event that the levels are outside the acceptable ranges, preventative measures will be introduced. This may include introducing silt curtains to contain the solids and prevent fish from entering a contaminated area or constructing catch basins to recover the run off and neutralizing it prior to disposal.

Patching concrete

- Spills: When patching concrete, all spills must be contained and prevented from entering the water.

Washing hand tools, pumps and transit mixer

- All tools, pumps, pipes, hoses and trucks used for finishing, placing or transporting fresh concrete must be washed off in such a way as to prevent the wash water and excess concrete from entering the marine environment. The wash water will be contained and disposed of upland in an environmentally acceptable manner.

Whenever there is the possibility of contaminants entering water, the contractor will monitor pH levels to ensure acceptable levels.

APPENDIX

Fisheries and Oceans Canada

Contact List

Name	Telephone No.	Fax. No.

NOTICE OF PROJECT

To: Fisheries and Oceans Canada

Attention:

Fax. No.:

From: “Contractor”

Telephone No.:

Fax. No.:

Representative:

Please be advised of the following marine/pile driving project:

Project Name:

Project Location:

Project Manager/Superintendent:

Project Telephone No.:

Project Fax. No.:

Project commencement date:

WATER QUALITY GUIDELINE SERIES

British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture

Guideline Summary – November 2023

Ministry of Water, Land and Resource Stewardship

Water Protection & Sustainability Branch

BRITISH COLUMBIA

No. WQG-20

The **Water Quality Guideline Series** is a collection of British Columbia (B.C.) Ministry of Environment and Climate Change Strategy ambient water quality guidelines. Water quality guidelines are developed for a variety of water values; aquatic life, agriculture, drinking water sources, recreation and aesthetics and wildlife. The Water Quality Guideline Series focuses on publishing water quality guideline technical reports and guideline summaries using the best available science to aid in the management of B.C.'s water resources. This document is found on the B.C. approved water quality guidelines webpage: http://www2.gov.B.C.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines

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Cover Photo: Chesterfield Lake; the headwaters of the Warneford River which is a tributary to the Kwadacha River in Northeast B.C. Photo by: Greg Tamblyn.

Updates from the 2021 version:

- Antimony WQGs table has been added (Table 2).
- The tables numbering has been updated.
- Arsenic WQGs for freshwater and marine aquatic life corrected. These are long-term chronic WQGs (Table 2).
- Zinc table updated with 2023 WQGs (Table 46).
- Aluminum table updated with 2023 WQGs (Table 1).

Updates from the 2019 version:

- Molybdenum table updated with 2021 WQGs (Table 24).
- The unit for chlorate WQG was corrected (Table 6).
- Updated links to WQG technical and overview documents.
- Updated water quality guideline series title page.

Updates from the 2018 version:

- The copper WQG (Table 12a and 12b) has been updated to reflect the updated B.C. copper WQG for the protection of aquatic life.
- Livestock and Irrigation WQGs for pH (Table 30) were added.
- Sediment WQGs were removed for PAHs (Table 33). These were rescinded in 2017. WQGs for PAHs in sediments can be found in the working WQGs.

Updates from the 2017 version:

- In table 46, the term “short-term average” was corrected to “short-term maximum”.

Contents

Introduction

This document summarizes the British Columbia (B.C.) approved water quality guidelines (WQGs). This document will be updated periodically to incorporate new information and represent the best guidance the Ministry of Environment and Climate Change Strategy (ENV) can provide at the time of publication but may not contain the most recent additions or updates to the B.C. approved WQGs at any one time. Readers should refer to the WQGs website for the most recent approved WQG documents.

BC's approved water quality guidelines

Many jurisdictions develop WQGs to protect water quality. B.C.'s WQGs represent safe levels of substances that protect different water uses, including: drinking water, recreation, aquatic life, wildlife and agriculture. Approved WQGs for aquatic life, wildlife and agriculture are summarized in this document. In B.C., the definition of water quality includes the sediments, therefore WQG documents may include sediment quality values.

WQGs provide policy direction to those making decisions affecting water quality. Although WQGs do not have any direct legal standing, once approved, BC WQGs must be considered in any decision affecting water quality made within the ENV. WQGs are used to assess water quality and may be used as the basis for determining the allowable limits in waste discharge authorizations. Exceeding a WQG does not imply that unacceptable risks exists, but rather that the potential for adverse effects may be increased and additional investigation may be required. BC's approved WQGs are located at: http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines.

All the WQGs reported in this document are ambient guidelines, meaning they represent the background condition or natural state of the surrounding environment.

Long-term chronic and short-term acute water quality guidelines

Long-term chronic (i.e., "average") WQGs are intended to protect the most sensitive species and life stage against sub-lethal and lethal effects for indefinite exposures. An averaging period approach is used for these WQGs. This approach allows concentrations of a substance to fluctuate above and below the guideline provided that the short-term acute is never exceeded and the long-term chronic is met over the specified averaging period (e.g., 5 samples in 30 days).

The averaging period for the long-term chronic WQG may differ depending on the substance under investigation and is somewhat arbitrary. These averaging periods were chosen as reasonable and practical durations to address long-term effects and to fit into monitoring timetables for provincial agencies. Five samples are considered the minimum needed to calculate the average; however, in some cases where the concentrations fluctuate widely in nature, more than 5 samples may be necessary. On the other hand, if concentrations are uniform and rarely exceed the long-term average guideline, less frequent monitoring may be justified. In this case, failure of any individual sample to meet the long-term average guideline would serve as an alert signal to increase the monitoring frequency.

Short-term acute (i.e., "maximum") WQGs are set to protect against severe effects such as lethality (e.g. LC_{50}) or other equivalent measures (e.g., EC_{50}) to the most sensitive species and life stage over a defined short-term exposure period (e.g., 96 hours).

Interim water quality guidelines

An interim WQG can be developed in cases where there are insufficient data available to meet the minimum requirements of a full guideline. The interim WQGs may be upgraded to approved WQG status when the data gap is filled. While interim and working WQGs are both intended to be temporary, only the latter are based on guidelines approved elsewhere.

Working water quality guidelines

For substances that are relevant to B.C. but do not have formally approved WQGs, working water quality guidelines (WWQGs) and working sediment quality guidelines (WSQGs) are adopted. The WWQGs and WSQGs may be based on historic information or different derivation protocols from a number of different agencies and, therefore, should be used with caution.

The WWQGs are obtained from various Canadian provincial and federal jurisdictions (primarily the Canadian Council of the Ministers of the Environment or CCME), as well as the United States, Europe, and Australia/New Zealand, and from published scientific literature. WWQGs provide benchmarks for those substances that have not yet been fully assessed and formally endorsed by the ENV.

In addition to developing WQGs, many jurisdictions develop sediment guidelines to serve as benchmarks for the protection of benthic aquatic life in freshwater and marine environments. The WSQGs also provide benchmarks for those substances that have not yet been fully assessed and formally endorsed by the ENV and, like WWQGs, are obtained from other jurisdictions, including the CCME.

Hardness-based guidelines

Guidelines for five metals: cadmium, fluoride, lead, manganese and zinc, are given as an equation that includes a parameter for ambient hardness. Hardness, or the concentration of calcium and magnesium ions, is known to ameliorate the effect of certain metals on aquatic organisms. The guideline equations were derived from experimental data that tested a specific range of hardness and therefore the equation is only applicable within this range. Ambient hardness conditions outside this range may require a site-specific assessment. For more information on each individual WQG, please review the technical report.

How to use this document

This document presents only B.C.-approved WQGs. Water quality guideline summary tables are presented alphabetically, by substance. Each table includes explanatory notes and links to the appropriate technical document.

For WQGs that are dependent on other factors (e.g. pH, water hardness), worked examples are provided.

Users of this document are encouraged, when needed, to consult the technical reports for additional details and information on the WQGs presented here.

Water Quality Guidelines Summary Tables

Table 1. Water quality guidelines for total aluminum (Al).

Water Use	Long-term Chronic WQG (µg/L)	Short-term Acute WQG (mg/L)
Freshwater Aquatic Life*	$\text{WQG} = \frac{e^{\{[0.645*\ln(DOC)]+[2.255*\ln(hardness)]+[1.995*pH]+[-0.284*(\ln(hardness)*pH)]-9.898\}}}{3}$ E.g., for a water with the following chemistry (pH = 7.5, DOC = 0.5 mg/L, hardness = 50 mg/L) the A WQG is 55 µg Al/L (total Al)	
Wildlife		5
Livestock		5
Irrigation		5

- *Source:* *Aluminum Water Quality Guidelines – Freshwater Aquatic Life (2023)* and *Aluminum Water Quality Guidelines - Wildlife, Livestock Watering, and Irrigation (1988).*
- *For an example of this equation in Excel download the Al aquatic life WQG calculator.
- The freshwater aquatic life WQG is valid between hardness of 10 and 430 mg $CaCO_3$/L, pH 6 and 8.7 and DOC 0.08 and 12.3 mg/L.

