

## AN UPDATE ON THE DEPARTMENT OF NATIONAL DEFENCE SEDIMENT REMEDICATION IN ESQUIMALT HARBOUR

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### ABSTRACT

Esquimalt Harbour, located at the south end of Vancouver Island, British Columbia, is the primary Pacific homeport for the Royal Canadian Navy (RCN). The majority of the aquatic lands in the harbour are owned and managed by the Department of National Defence (DND). Addressing environmental risks associated with contaminated sediments in Esquimalt Harbour is a high priority for RCN and DND due to the levels of contamination present and the potential human health and environmental risks of exposure to these sediments. Given that the contamination present is the result of historical activities and sources, Esquimalt Harbour is eligible for the Federal Contaminated Sites Action Plan (FCSAP) program. The presence of these contaminants and associated risks has also led to Esquimalt Harbour being classified as a Class 1 Contaminated Site (High Priority for Action) under Fisheries and Oceans Canada's (DFO's) Aquatic Site Classification System. Managing these risks through remediation or other risk management measures supports DND's environmental stewardship objectives.

This paper provides an update on sediment remediation in Esquimalt Harbour. The purpose of the sediment remediation is to reduce the ecological and human health risks associated with the contaminated sediments found in Esquimalt Harbour. The sediment remediation program has prioritized four portions of Esquimalt Harbour for early remedial action and is continuing to develop a larger harbour-wide strategy using both risk management and remedial actions at five other harbour hotspots. The nine sites chosen for remedial action were selected based on a number of factors, including the degree of contamination, recontamination potential, and constraints imposed by the presence of RCN infrastructure (e.g., jetties). The paper will provide an update of the scope and schedule of the sediment remediation in Esquimalt Harbour and discuss some of the challenges of conducting such work. Significant challenges include the schedule and operational constraints of attempting to complete this project in a working harbour, coordinating with ongoing capital improvement projects, and obtaining project approvals through both DND and FCSAP project authorization frameworks.

**Keywords:** Sediment contamination, harbour-wide cleanup, remedial dredging, Esquimalt, British Columbia, Canada.

### INTRODUCTION

#### Site Background

Esquimalt Harbour is located at the south end of Vancouver Island (Figure 1) and is bounded to the west by the City of Colwood, to the north and northeast by the Township of View Royal, to the east by the Esquimalt and Songhees First Nations reserves, and to the southeast by Canadian Forces base (CFB) Esquimalt Dockyard. Esquimalt Harbour is the primary Pacific homeport of the Royal Canadian Navy (RCN). The majority of Esquimalt Harbour is part of a federally owned 354-hectare waterlot that is currently administered by the Department of National Defence (DND). The majority of the foreshore land is owned and managed by the Federal Government, with DND having the largest holding and use of the harbour for the operation of CFB Esquimalt. DND leases a portion of the harbour to the Esquimalt and Songhees First Nations. In addition to DND, a smaller waterlot is owned by Public Works and Government Services Canada (PWGSC), from which the Esquimalt Graving Dock operates.

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The depth of seabed in Esquimalt Harbour ranges from shallow mudflats in the north part of the harbour to a depth of 16 metres at the harbour entrance. In general, the harbour consists of nearshore slopes to a relatively consistent flat harbour bottom punctuated by irregular bedrock outcrops. Most of the seafloor is muddy sand to sandy mud, with significant deposits of wood waste in the northern portions of the harbour.