Table 2. Water quality guidelines for antimony (Sb).

Water Use	Maximum WQG (µg/L total Sb)	Long-term Chronic WQG (µg/L total Sb)
Freshwater Aquatic Life	250	74

- *Source:* *Antimony Water Quality Guidelines for the protection of Freshwater Aquatic Life (2023)*

Table 3. Water quality guidelines for arsenic (As).

Water Use	Maximum WQG (µg/L total As)	Long-term Chronic WQG(ug/L total As)
Freshwater Aquatic Life		5
Marine Aquatic Life		12.5 *
Wildlife	25 *	
Livestock	25 *	
Irrigation	100 *	

- * *Interim WQG*.
- *Source:* *Ambient Water Quality Guidelines for Arsenic: Overview Report (2002)*

Table 4. Water quality guidelines for benzene (C_6H_6).

Water Use	Long-term Chronic WQG (µg/L total C_6H_6)
Freshwater Aquatic Life	40 *
Marine & Estuarine Aquatic Life	110 †

- * *Revised interim BC WQG based on review of Canadian Council of Ministers of the Environment (1999) WQG.*
- *† Interim Canadian Council of Ministers of the Environment (1999) WQG.*
- *Source: Ambient Water Quality Guidelines for Benzene: Overview Report (2007).*

Table 5A. Water quality guidelines for boron (B).

Water Use	Long-term Chronic WQG (mg/L total B)
Freshwater & Marine Aquatic Life	1.2
Wildlife	5.0
Livestock	5.0
Irrigation	Crop-dependent, see Table 4B

- *Source: Ambient Water Quality Guidelines for Boron: Overview Report (2003).*

Table 5B. Water quality guidelines for boron (B) to protect irrigation uses.

Tolerance	Long-term Chronic WQG (mg/L total B)	Agricultural Crop
Very Sensitive	< 0.5	Blackberry
Sensitive	0.5 – 1.0	Peach, cherry, plum, grape, cowpea, onion, garlic, sweet potato, wheat, barley, sunflower, mung bean, sesame, lupin, strawberry, Jerusalem artichoke, kidney bean, lima bean
Moderately Sensitive	1.0 – 2.0	Red pepper, pea, carrot, radish, potato, cucumber
Moderately Tolerant	2.0 – 4.0	Lettuce, cabbage, celery, turnip, Kentucky bluegrass, oat, corn, artichoke, tobacco, mustard, clover, squash, muskmelon
Tolerant	4.0 – 6.0	Sorghum, tomato, alfalfa, purple vetch, parsley, red beet, sugar beet
Very Tolerant	6.0 – 15.0	Asparagus

- *Source: Ambient Water Quality Guidelines for Boron: Overview Report (2003).*

Table 6. Water quality guidelines for cadmium (Cd).

Freshwater Long-term Chronic WQG (µg/L dissolved Cd)	**Freshwater Short-term Acute WQG (µg/L dissolved Cd)**
$WQG = e^{[0.736 \times \ln(hardness^*) - 4.943]}$ E.g. Hardness = 50 mg/L $CaCO_3$ $WQG = 2.718^{[0.736 \times \ln(50) - 4.943]}$ $= 2.718^{[0.736 \times 3.912 - 4.943]}$ $= 2.718^{-2.064}$ $= 0.127$	$WQG = e^{[1.03 \times \ln(hardness^{**}) - 5.274]}$ E.g. Hardness = 50 mg/L $CaCO_3$ $WQG = 2.718^{[1.03 \times \ln(50) - 5.274]}$ $= 2.718^{[1.03 \times 3.912 - 5.274]}$ $= 2.718^{-1.245}$ $= 0.288$

- **Long-term chronic WQG applies to water hardnesses (mg/L $CaCO_3$) between 3.4 – 285 mg/L.*
- ***Short-term acute WQG applies to water hardnesses (mg/L $CaCO_3$) between 7 – 455 mg/L.*
- *When water hardness exceeds highest hardness tested (i.e. upper bound), a site-specific assessment may be required.*
- *Source: A User's Guide for the Ambient Water Quality Guidelines for Cadmium (2015).*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines, both for total Cd, are available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf*

Table 7. Water quality guidelines for chlorate (ClO_3^-).

Water Use	**Long-term Chronic WQG (µg/L ClO_3^-)**
Freshwater Aquatic Life	30,000
Marine Aquatic Life	5
Wildlife & Livestock	5,000

- *Source: Ambient Water Quality Guidelines for Chlorate: Technical Background Report (2002).*

Table 8. Water quality guidelines for chloride (Cl^-).

Water Use	WQG (mg/L total Cl^-)
Freshwater Aquatic Life * Long-term Chronic Short-term Acute	 150 600
Marine Aquatic Life	Human activities should not cause the Cl^- of marine and estuarine waters to fluctuate by more than 10% of the natural Cl^- expected at that time and depth.
Wildlife	600
Livestock	600
Irrigation	100

- ** When ambient Cl^- concentrations exceed WQGs, increases in Cl^- due to human activities should be avoided.*
- *Source: Ambient Water Quality Guidelines for Chloride: Overview Report (2003).*

Table 9. Water quality guidelines for chlorine (Cl).

Water Use	WQG for Continuous Exposure (µg/L TRC or CPO)	WQG for Controlled Intermittent Exposure (µg/L TRC or CPO)	WQG for Short-term Controlled Intermittent Exposure (µg/L TRC or CPO)
Freshwater Aquatic Life	2	$1{,}074\ (\text{duration})^{-0.74}$	100 regardless of duration of exposure
Marine & Estuarine Aquatic Life	3	$20.36\ (\text{duration})^{-0.4}$	40 regardless of duration of exposure
Irrigation			1,000

- *TRC = total residual Cl in fresh water, CPO = Cl-produced oxidants in marine or estuarine water.*
- *The continuous exposure average should be based on at least 5 samples equally spaced in time, and the averaging period should be not be less than 4 days or more than 30 days for fresh water, and not less than 2 hours or more than 30 days for marine or estuarine water. This is the threshold of long-term toxicity.*
- *The duration in controlled intermittent exposures, the exposure period (min), is the threshold of short-term toxicity.*
- *For the maximum controlled intermittent exposure of aquatic life, the total duration of exposure in any consecutive 24-hour period should not exceed 2 hours, and is the threshold of short-term toxicity.*
- *The irrigation criterion applies to plants grown hydroponically or in soil-less media and should be applied as a maximum under continuous or intermediate exposure situations.*
- *Source: Ambient Water Quality Criteria for Chlorine: Technical Appendix (1989).*

Table 10A. Water quality guidelines for chlorophenols (C_6H_5ClO).

Water Use	Short-term Acute WQG (mg/L)
Aquatic Life (Fresh, Marine & Estuarine Waters) - Toxicity WQGs for Aquatic Life	Use Table 9B
Livestock & Wildlife Drinking Water - Toxicity for Lactating Animals (High Temperatures & High Water Intake Rates)	MCPs: 185 DCPs: 46 TCPs: 21 TTCPs: 41 PCP: 17.5
Livestock & Wildlife Drinking Water - Toxicity for Non-Lactating Animals (Normal Temperatures & Low Water Intake Rates)	MCPs: 1,854 DCPs: 460 TCPs: 210 TTCPs: 410 PCP: 175

- *DCPs = dichlorophenols, MCPs = monochlorophenols, PCPs = pentachlorophenols, TCPs = trichlorophenols, TTCPs = tetrachlorophenols.*
- *Source: Ambient Water Quality Guidelines for Chlorophenol - First Update: Overview Report (1997).*

Table 10B. Water quality guidelines for chlorophenols (C_6H_5ClO) to protect aquatic life.