**Figure 1. Vicinity Map.**

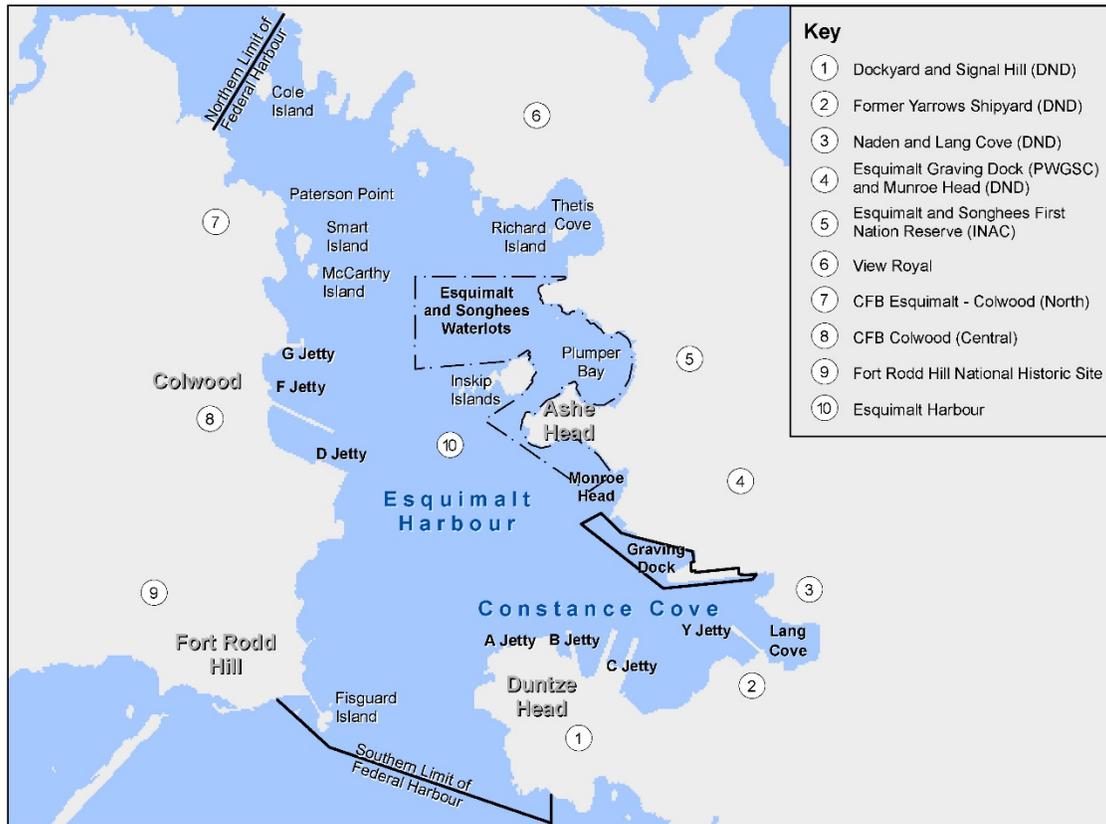
### Site History

Esquimalt Harbour was originally used by the First Nations for food, shelter, and transportation before the British came to the area in the mid-19th century. The Royal Navy established residence in the harbour in the 1840s. In 1861, planning began for a drydock in Esquimalt Harbour on the south shore of Constance Cove to service naval and commercial ships, with construction commencing in 1876 and the dock opening in 1887. The land that is now CFB Esquimalt was transferred from the Royal Navy to the RCN in 1910.

The beginning of World War II (approximately 1939) spurred additional expansion and renovation due to increased demand on the CFB Esquimalt facilities. The jetties at that time were named Dockyard Jetty (A Jetty), Refitting Jetty (B Jetty), Naval Ordnance Jetty (C Jetty, the old coal wharf), Magazine Jetty (G Jetty), Fuel Oil Jetty (F Jetty), and D Jetty (Figure 2). In 1987, the original C Jetty was decommissioned, and the area was dredged prior to construction of a new concrete twin finger-pier jetty. The dredged material from the construction of the new C Jetty was deposited within Lang Cove. The original F Jetty was also replaced in the early 2000s with sediment that was dredged and disposed of in upland facilities.

Shipbuilding, ship repair, and other industrial activity has also occurred in Esquimalt Harbour outside of CFB Esquimalt. A private shipyard (that later became the Yarrow's Shipyard) was erected near Lang Cove in 1893 and included a marine railway structure. Activity at the Yarrow's Shipyard peaked during World War II and was ultimately shut down in 1996. The Yarrow's Shipyard was subsequently acquired by DND and became the site of the current Y Jetty. Additionally, in 1921, PWGSC began construction of a new modern graving dock. It was in operation by 1926, becoming one of the largest drydocks in the world, and is still in operation to this day. In the 1960s, PWGSC built E Jetty (or South Jetty) adjacent to its graving dock. The Esquimalt Graving Dock, owned by PWGSC, is primarily a maintenance and repair facility, with maintenance operations being carried out by private firms. Other industries that operated in Esquimalt Harbour were a saw mill, plywood mill, blacksmith's shop, slaughterhouse, flour

mill, cannery, log booming operations, float plane base, auto repair facility, concrete plant, and coal storage. Stormwater inputs to Esquimalt Harbour have also been a historical and ongoing contributor to harbour impacts.



**Figure 2. Features of Esquimalt Harbour.**

### Sediment Contamination

Historical activities have generated a wide variety of organic and inorganic contaminants, which made their way into the harbour and became engrained in the underlying sediments. The presence of these contaminants in Esquimalt Harbour has resulted in the harbour being designated a Class 1 Contaminated Site (High Priority for Action), as per the Fisheries and Oceans Canada's (DFO's) Aquatic Site Classification System. This Class 1 designation reflects that there are more than 25 known chemicals of concern (COCs) in Esquimalt Harbour, all of which exceed the Canadian Environmental Quality Guidelines for sediments. The COCs in Esquimalt Harbour include metals (such as mercury and lead), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

Concentrations of the various COCs in sediments vary significantly within Esquimalt Harbour (Figure 3). In some areas of Esquimalt Harbour, concentrations are significantly greater than the Probable Effects Level (PEL) established by the Canadian Council of Ministers of the Environment (CCME). The PEL is a sediment quality guideline used to gauge sediment contamination levels. Per CCME, when contaminant concentrations exceed the PEL, adverse effects in sea life exposed to the sediments are more likely to occur (CCME 2001).

To further assess the potential impacts of contaminated sediment on human health, a quantitative human health risk assessment of Esquimalt Harbour was completed in 2010 and updated in 2017. The human health risk assessment indicates that contaminants in Esquimalt Harbour are being absorbed by fish and shellfish within the harbour at concentrations that present potential risks to humans who consume seafood from the harbour. As a result, DND requested that Health Canada's Food Directorate, the governmental authority for food consumption guidance, evaluate

whether the consumption of seafood harvested from Esquimalt Harbour could pose a risk to human health. Based on Health Canada's review, a recommendation was made to limit seafood consumption in the harbour. As a result of the Health Canada recommendation in October 2009, DFO issued a consumption advisory limiting the First Nations' and recreational consumption of seafood within Esquimalt Harbour.

## **OVERVIEW OF SEDIMENT REMEDIATION IN ESQUIMALT HARBOUR**

### **Sediment Remediation Overview**

Hotspots within Esquimalt Harbour have been delineated to address areas with the greatest concentrations of COCs that exceed the PEL values and have the potential to increase human and ecological risk receptors. Nine distinct areas have been identified as these higher-concentration hotspots (Figure 4). The larger hotspots continue to be sources of contamination for other parts of the harbour through sediment transport. The nine areas, hereafter referred to as Remedial Planning Areas, consist of the following:

- A/B Jetty
- C Jetty & ML Floats
- Constance Cove
- Y Jetty
- Lang Cove
- D Jetty
- F/G Jetty
- Ashe Head
- Plumper Bay

All nine of the Remedial Planning Areas are at various stages of completion. There was one other high-concentration hotspot in the harbour, the Esquimalt Graving Dock waterlot, which is PWGSC's responsibility. PWGSC has completed remediation of its waterlot as of fall 2016.