Chlorophenol Congeners	pH 5.7	pH 6.2	pH 6.7	pH 7.2	pH 7.7	pH 8.2	pH 8.7	pH 9.2
2-MCP	3.9	6.4	11	17	29	48	79	130
3-MCP	3.4	5.6	9.3	15	25	42	70	115
4-MCP	1.7	2.9	4.8	7.8	13	22	36	59
2,3-DCP	1.1	1.8	3.1	5.1	8.3	14	23	38
2,4-DCP	0.6	1.0	1.6	2.6	4.3	7.2	12	20
2,5-DCP	0.5	0.8	1.4	2.3	3.7	6.3	10	17
2,6-DCP	2.0	3.3	5.5	9.1	15	25	41	68
3,4-DCP	0.6	1.0	1.6	2.7	4.4	7.4	12	20
3,5-DCP	0.59	0.7	1.2	2.0	3.4	5.6	9.2	15
2,3,4-TCP	0.5	0.8	1.3	2.2	3.6	6.0	9.9	16
2,3,5-TCP	0.5	0.8	1.3	2.2	3.7	6.1	10	17
2,3,6-TCP	1.6	2.6	4.4	7.2	12	20	33	54
2,4,5-TCP	0.5	0.7	1.2	2.0	3.3	5.6	9.2	15
2,4,6-TCP	1.2	1.9	3.2	5.3	8.8	15	24	40
3,4,5-TCP	0.2	0.3	0.5	0.9	1.4	2.4	3.9	6.4
2,3,4,5-TTCP	0.4	0.6	1.0	1.7	2.8	4.7	7.8	13
2,3,4,6-TTCP	1.1	1.84	2.9	4.9	8.0	13	22	36
2,3,5,6-TTCP	0.5	0.8	1.3	2.2	3.6	6.1	10	17
2,3,4,5,6-PCP	0.2	0.3	0.5	0.7	1.2	2.0	3.4	5.5

- *DCPs = dichlorophenols, MCPs = monochlorophenols, PCPs = pentachlorophenols, TCPs = trichlorophenols, TTCPs = tetrachlorophenols.*
- *All values are short-term acute (µg/L).*
- *Multiply values by 2 when temperature is 0 °C and by 0.5 for 20 °C.*
- *These are final WQGs for PCP and interim WQGs for the other chlorophenol congeners.*
- *Source: Ambient Water Quality Guidelines for Chlorophenol - First Update: Overview Report (1997).*

Table 11. Water quality guidelines for cobalt (Co).

Water Use	WQG (µg/L total Co)
Freshwater Aquatic Life Long-term Chronic Short-term Acute	 4 110

- *Source: Ambient Water Quality Guidelines for Cobalt: Overview Report (2004).*

Table 12. Water quality guidelines for colour.

Water Use	Colour Units	WQG
Aquatic Life - Fresh, Marine & Estuarine	Apparent	30-day average transmission of white light ≥ 80% of background
Aquatic Life - Fresh, Marine & Estuarine	True	30-day average true colour of filtered water samples shall not exceed background levels by more than 5 mg/L Pt in clear water systems or 20% in coloured systems
Wildlife	Apparent	30-day average transmission of white light ≥ 80% of background
Wildlife	True	30-day average true colour of filtered water samples shall not exceed background levels by more than 5 mg/L Pt in clear water systems or 20% in coloured systems

- *Source: Ambient Water Quality Guidelines (Criteria) for Colour: Overview Report (1999).*

Table 13a. Water quality guidelines for copper (Cu).

Water Use	Long-term Chronic WQG (µg/L total Cu)	Short-term Acute WQG (µg/L total Cu)
Freshwater Aquatic Life (dissolved)	Calculated using BC BLM*	Calculated using BC BLM
Marine & Estuarine Aquatic Life (total)	≤ 2	3
Wildlife (total)		300
Livestock (total)		300
Irrigation (total)		200

- ** Water chemistry (e.g. pH, DOC and hardness) is needed to calculate Cu WQGs using BC BLM. Examples of calculated Cu WQGs are provided in Table 12b.*
- *If natural background levels exceed the WQGs for aquatic life, then any allowed increase in total Cu above natural levels should be based on site-specific data.*
- *Source: Copper Water Quality Guideline for the Protection of Freshwater Aquatic Life-User's Guide.*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Table 13b. Examples of long-term chronic and short-term acute WQGs calculated for eight different water chemistry scenarios.

Scenario	Water Chemistry Conditions				Chronic WQG (µg/L dissolved Cu)	Acute WQG (µg/L dissolved Cu)
	Temperature (°C)	Hardness (mg/L)	DOC (mg/L)	pH		
1	15	30	3	6.5	0.2	0.9
2	15	30	3	8	1.2	7.3
3	15	30	12.5	6.5	0.6	3.8
4	15	30	12.5	8	5.1	30.2
5	15	150	3	6.5	0.2	1.6
6	15	150	3	8	2.0	11.4
7	15	150	12.5	6.5	1.0	6.8
8	15	150	12.5	8	8.1	46.9

Table 14. Water quality guidelines for cyanide (CN^-).

Water Use	WQG (µg/L Weak-acid Dissociable CN^-)
Freshwater Aquatic Life - Long-term Chronic	≤ 5
Freshwater Aquatic Life - Short-term Acute	10
Marine & Estuarine Aquatic Life - Short-term Acute	1

- *Source: Water Quality Criteria for Cyanide: Overview Report (1986).*

Table 15. Water quality guidelines for diisopropanolamine (DIPA).

Water Use	WQG (µg/L DIPA)
Freshwater Aquatic Life	1.6
Livestock	38
Irrigation	3.9

- *Source: Ambient Water Quality Guidelines for Diisopropanolamine (DIPA): Overview Report (2003).*

Table 16. Water quality guidelines for ethylbenzene (C_8H_{10}).

Water Use	Long-term Chronic WQG (mg/L ethylbenzene)
Freshwater Aquatic Life	0.20 *
Marine Aquatic Life	0.25 *

- ** Revised interim BC WQGs based on review of Canadian Council of Ministers of the Environment (1996) WQGs.*
- *Source: Ambient Water Quality Guidelines for Ethylbenzene: Overview Report (1999).*

Table 17. Water quality guidelines for fluoride (F^-).

Water Use	Long-term Chronic WQG (mg/L total F^-)	Short-term Acute WQG (mg/L total F^-)
Freshwater Aquatic Life (Water hardness ≤ 10 mg/L)		0.4
Freshwater Aquatic Life (Water hardness > 10 mg/L)		WQG = [-51.73 + 92.57 $\log_{10}$ (hardness*)] × 0.01 E.g. When hardness = 50 mg/L $CaCO_3$ WQG = [-51.73 + 92.57 $\log_{10}$ (50)] 0.01 = [-51.73 + 92.57(1.699)] 0.01 = [105.544] 0.01 = 1.055
Marine Aquatic Life		1.5
Wildlife	1.0	1.5
Dairy Cows, Breeding Stock - Long-Lived Animals	1.0	1.5
Livestock - High F^- Diets, Mineral or Bone Meal, Feed Additives	1.0	2.0
All Other Livestock - Normal Diet	2.0	4.0
Irrigation - All Soils	1.0	2.0

- **Short-term acute WQG* equation applies to water hardness between 10 – 385 mg/L $CaCO_3$, and is an interim WQG until carefully controlled experiments can determine the appropriate levels of F^- under various combinations of water temperature and hardness.*
- *When water hardness exceeds highest hardness tested (i.e. upper bound), a site-specific assessment may be required.*
- *The Okanagan Valley is the only area in BC where background values generally exceed 0.2, and even there levels do not generally exceed 0.3.*
- *Source: Ambient Water Quality Criteria for Fluoride (1995, 2011).*

Table 18. Water quality guidelines for total gas pressure (TGP).

Water Use	WQG (mm Hg TGP)
Freshwater & Marine Aquatic Life	Short-term acute Δ P $\leq$ 76 (or $\leq$ 110% at sea level)
Background Levels Higher than WQGs	No increase in Δ P or % TGP
Hatchery Environments	Short-term acute Δ P = 24 (or 103% at sea level); Δ P = 0 when p O_2 $\leq$ 100

- *Δ P = excess gas pressure (mm Hg), p O_2 = partial pressure of dissolved oxygen in (mm Hg).*
- *Source: Water Quality Guidelines for Total Gas Pressure: First Update (2004).*

Table 19. Water quality guidelines for iron (Fe).

Water Use	Form	Short-term acute WQG (mg/L)
Freshwater Aquatic Life	Total Fe	1
	Dissolved Fe	0.35

- *Source: Ambient Aquatic Life Guidelines for Iron: Overview Report (2008).*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Table 20. Water quality guidelines for lead (Pb).