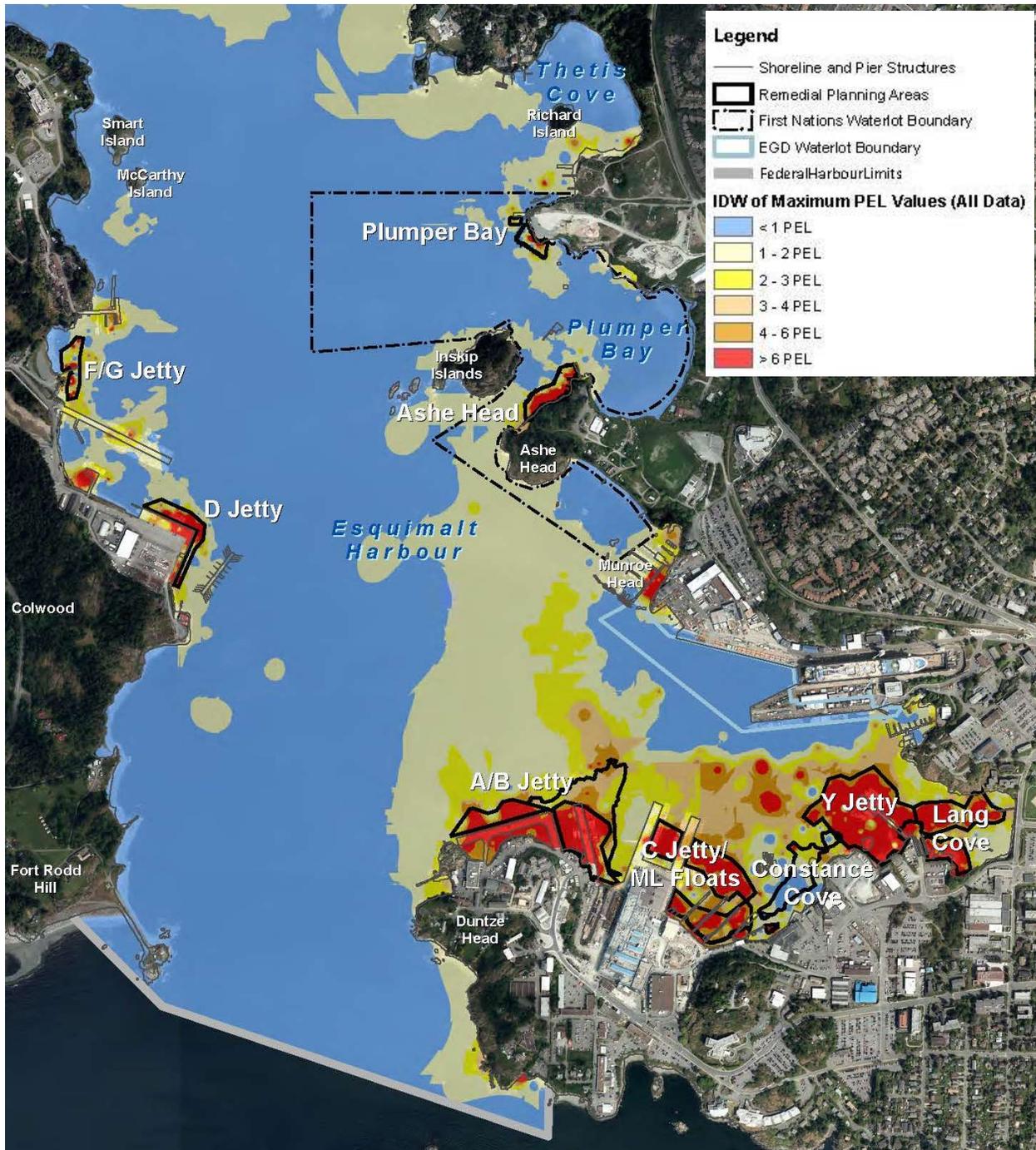


Figure 3. Boundaries of current Remedial Planning Areas in Esquimalt Harbour.

### Project Purpose and Strategy

The overall objective of the sediment remediation in the harbour is to minimize the human health and ecological risks associated with contaminated sediments found in Esquimalt Harbour within existing resource constraints. Through these reductions in human health and ecological risks, the liabilities associated with Esquimalt Harbour will also be reduced. More specifically, the goals and business outcomes of the project are as follows:

- Remediate prioritized Remedial Planning Areas of Esquimalt Harbour.

- Implement a harbour-wide risk management plan that addresses areas of Esquimalt Harbour with lesser levels of contamination.
- Reduce the liability associated with Esquimalt Harbour contaminated sediments.
- Minimize health risks associated with seafood affected by historical contaminants.
- Reduce ecological risks associated with contaminated sediments.
- Sustain long-term RCN operations in Esquimalt Harbour.
- Minimize recontamination potential.
- Uphold the DND's and RCN's reputations with the public, stakeholders, and First Nations.
- Avoid significant impacts to RCN operations.
- Optimize the project to best fit and respond to resource constraints and opportunities.

### Remedial Overview of Esquimalt Harbour

Remedial actions for the sites typically consist of remedial dredging with associated environmental controls and subsequent material placement. The extent of removal depends on working within the constraints of the active naval harbour, around functioning jetties, and within the geology of Esquimalt Harbour. The goal of the remedial designs is to remove the extent of sediment contamination that exceeds project-specific thresholds while maintaining existing structures and engineered slopes (e.g., riprap). To meet the remedial objectives, techniques focus on removal to the extent practicable to facilitate a reduction in DND liability and meet the objectives of the FCSAP funding source (i.e., addressing legacy contamination). Once removal actions have been completed, material placement actions are used to augment the removal actions and meet remedial objectives. The remediation techniques being considered include open-water dredging; nearshore dredging and excavation; underpier dredging (i.e., removal of sediments under existing jetties); nearshore engineered capping; placement of underpier and nearshore remedial cover material to facilitate stabilization of contaminated sediments left in place; placement of residuals management cover (RMC); and enhanced natural recovery (ENR). Supplemental sequencing and recontamination measures, including additional sampling and contingency dredging efforts, have been built into the program to allow for completion of the multiple phases of the project while still meeting remedial objectives in the midst of a working harbour.

Areas and estimated volumes of contaminated sediments associated with each of the sediment Remedial Planning Areas are provided in Table 1. Boundaries of each area are shown in Figure 3.

**Table 1. Preliminary area and dredge volume estimates of the Remedial Planning Areas in Esquimalt Harbour.**

<b>Remedial Planning Area</b>	<b>Area (m<sup>2</sup>)</b>	<b>Dredge Volume (m<sup>3</sup>)</b>
A/B Jetty	37,000	140,100
C Jetty	32,200	47,900
Constance Cove	10,700	20,800
Y Jetty	32,300	57,000
Lang Cove	6,200	11,500
D Jetty	7,700	14,300
F/G Jetty	5,600	10,100
Ashe Head	4,500	9,100
Plumper Bay	2,000	4,400
<b>Total</b>	<b>138,200</b>	<b>315,200</b>

Notes:

m<sup>2</sup>: square metre

m<sup>3</sup>: cubic metre

### Site-specific Remedial Actions

The boundaries of the Esquimalt Harbour Remedial Planning Areas were delineated primarily based on sediment chemistry data. These data were extrapolated into remedial dredge prisms and areas of material placement to facilitate remedial actions as part of the various phases of sediment remediation in Esquimalt Harbour. The Remedial Planning

Areas are at different stages of completion, with the bulk of the sites still in the design stage and several others recently completed, out to tender, or recently awarded. The following are brief descriptions of each Remedial Planning Area and remedial actions that have either been completed or are being contemplated.