Water Use	Long-term Chronic WQG (µg/L total Pb)	Short-term Acute WQG (µg/L total Pb)
Freshwater Aquatic Life (Water Hardness ≤ 8 mg/L $CaCO_3$)		3
Freshwater Aquatic Life (Water Hardness > 8 mg/L $CaCO_3$)	WQG ≤ $3.31 + e^{[1.273 \ln (\text{hardness}^*) - 4.704]}$ E.g. Hardness = 50 mg/L $CaCO_3$ WQG ≤ $3.31 + 2.718^{[1.273 \ln(50) - 4.704]}$ ≤ $3.31 + 2.718^{[1.273(3.912) - 4.704]}$ ≤ $3.31 + 2.718^{[0.276]}$ ≤ 3.31 + 1.318 ≤ 4.628 In addition, no more than 20% (e.g. 1 in 5) of values in a 30-day period should exceed 1.5 times the long-term chronic WQG.	WQG = $e^{[1.273 \ln (\text{hardness}^*) -1.460]}$ E.g. Hardness = 50 mg/L $CaCO_3$ WQG = $2.718^{[1.273 \ln(50) - 1.460]}$ = $2.718^{[1.273(3.912) - 1.460]}$ = $2.718^{[3.520]}$ = 33.785
Marine & Estuarine Aquatic Life	≤ 2 total lead (80% of values ≤ 2 total lead)	140
Wildlife		100
Livestock		100
Irrigation (Neutral & Alkaline Fine-Textured Soils)		400
Irrigation (All Other Soils)		200

- **Long-term chronic and short-term acute WQGs both apply to water hardnesses between 8 – 360 mg/L $CaCO_3$.*
- *If natural levels exceed the WQGs for aquatic life, then any allowed increase in total Pb above natural levels should be based on site-specific data.*
- *When water hardness exceeds highest hardness tested (i.e. upper bound), a site-specific assessment may be required.*
- *Source: Water Quality Criteria for Lead: Overview Report (1987).*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Table 21. Water quality guidelines for manganese (Mn).

Freshwater Long-term Chronic WQG (mg/L total Mn)	Freshwater Short-term Acute WQG (mg/L total Mn)
WQG ≤ 0.0044 hardness* + 0.605 E.g. When hardness = 50 mg/L $CaCO_3$ WQG ≤ 0.0044(50) + 0.605 ≤ 0.825	WQG ≤ 0.01102 hardness** + 0.54 E.g. When hardness = 50 mg/L $CaCO_3$ WQG ≤ 0.01102(50) + 0.54 ≤ 1.091

- **Long-term average WQG* *applies to water hardness between 37 – 450 mg/L $CaCO_3$.*
- ***Short-term maximum WQG* *applies to water hardness between 25 – 259 mg/L $CaCO_3$.*
- *When water hardness is outside hardness range tested (i.e. lower or upper bound), a site-specific assessment may be required.*
- *Source: Ambient Water Quality Guidelines for Manganese: Overview Report (2001).*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Table 22. Water quality guidelines for mercury (Hg).

Water Use	Long-term Chronic WQG (µg/L total Hg)	Short-term Acute WQG (µg/L total Hg)
Aquatic Life (Freshwater, Estuarine & Marine) * & Wildlife	WQG = 0.0001 / (MeHg/total Hg), where MeHg is mass (or concentration) of methyl mercury and THg is total mass (or concentration) of mercury in a given water volume E.g. MeHg = 1 g and total Hg = 100 g WQG = 0.0001 / (1/100) = 0.01 Note: When MeHg ≤ 0.5% of total Hg, WQG = 0.02	
Livestock		3.0
Irrigation		2.0

- ** If natural levels exceed the WQGs for aquatic life, then any increase allowed above the natural levels should be based on site-specific data.*
- *Source: Ambient Water Quality Guidelines for Mercury: Overview Report – First Update (2001).*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/bc_env_working_water_quality_guidelines.pdf.

Table 23. Tissue residue guideline for methyl mercury (MeHg).

Water Use	WQG (µg/g wet weight MeHg)
In Fish or Shellfish Consumed by Wildlife	0.033

- *Source: Ambient Water Quality Guidelines for Mercury: Overview Report – First Update (2001).*

Table 24. Water quality guidelines for methyl tert-butyl ether, MTBE ($C_5H_{12}O$).

Water Use	Short-term Acute WQG (mg/L total MTBE)
Freshwater Aquatic Life	3.4
Marine & Estuarine Aquatic Life	0.44
Livestock *	11.0

- ** Concentrations above the taste and odour thresholds that are below the livestock WQG may result in certain livestock avoiding water, reducing consumption, and suffering adverse effects.*
- *Source: Ambient Water Quality Guidelines for Methyl Tertiary-butyl Ether (MTBE) (2001).*

Table 25. Water quality guidelines for molybdenum (Mo).

Water Use	Long-term Chronic WQG (mg/L total Mo)	Short-term Acute WQG (mg/L total Mo)
Freshwater Aquatic Life	7.6	46
Livestock (ruminant)	0.016	--
Livestock (non-ruminant)	0.284	--
Wildlife (ruminant)	0.034	--
Wildlife (non-ruminant)	0.284	--
Irrigation (non-forage crops)	0.028*	--
Irrigation (forage crops-poorly drained soil)	0.01	0.05
Irrigation (forage crops-well- drained soil)	0.02	0.05

- *Note: this guideline is intended to be protective of terrestrial plants and is not necessarily protective of livestock consuming these plants.
- *Source: Water Quality Criteria for Molybdenum: Technical Report (2021).*

Table 26. Water quality guidelines for naphthalene ($C_{10}H_8$).

Water Use	Short-term Acute WQG (µg/L naphthalene)
Freshwater Aquatic Life	1

- *Source: Ambient Water Quality Guideline for Naphthalene to Protect Freshwater Life: Overview Report – First Update (2007)*
- *Working WQGs for other water uses, and working Sediment Quality Guidelines are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Table 27A. Water quality guidelines for nitrogen (N).

Water Use	Nitrate WQG (mg/L N)	Nitrite WQG (mg/L N)	Total Ammonia WQG (mg/L N)
Freshwater Aquatic Life - Long-term Chronic	3.0	0.02 when Cl^- ≤ 2 - also see Table 26B	See Table 26C
Freshwater Aquatic Life - Short-term Acute	32.8	0.06 when Cl^- ≤ 2 - also see Table 26B	See Table 26D
Marine Aquatic Life - Long-term Chronic	3.7	None proposed	See Table 26E
Marine Aquatic Life - Short-term Acute			See Table 26F
Wildlife – Short-term Acute	100 *	10	
Livestock – Short-term Acute	100 *	10	

- ** When nitrate and nitrite are present, total nitrate- plus nitrite-nitrogen should not exceed the nitrate WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

Table 27B. Water quality guidelines for nitrite (NO^{2-}).

Chloride (mg/L Cl^-)	Freshwater Long-term Chronic NO^{2-} WQG (mg/L as N)	Freshwater Short-term Acute NO^{2-} WQG (mg/L as N)
< 2	0.02	0.06
2 to 4	0.04	0.12
4 to 6	0.06	0.18
6 to 8	0.08	0.24
8 to 10	0.10	0.30
> 10	0.20	0.60

- *The long-term chronic Cl^- concentration should be used to find the appropriate long-term chronic NO^{2-} WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

Table 27C. Long-term chronic water quality guidelines for ammonia nitrogen (NH_3 as mg/L N) to protect freshwater aquatic life.

	Temperature (°C)						
pH	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**
6.5	2.08	2.05	2.02	1.99	1.97	1.94	1.92
6.6	2.08	2.05	2.02	1.99	1.97	1.94	1.92
6.7	2.08	2.05	2.02	1.99	1.97	1.94	1.92
6.8	2.08	2.05	2.02	1.99	1.97	1.94	1.92
6.9	2.08	2.05	2.02	1.99	1.97	1.94	1.92
7.0	2.08	2.05	2.02	1.99	1.97	1.94	1.92
7.1	2.08	2.05	2.02	1.99	1.97	1.94	1.92
7.2	2.08	2.05	2.02	1.99	1.97	1.94	1.92
7.3	2.08	2.05	2.02	1.99	1.97	1.94	1.92
7.4	2.08	2.05	2.02	2.00	1.97	1.95	1.92
7.5	2.08	2.05	2.02	2.00	1.97	1.95	1.92
7.6	2.09	2.05	2.03	2.00	1.97	1.95	1.93
7.7	2.09	2.05	2.03	2.00	1.98	1.95	1.93
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65
7.9	1.50	1.48	1.46	1.44	1.43	1.41	1.39
8.0	1.26	1.24	1.23	1.21	1.20	1.18	1.17
8.1	1.00	0.989	0.976	0.963	0.952	0.942	0.932
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.161
9.0	0.135	0.134	0.133	0.132	0.132	0.131	0.131

Table 27C continued

	Temperature (°C)						
pH	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**
6.5	1.90	1.88	1.86	1.84	1.82	1.81	1.80
6.6	1.90	1.88	1.86	1.84	1.82	1.81	1.80
6.7	1.90	1.88	1.86	1.84	1.83	1.81	1.80
6.8	1.90	1.88	1.86	1.84	1.83	1.81	1.80
6.9	1.90	1.88	1.86	1.84	1.83	1.81	1.80
7.0	1.90	1.88	1.86	1.84	1.83	1.81	1.80
7.1	1.90	1.88	1.86	1.84	1.83	1.81	1.80
7.2	1.90	1.88	1.86	1.85	1.83	1.81	1.80
7.3	1.90	1.88	1.86	1.85	1.83	1.82	1.80
7.4	1.90	1.88	1.87	1.85	1.83	1.82	1.80
7.5	1.91	1.88	1.87	1.85	1.83	1.82	1.81
7.6	1.91	1.89	1.87	1.85	1.84	1.82	1.81
7.7	1.91	1.89	1.87	1.86	1.84	1.83	1.81
7.8	1.63	1.62	1.60	1.59	1.57	1.56	1.55
7.9	1.38	1.36	1.35	1.34	1.33	1.32	1.31
8.0	1.16	1.15	1.14	1.13	1.12	1.11	1.10
8.1	0.922	0.914	0.906	0.899	0.893	0.887	0.882
8.2	0.736	0.730	0.724	0.718	0.714	0.709	0.706
8.3	0.588	0.583	0.579	0.575	0.571	0.568	0.566
8.4	0.471	0.467	0.464	0.461	0.458	0.456	0.455
8.5	0.377	0.375	0.372	0.370	0.369	0.367	0.366
8.6	0.303	0.301	0.300	0.298	0.297	0.297	0.296
8.7	0.244	0.243	0.242	0.241	0.241	0.240	0.240
8.8	0.197	0.197	0.196	0.196	0.196	0.196	0.196
8.9	0.160	0.160	0.160	0.160	0.160	0.161	0.161
9.0	0.131	0.131	0.131	0.131	0.132	0.132	0.133

Table 27C continued

	Temperature (°C)						
pH	**14.0**	**15.0**	**16.0**	**17.0**	**18.0**	**19.0**	**20.0**
6.5	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.6	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.7	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.8	1.78	1.77	1.64	1.52	1.42	1.32	1.22
6.9	1.78	1.77	1.64	1.53	1.42	1.32	1.22
7.0	1.79	1.77	1.64	1.53	1.42	1.32	1.22
7.1	1.79	1.77	1.65	1.53	1.42	1.32	1.23
7.2	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.3	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.4	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.5	1.80	1.78	1.66	1.54	1.43	1.33	1.23
7.6	1.80	1.79	1.66	1.54	1.43	1.33	1.24
7.7	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.31	1.30	1.21	1.12	1.04	0.970	0.904
8.0	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- *The average of the 5 measured NH_3 values must be less than the average of the 5 corresponding tabled NH_3 values (WQGs) obtained by finding the measured pH and temperature values in the table.*
- *No more than 1 of 5 of the measured values can exceed 1.5 times the corresponding WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

Table 27D. Short-term acute water quality guidelines for ammonia nitrogen (NH_3 as mg/L N) to protect freshwater aquatic life.

	Temperature (°C)						
pH	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**
6.5	28.7	28.3	27.9	27.5	27.2	26.8	26.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9
6.9	24.6	24.2	23.9	23.6	23.3	23.0	22.7
7.0	23.2	22.8	22.5	22.2	21.9	21.6	21.4
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9
7.2	19.9	19.6	19.3	19.0	18.8	18.6	18.3
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7
7.4	16.2	16.0	15.7	15.5	15.3	15.2	15.0
7.5	14.4	14.1	14.0	13.8	13.6	13.4	13.3
7.6	12.6	12.4	12.0	11.9	11.9	11.7	11.6
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10.0
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57
7.9	7.82	7.71	7.60	7.51	7.42	7.33	7.25
8.0	6.55	6.46	6.37	6.29	6.22	6.14	6.08
8.1	5.21	5.14	5.07	5.01	4.95	4.90	4.84
8.2	4.15	4.09	4.04	3.99	3.95	3.90	3.86
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98
8.6	1.69	1.67	1.65	1.63	1.61	1.60	1.59
8.7	1.35	1.33	1.32	1.31	1.30	1.29	1.28
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836
9.0	0.703	0.697	0.692	0.688	0.685	0.682	0.681

Table 27D continued

	Temperature (°C)						
pH	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**
6.5	26.2	26.0	25.7	25.5	25.2	25.0	24.8
6.6	25.5	25.2	25.0	24.7	24.5	24.3	24.1
6.7	24.6	24.4	24.1	23.9	23.7	23.5	23.3
6.8	23.6	23.4	23.1	22.9	22.7	22.5	22.3
6.9	22.5	22.2	22.0	21.8	21.6	21.4	21.3
7.0	21.1	20.9	20.7	20.5	20.3	20.2	20.0
7.1	19.7	19.5	19.3	19.1	18.9	18.8	18.7
7.2	18.1	17.9	17.8	17.6	17.4	17.3	17.2
7.3	16.5	16.3	16.2	16.0	15.9	15.7	15.6
7.4	14.8	14.7	14.5	14.4	14.2	14.1	14.0
7.5	13.1	13.0	12.9	12.7	12.6	12.5	12.4
7.6	11.5	11.4	11.3	11.2	11.1	11.0	10.9
7.7	9.92	9.83	9.73	9.65	9.57	9.50	9.43
7.8	8.48	8.40	8.32	8.25	8.18	8.12	8.07
7.9	7.17	7.10	7.04	6.98	6.92	6.88	6.83
8.0	6.02	5.96	5.91	5.86	5.81	5.78	5.74
8.1	4.80	4.75	4.71	4.67	4.64	4.61	4.59
8.2	3.83	3.80	3.76	3.74	3.71	3.69	3.67
8.3	3.06	3.03	3.01	2.99	2.97	2.96	2.94
8.4	2.45	2.43	2.41	2.40	2.38	2.37	2.36
8.5	1.96	1.95	1.94	1.93	1.92	1.91	1.91
8.6	1.58	1.57	1.56	1.55	1.55	1.54	1.54
8.7	1.27	1.26	1.26	1.25	1.25	1.25	1.25
8.8	1.03	1.02	1.02	1.02	1.02	1.02	1.02
8.9	0.833	0.832	0.831	0.831	0.832	0.834	0.838
9.0	0.681	0.681	0.681	0.682	0.684	0.688	0.692

Table 27D continued

	Temperature (ºC)						
pH	**14.0**	**15.0**	**16.0**	**17.0**	**18.0**	**19.0**	**20.0**
6.5	24.6	24.5	24.3	24.2	24.0	23.9	23.8
6.6	23.9	23.8	23.6	23.5	23.3	23.3	23.2
6.7	23.1	23.0	22.8	22.7	22.6	22.5	22.4
6.8	22.2	22.0	21.9	21.8	21.7	21.6	21.5
6.9	21.1	21.0	20.8	20.7	20.6	20.5	20.4
7.0	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.5	18.4	18.3	18.2	18.1	18.0	17.9
7.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.4	12.3	12.2	12.2	12.1	12.1	12.0
7.6	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.37	9.31	9.26	9.22	9.18	9.15	9.12
7.8	8.02	7.97	7.93	7.90	7.87	7.84	7.82
7.9	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8.0	5.71	5.68	5.66	5.62	5.61	5.60	5.74
8.1	4.56	4.54	4.53	4.51	4.50	4.49	4.49
8.2	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.90	1.90	1.90	1.90	1.90	1.91	1.92
8.6	1.54	1.54	1.54	1.55	1.56	1.56	1.57
8.7	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.842	0.847	0.853	0.861	0.870	0.880	0.891
9.0	0.698	0.704	0.711	0.720	0.729	0.740	0.752

- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

Table 27E. Long-term chronic water quality guidelines for ammonia nitrogen (NH_3 as mg/L N) to protect marine aquatic life.

For Salinity of 10 ppt (g/kg)

	Temperature (ºC)					
pH	**0**	**5**	**10**	**15**	**20**	**25**
7.0	41	29	20	14	9.4	6.6
7.2	26	18	12	8.7	5.9	4.1
7.4	17	12	7.8	5.3	3.7	2.6
7.6	10	7.2	5.0	3.4	2.4	1.7
7.8	6.6	4.7	3.1	2.2	1.5	1.1
8.0	4.1	2.9	2.0	1.4	0.97	0.69
8.2	2.7	1.8	1.3	0.87	0.62	0.44
8.4	1.7	1.2	0.81	0.56	0.41	0.29
8.6	1.1	0.75	0.53	0.37	0.27	0.20
8.8	0.69	0.50	0.34	0.25	0.18	0.14
9.0	0.44	0.31	0.23	0.17	0.13	0.10

For Salinity of 20 ppt (g/kg)

	Temperature (ºC)					
pH	**0**	**5**	**10**	**15**	**20**	**25**
7.0	44	30	21	14	9.7	6.6
7.2	27	19	13	9.0	6.2	4.4
7.4	18	12	8.1	5.6	4.1	2.7
7.6	11	7.5	5.3	3.4	2.5	1.7
7.8	6.9	4.7	3.4	2.3	1.6	1.1
8.0	4.4	3.0	2.1	1.5	1.0	0.72
8.2	2.8	1.9	1.3	0.94	0.66	0.47
8.4	1.8	1.2	0.84	0.59	0.44	0.30
8.6	1.1	0.78	0.56	0.41	0.28	0.20
8.8	0.72	0.50	0.37	0.26	0.19	0.14
9.0	0.47	0.34	0.24	0.18	0.13	0.10

Table 27E continued

For Salinity of 30 ppt (g/kg)

	Temperature (ºC)					
pH	**0**	**5**	**10**	**15**	**20**	**25**
7.0	47	31	22	15	11	7.2
7.2	29	20	14	9.7	6.6	4.7
7.4	19	13	8.7	5.9	4.1	2.9
7.6	12	8.1	5.6	3.7	3.1	1.8
7.8	7.5	5.0	3.4	2.4	1.7	1.2
8.0	4.7	3.1	2.2	1.6	1.1	0.75
8.2	3.0	2.1	1.4	1.0	0.69	0.50
8.4	1.9	1.3	0.90	0.62	0.44	0.31
8.6	1.2	0.84	0.59	0.41	0.30	0.22
8.8	0.78	0.53	0.37	0.27	0.20	0.15
9.0	0.50	0.34	0.26	0.19	0.14	0.11

- *The average of the 5 measured NH_3 concentrations must be less than the corresponding tabled NH_3 value (WQG) found by using the average of the 5 measured pH, temperature, and salinity values.*
- *No more than 1 of 5 of the measured values can exceed 1.5 times the corresponding WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

Table 27F. Short-term acute water quality guidelines for ammonia nitrogen (NH_3 as mg/L N) to protect marine aquatic life.

For Salinity of 10 ppt (g/kg)

	Temperature (ºC)					
pH	**0**	**5**	**10**	**15**	**20**	**25**
7.0	270	191	131	92	62	44
7.2	175	121	83	58	40	27
7.4	110	777	52	35	25	17
7.6	69	48	33	23	16	11
7.8	44	31	21	15	10	7.1
8.0	27	19	13	9.4	6.4	4.6
8.2	18	12	8.5	5.8	4.2	2.9
8.4	11	7.9	5.4	3.7	2.7	1.9
8.6	7.3	5.0	3.5	2.5	1.8	1.3
8.8	4.6	3.3	2.3	1.7	1.2	0.92
9.0	2.9	2.1	1.5	1.1	0.85	0.67

Table 26F continued

For Salinity of 20 ppt (g/kg)

	Temperature (ºC)					
pH	**0**	**5**	**10**	**15**	**20**	**25**
7.0	291	200	137	96	64	44
7.2	183	125	87	60	42	29
7.4	116	79	54	37	27	18
7.6	73	50	35	23	17	11
7.8	46	31	23	15	11	7.5
8.0	29	20	14	9.8	6.7	4.8
8.2	19	13	8.9	6.2	4.4	3.1
8.4	12	8.1	5.6	4.0	2.9	2.0
8.6	7.5	5.2	3.7	2.7	1.9	1.4
8.8	4.8	3.3	2.5	1.7	1.3	0.94
9.0	3.1	2.3	1.6	1.2	0.87	0.69

For Salinity of 30 ppt (g/kg)

	Temperature (ºC)					
pH	**0**	**5**	**10**	**15**	**20**	**25**
7.0	312	208	148	102	71	48
7.2	196	135	94	64	44	31
7.4	125	85	58	40	27	19
7.6	79	54	37	25	21	12
7.8	50	33	23	16	11	7.9
8.0	31	21	15	10	7.3	5.0
8.2	20	14	9.6	6.7	4.6	3.3
8.4	12.7	8.7	6.0	4.2	2.9	2.1
8.6	8.1	5.6	4.0	2.7	2.0	1.4
8.8	5.2	3.5	2.5	1.8	1.3	1.0
9.0	3.3	2.3	1.7	1.2	0.94	0.71

- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

Table 28. Water quality guidelines for nutrients and algae.

Water Use	Total Phosphorous (µg/L P)	Short-term Acute Chlorophyll *a* (mg/m^2)
Aquatic Life - Streams		100 mg/m^2
Aquatic Life - Lakes (Salmonids Are Predominant Fish Species)	5 to 15 (inclusive)	

- *Total P in lakes is either the spring overturn concentration, if the residence time of the epilimnetic water exceeds 6 months, or the mean epilimnetic growing season concentration, if residence time of epilimnetic water is below 6 months.*
- *Chlorophyll a WQGs in streams apply to naturally growing periphytic algae.*
- *Source: Water Quality Criteria for Nutrients and Algae: Overview Report (2001).*

Table 29. Water quality guidelines for organic carbon.

Water Use	Fraction	WQG
Freshwater Aquatic Life	Dissolved	Long-term median within 20% of background median *
Freshwater Aquatic Life	Total	Long-term median within 20% of background median *
Wildlife	Dissolved	Long-term median within 20% of background median *
Wildlife	Total	Long-term median within 20% of background median *

- ** The 30-day median for both DOC and TOC shall be within 20% of seasonally-adjusted median background levels as measured historically or at appropriate reference sites. The 30-day median calculation should be based on a minimum of 5 weekly samples taken over a period of 30 days.*
- *Source: Ambient Water Quality Guidelines for Organic Carbon: Overview Report (2001).*

Table 30. Water quality guidelines for dissolved oxygen (DO).

Life Stages	All Life Stages Other than Buried Embryo / Alevin	Buried Embryo / Alevin Life Stages *	Buried Embryo / Alevin Life Stages
Location	Water Column (mg/L O_2)	Water Column † (mg/L O_2)	Interstitial Water (mg/L O_2)
Long-term Chronic WQG	8	11	8
Instantaneous Minimum WQG	5	9	6

- ** Instream concentrations from spawning to the point of yolk sac absorption or 30 days post-hatch.*
- *† Water column concentrations recommended to achieve interstitial DO values when the latter are unavailable. Interstitial oxygen measurements supersede water column data.*
- *The instantaneous minimum level is to be maintained at all times.*
- *If a diurnal cycle exists in the water body, measurements should be taken when oxygen levels are lowest (usually early morning).*
- *Source: Ambient Water Quality Criteria for Dissolved Oxygen: Overview Report (1997).*

Table 31. Water quality guidelines for pH.

Environment	pH	WQG
Freshwater	< 6.5	No statistically significant * decrease in pH from background. No restriction on the increase in pH except in boggy areas that have a unique fauna or flora. Site-specific ambient water quality objectives to restict the pH increase in areas with a unique fauna and flora are recommended.
Freshwater	6.5-9.0	Unrestricted change permitted within this pH range. This component of the freshwater WQGs should be used cautiously if the pH changes causes the carbon dioxide concentrations to exceed a 10 µmol/L minimum or a 1360 µmol/L short-term. Carbon dioxide concentrations below 10 µmol/L can cause a shift in the phytoplankton community to cyanobacteria, while CO_2 concentrations above 1360 µmol/L can be toxic to fish.
Freshwater	> 9.0	No statistically significant * increase in pH from background. Short-term increases (2-3 days) to pH 9.5 are permitted for lake restoration projects. Decreases in pH are permitted as long as carbon dioxide concentrations are not elevated above 1360 µmol/L. CO_2 concentrations above 1360 µmol/L may be toxic to fish.
Marine Water	7.0-8.7	Unrestricted change within this range (for protection of mollusc embryo development).
Livestock		5.0-9.5
Irrigation		5.0-9.5

- ** Streams: Statistical comparison of background (upstream) and downstream results shold use a 1-tailed, 2-sample t-test, at the 0.05 probability level. The minimun sampling requirement is 5 measurements collected weekly in 30 days. The 2-sample t-test requires the different stations to have similar variances (use the F-test). If, at the downstream site, data from spills of discharge events are pooled with steady state data, the variance may increase and become dissimilar to the upstream site invalidating the 2-sample t-test. To reduce the variance, consider the data from the steady state and the event as independent data sets. Additional pH measurements, or a pH sensor with an automatic recorder are recommended for sites subject to event-driven pH fluctuations. Lakes: Same as streams or, if background stations are not available, predischarge data should be collected near the zone of influence, once every 3 weeks for 1 or 2 years to determine the temporal variation. A pH sensor with an automatic recorder would collect more data and provide a better understanding of the temporal variability than normal field sampling.*
- *Source: Ambient Water Quality Criteria for pH: Technical Appendix (1991).*

Table 32. Water quality guidelines for the pharmaceutically active compound (PhAC) 17α-ethinylestradiol (EE2).

Water Use	WQG (ng/L EE2)
Freshwater Long-term Chronic	0.50
Freshwater Short-term Acute	0.75

- *Source: Water Quality Guidelines for Pharmaceutically-active Compounds (PhACs): 17 α-ethinylestradiol (EE2) (2009).*

Table 33. Water quality guidelines for phenols.

Non-halogenated Phenol Species	Freshwater Short-term Acute WQG (µg/L phenols)
4-hydroxyphenol (hydroqinone, quinol)	4.5
3-hydroxyphenol (resorcinol)	12.5
Total of all other phenols *	50.0

- ** Total phenols minus all chlorinated phenols minus hydroqinone minus resorcinol.*
- *Source: Ambient Interim Water Quality Guidelines for Phenols: Summary Report (2002)*

Table 34. Water quality guidelines for aquatic life for polycyclic aromatic hydrocarbons (PAHs).

PAH	Freshwater (Long-term Chronic) WQG (µg/L)	Freshwater (Phototoxic) WQG (µg/L)	Marine Water WQG (µg/L)
Acenaphthene	6		6
Acridene	3	0.05	
Anthracene	4	0.1	
Benz[a]anthracene	0.1	0.1	
Benzo[a]pyrene	0.01		0.01
Chrysene			0.1
Fluoranthene	4	0.2	
Fluorene	12		12
Methylated Naphthalene			1
Naphthalene	1		1
Phenanthrene	0.3		
Pyrene		0.02	

- *Source: Ambient Water Quality Criteria for Polycyclic Aromatic Hydrocarbons (PAHs): Overview Report (1993)*
- *Working WQGs and working Sediment Quality Guidelines for other PAHs are available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf*

Table 35. Water quality guidelines for polychlorinated biphenyls (PCBs).

Water Use	PCBs	Short-term Acute WQG
Freshwater & Marine Aquatic Life	Total PCB 105 PCB 169 PCB 77 PCB 126	0.1 ng/L 0.09 ng/L 0.06 ng/L 0.04 ng/L 0.00025 ng/L
Freshwater & Marine Aquatic Life – Sediment (Containing 1% Organic Carbon *)	Total	0.02 µg/g dry weight
Freshwater & Marine Aquatic Life - Fish &/or Shellfish (for Wildlife Consumption: Whole Animal)	Total	0.1 µg/g wet weight
Irrigation	Total	0.5 µg/L

- ** If sediment organic carbon (OC) ≠ 1%, then WQG = (0.02 µg/g dry weight) x (% OC × 100). For example, if sediment contains 3% OC, then WQG = 0.02 × 3 = 0.06 µg/g dry weight.*
- *Source: Ambient Water Quality Criteria for Polychlorinated Biphenyls (PCBs): Overview Report (1992)*

Table 36. Water quality guidelines for selenium (Se).

Water Use	Long-term Chronic Se WQG	WQG Derivation Method/Approach
Aquatic Life *Water column freshwater & marine* *Alert concentration* *WQG* *Sediment - Alert concentration* *Dietary* *Invertebrate tissue (interim)* *Tissue* (fish) *Egg/ovary* *Whole-body (WB)* *Muscle/muscle plug (interim)*	 1 µg/L 2 µg/L 2 µg/g (dw) 4 µg/g (dw) 11 µg/g (dw) 4 µg/g (dw) 4 µg/g (dw)	*Water column*: Review of previous WQG (uncertainty factor (UF) applied to toxicity threshold); weight of evidence including food web modelling and reported relationships between impacts and Se concentrations in water. *Sediment*: Weight of evidence; lowest published toxicity thresholds, no UF applied; insufficient data for full WQGs at this time. *Dietary:* Weight of evidence; lowest published toxicity thresholds, no UF applied; insufficient data for full WQGs at this time. Invertebrate tissue as surrogate for aquatic dietary tissue. *Egg/ovary:* Combination weight of evidence and mean of published effects data with an UF of 2 applied; *Whole-body*: previous WB WQG compared with published literature, mean of published effects data with UF (2) applied and weight of evidence; *Muscle*: WB translation to derive muscle WQG, no additional UF applied to muscle WQG.
Wildlife *Water column* *Bird egg*	 2 µg/L 6 µg/g (dw)	The *water column* WQG for aquatic life (fish) is adopted for wildlife since dietary accumulation is most critical. *Bird eggs* were used as surrogate for all wildlife; weight of evidence; egg Se most direct/sensitive measure; mallard EC10 with UF of 2 applied.
Livestock *2001 WQG not updated*	 30 µg/L	Not updated at this time
Irrigation *2001 WQG not updated*	 10 µg/L	Not updated at this time

- *Source: Companion Document to Ambient Water Quality Guidelines for Selenium – Update (2014)*

Table 37. Sampling guidance for selenium (Se) water quality guidelines.

Water Use	WQG for Total Se	Sampling Guidance
Aquatic Life *Water column freshwater & marine* *Alert concentration* *WQG* *Sediment - Alert concentration* *Dietary* *Invertebrate tissue (interim)* *Tissue* (fish) *Egg/ovary* *Whole-body (WB)* *Muscle/muscle plug (interim)*	 1 µg/L 2 µg/L 2 µg/g (dw) 4 µg/g (dw) 11 µg/g (dw) 4 µg/g (dw) 4 µg/g (dw)	*Water*: 30-day average determined as the mean concentration of 5 evenly spaced samples collected over 30 days and measured as total Se. *Sediment*: Mean of ≥ 5 samples collected in a representative area. *Dietary:* Mean concentration ≥ 8 replicate (composite) tissue samples representing an appropriate invertebrate or other prey species. *Egg/ovary*: Mean of ≥ 8 egg or ripe ovary (from 8 individual fish) in a representative area, reported as dry weight. *Whole-body*: Mean of ≥ 8 fish in a representative area, reported as dry weight. *Muscle*: Mean of ≥ 8 muscle tissue samples (from 8 individual fish) in a representative area, reported as dry weight.
Wildlife *Water* *Bird egg*	 2 µg/L 6 µg/g (dw)	*Water*: 30-day average determined as the mean concentration of 5 evenly spaced samples collected over 30 days and measured as total Se. *Bird egg*: Mean of ≥ 8 eggs (from 8 individual nests) in a representative area, reported as dry weight. A statistical analysis could also be used to determine a more specific sampling design.
Livestock *2001 WQG (not updated in 2014)*	 30 µg/L	*Water*: A maximum WQG not to be exceeded.
Irrigation *2001 WQG (not updated in 2014)*	 10 µg/L	*Water*: A maximum WQG not to be exceeded.

- *Source: Companion Document to Ambient Water Quality Guidelines for Selenium – Update (2014)*

Table 38. Recommended monitoring and assessment framework for selenium (Se).

Water [Se] < 1 µg/L

- Continue monitoring to determine trends in concentrations, as necessary;
- Monitoring of other compartments may be desirable to determine baseline conditions.

Water [Se] > 1 µg/L < 2 µg/L

- Continue monitoring to determine trends in concentrations;
- Measure sediment [Se]:
    - If < 2 µg/g (dw), monitor periodically at an appropriate frequency to determine if changes are occurring over time;
    - If > 2 µg/g (dw), monitor other compartments as necessary.

Water [Se] > 2 µg/L

- Recommend:
    - Determine sediment [Se], compare with sediment Se alert concentration;
    - Determine invertebrate tissue [Se], compare with Se interim dietary WQG;
- As necessary:
    - Determine fish tissue [Se];
    - Determine bird egg [Se].
- If natural background [Se] is > 2 µg/L, conduct sufficient sampling of each appropriate compartment above to establish background concentrations;
- If natural background [Se] is < 2 µg/L, conduct ongoing monitoring to determine trends for each appropriate compartment over time.
- Consider assessing other indicators (e.g. fish population structure, environmental effects assessment)

Water [Se] > 10 µg/L and/or fish tissue is > Human Consumption Screening Values

- As necessary:
    - Consult the local health authority

- *Source: Companion Document to Ambient Water Quality Guidelines for Selenium – Update (2014)*

Table 39. Water quality guidelines for silver (Ag).

Environment	Conditions	Long-term Chronic WQG (µg/L total Ag)	Short-term Acute WQG (µg/L total Ag)
Freshwater	Hardness ≤ 100 mg/L	0.05	0.1
Freshwater	Hardness > 100 mg/L	1.5	3.0
Marine Water	Open coast & estuaries	1.5	3.0

- *Source: Ambient Water Quality Criteria for Silver: Overview Report (1996).*

Table 40. Water quality guidelines for sulfolane ($C_4H_8O_2S$).

Water Use	Long-term Chronic WQG (mg/L Sulfolane)
Freshwater Aquatic Life	50
Livestock	14
Irrigation	8.4

- *Source: Ambient Water Quality Guidelines for Sulfolane: Overview Report (2003).*

Table 41. Water quality guidelines for sulphate (SO_4^{2-}) to protect freshwater aquatic life.

Water Hardness * (mg/L $CaCO_3$)	Freshwater Long-term Chronic WQG (mg/L total SO_4^{2-})
Very Soft (0-30)	128
Soft to Moderately Soft (31-75)	218
Moderately Soft/Hard To Hard (76-180)	309
Very Hard (181-250)	429
>250	Determined on a site-specific basis †

- ** Water hardness categories adapted from the Canadian Council of Ministers of the Environment.*
- *† Toxicity tests on early stage rainbow trout were only conducted up to a water hardness of 250 mg/L. Natural background concentrations of water hardness in BC are generally much lower than that.*
- *When water hardness exceeds highest hardness tested (i.e. upper bound), a site-specific assessment may be required.*
- *Source: Ambient Water Quality Guidelines for Sulphate: Technical Appendix (2013)*
- *Working water quality guidelines for other water uses are available at:* https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Table 42. Water quality guideline for sulphate (SO_4^{2-}) to protect livestock.

Water Use	WQG (mg/L total $SO4^{2-}$)
Livestock	1,000

- *Source: Ambient Water Quality Guidelines for Sulphate: Technical Appendix (2013)*
- *Working water quality guidelines for other water uses are available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf*

Table 43A. Water quality guidelines for temperature.

Water Use	WQG (°C)
Freshwater Aquatic Life - Streams with Bull Trout &/or Dolly Varden	Short-term daily temperature is 15. Short-term incubation temperature is 10. Minimum incubation temperature is 2. Short-term spawning temperature is 10.
Freshwater Aquatic Life - Streams with Known Fish Distribution	± 1 change beyond optimum temperature range as shown in Table 42B for each life history phase of the most sensitive salmonid species present. Hourly rate of change not to exceed 1.
Freshwater Aquatic Life - Streams with Unknown Fish Distribution	MWMT = 18. (Short-term daily temperature = 19). Hourly rate of change not to exceed 1. Short-term incubation temperature = 12 (in spring and fall).
Freshwater Aquatic Life - Lakes & Impoundments	± 1 change from ambient background.
Marine & Estuarine Aquatic Life	± 1 change from ambient background. Hourly rate of change up to 0.5. See footnote.
Wildlife & Livestock Irrigation	± 1 change from ambient background. Hourly rate of change should not exceed 0.5.

- *MWMT, mean weekly short-term temperature, is defined as the average of the warmest daily short-term temperatures for 7 consecutive days.*
- *The natural temperature cycle characteristic of the site should not be altered in amplitude or frequency by human activities.*
- *Source: Water Quality Guidelines for Temperature: Overview Report (2001).*

Table 43B. Optimum temperature ranges of specific life history stages of salmonids and other cold-water fishes for water quality guideline application.

Species	Incubation (ºC)	Rearing (ºC)	Migration (ºC)	Spawning (ºC)
Salmon				
Chinook	5.0-14.0	10.0-15.5	3.3-19.0	5.6-13.9
Chum	4.0-13.0	12.0-14.0	8.3-15.6	7.2-12.8
Coho	4.0-13.0	9.0-16.0	7.2-15.6	4.4-12.8
Pink	4.0-13.0	9.3-15.5	7.2-15.6	7.2-12.8
Sockeye	4.0-13.0	10.0-15.0	7.2-15.6	10.6-12.8
Trout				
Brown	1.0-10.0	6.0-17.6		7.2-12.8
Cutthroat	9.0-12.0	7.0-16.0		9.0-12.0
Rainbow	10.0-12.0	16.0-18.0		10.0-15.5
Char				
Arctic Char	1.5-5.0	5.0-16.0		4.0
Brook Trout	1.5-9.0	12.0-18.0		7.1-12.8
Bull Trout	2.0-6.0	6.0-14.0		5.0-9.0
Dolly Varden		8.0-16.0		
Lake Trout	5.0	6.0-17.0		10.0
Grayling				
Arctic Grayling	7.0-11.0	10.0-12.0		4.0-9.0
Whitefish				
Lake Whitefish	4.0-6.0	12.0-16.0		> 8.0
Mountain Whitefish	< 6.0	9.0-12.0		< 6.0
Other Species				
Burbot	4.0-7.0	15.6-18.3		0.6-1.7
White Sturgeon	14.0-17.0			14.0

- *Source: Water Quality Guidelines for Temperature: Overview Report (2001).*

Table 44. Water quality guideline for toluene (C_7H_8).

Water Use	WQG (µg/L Toluene)
Freshwater Long-term Chronic	0.5

- *Source: Ambient Aquatic Life Guidelines for Toluene (2007)*

Table 45. Water quality guidelines for turbidity, and suspended and benthic sediments.

Water Use	Turbidity	Non-filterable Residue (Total Suspended Solids)	Streambed Substrate Composition
Aquatic Life (Fresh, Marine, Estuarine)	Change from background of 8 NTU at any one time for a duration of 24 h in all waters during clear flows or in clear waters Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters Change from background of 5 NTU at any time when background is 8 - 50 NTU during high flows or in turbid waters Change from background of 10% when background is > 50 NTU at any time during high flows or in turbid waters	Change from background of 25 mg/L at any one time for a duration of 24 h in all waters during clear flows or in clear waters Change from background of 5 mg/L at any one time for a duration of 30 d in all waters during clear flows or in clear waters Change from background of 10 mg/L at any time when background is 25 - 100 mg/L during high flows or in turbid waters Change from background of 10% when background is > 100 mg/L at any time during high flows or in turbid waters	% fines not to exceed: • 10% < 2 mm • 19% < 3 mm • 28% < 6.35 mm at salmonid spawning sites Geometric mean diameter not less than 12 mm (minimum 30-d intra-gravel DO of 6 mg/L) Fredle number not less than 5 mm (minimum 30-d intra-gravel DO of 8 mg/L)
Wildlife & Irrigation	Change from background of 10 NTU when background is ≤ 50 NTU Change from background of 20% when background > 50 NTU	Change from background of 20 mg/L when background is ≤ 100 mg/L Change from background of 20% when background > 100 mg/L	
Livestock	Change from background of 5 NTU when background is ≤ 50 NTU Change from background of 10% when background is > 50 NTU	Change from background of 10 mg/L when background is ≤ 100 mg/L Change from background of 10% when background is > 100 mg/L	

- DO = dissolved oxygen, NTU = nephelometric turbidity units.
- To determine if guidelines have been exceeded, for short-term exposures, hourly samples taken over a 24-h period are preferred to demonstrate the continuity of an event. Initially, less frequent monitoring may be appropriate to determine the need for more extensive monitoring. For long-term

exposures, daily samples taken over a 30-d period are preferred, but may also be initially checked by less frequent monitoring.

- If it is not possible to measure turbidity using automated sampling equipment (needed to obtain hourly measurements over 24 h, and daily measurements over 30 d), non-automated equipment may be used instead (to obtain 5 measurements over 30 d).
- *Source: Ambient Water Quality Guidelines (Criteria) for Turbidity, Suspended and Benthic Sediments: Overview Report (2001)*

Table 46. Water quality guideline for xylene (C_8H_{10}).

Water Use	WQG (mg/L total Xylene)
Freshwater Long-term Chronic	0.03

- *Source: Ambient Water Quality Guidelines for Xylene: Overview Report (2007).*

Table 47. Water quality guidelines for zinc (Zn).

Water Use	Long-term Chronic (µg/L Zn)	Short-term Acute (µg/L Zn)
Freshwater Aquatic Life (dissolved Zn)	$WQG = \frac{\exp(0.947[\ln(\text{hardness})] - 0.815[\text{pH}] + 0.398[\ln(\text{DOC})] + 4.625)}{2}$	$WQG = \frac{\exp(0.833[\ln(\text{hardness})] + 0.240[\ln(\text{DOC})] + 0.526)}{2}$
Marine Life (total)	10	55
Livestock (total Zn)	2,000	
Irrigation (total Zn) - Soil pH < 6	1,000	
Irrigation (total Zn) - Soil pH ≥ 6 and < 7	2,000	
Irrigation (total Zn) - Soil pH ≥ 7	5,000	

- *Long-term Chronic WQG is valid for water hardness between 23.4 and 399 mg $CaCO_3$/L, pH 6.5 and 8.13 and DOC 0.3 and 22.9 mg/L.*
- *Short-term acute WQG applies to water hardness between 13.8 and 250.5 mg $CaCO_3$/L and DOC 0.3 and 17.3 mg/L.*
- *When water hardness exceeds highest hardness tested (i.e. upper bound), a site-specific assessment may be required.*
- *Source: Zinc Water Quality Guidelines – Freshwater Aquatic Life (2023)* and *Zinc Water Quality Guidelines – Marine and Agriculture 1997*
- Zn sediment WQGs are available in the *Working Sediment Quality Guidelines*