Sediment remediation is divided into three separate remedial actions: Open Water A Jetty, B Jetty, and under and behind A Jetty. The remedial efforts have been divided as such to align with A Jetty and B Jetty demolition and subsequent rebuilding project phases as part of the A/B Jetty Recapitalization Project. To facilitate removal of sediments throughout the site, remedial dredging is being sequenced between demolition and construction of the individual jetty structures to allow full removal of areas that would otherwise be under existing and future jetties and hence more difficult or impossible to remediate fully. The remediation of the open-water portion of A Jetty was completed in Fiscal Year 2016/2017 and consisted of remedial dredging in the open-water area off the face of the existing A Jetty structure. Sediment remediation associated with B Jetty was recently awarded as part of the larger jetty demolition and reconstruction project, and pre-construction submittals are currently pending. Remediation of B Jetty sediment is planned to be completed by March 31, 2018. This project will consist of dredging, with contingency dredging and RMC placed, as needed, after the completion of required dredging to facilitate meeting remedial objectives. The contaminated sediments under and behind the existing A Jetty will be the final area of remediation and are slated to be completed as part of the future demolition and rebuild of the A Jetty. The under and behind portion of the A Jetty work is also anticipated to include RMC placement in the open-water portion of A Jetty and portions of the B Jetty footprint to facilitate addressing any recontamination of those areas that may have occurred during the interim years between the multiple phases of remediation at the site.

C Jetty, Y Jetty, and Lang Cove will be required to be remediated while the jetties are in active service and will require additional measures to accommodate project sequencing and address contaminated underpier sediments. Recently, 60% design has been completed for these sites, and it is anticipated that construction of the sites will occur in 2018 and 2019. Remedial techniques in these areas have yet to be fully evaluated but generally consist of remedial dredging with material placement, as previously mentioned. These sites will incorporate a variety of material placement techniques to accomplish remedial objectives after remedial dredging has been completed. In nearshore areas at the Y Jetty and Lang Cove sites where contamination is known to extend into adjacent upland areas, a proposed solution is engineered capping. Suitability evaluations of capping are pending and will take into account the technical feasibility of placing a cap in intertidal zones, with irregular underlying bedrock, and include the requirements for habitat offsetting to account for nearshore impacts. One area in the central portion of Lang Cove is being considered as a candidate for ENR. Results from recent depositional studies have helped inform the decision to place ENR material to aid in the natural recovery of the cove, which sees minimal vessel traffic, and is known to have a significant depth of previously dredged material from historic operational dredging activities at other harbour jetties. Finally, placement of RMC to address generated residuals at each of the sites is being considered and will be determined after dredging is completed. Post-dredging confirmation sampling will inform this decision based on measured concentrations in the generated residuals layer relative to harbour-wide background contaminant concentrations. The ML Floats, within the C Jetty site, will be temporarily relocated and reinstated to facilitate dredging under their footprints. Additionally, all sites except Lang Cove are, and will remain, active berths for RCN Operations. Sequencing will be a key component of these projects to minimize the time that jetty berths are out of service, as the RCN will experience additional berthing pressures due to the A/B Jetty Recapitalization Project removing an important active jetty. This, in combination with other harbour projects potentially occurring at EGD and the construction of the Small Boat Floats project, will complicate sequencing and require routine coordination with the Queen's Harbour Master.

The D Jetty and F/G Jetty areas are undergoing active remediation, as of the date of this paper, with an estimated completion date of May 2017. Remedial actions at these sites consist of mechanical dredging of contaminated sediments with subsequent material placement. Backfill activities were required to place remedial cover, consisting of a sandy gravel material, in areas under the jetty that could not be reached through mechanical removal methods. Dredging at D Jetty was completed after removal of portions of the jetty fender system to facilitate removal of contaminated sediments adjacent to the jetty structure. Prior to reinstating the fender system, structural backfill was placed to facilitate pile embedment depths and provide additional support to the slopes under the jetty. Similarly, at the F/G Jetty site, remedial dredging was employed to remove contamination after an existing float and gangway were removed. Prior to reinstatement of the float, structural backfill was placed again to support pile embedment depths. To facilitate similar habitat structure after remediation, backfill of the F/G Jetty site to pre-construction bathymetry was completed, and a similar surface material to match pre-construction material gradation was placed on the surface. Additionally, contingency dredging was completed and RMC were placed after confirmation sampling was

completed to address generated residuals and missed inventory. Both sites were successfully completed on time and within project budgets.

Additional remediation is planned for the eastern portion of Constance Cove and will soon be put out to tender, with an award anticipated as of June 2017. This project consists of remedial dredging with associated environmental controls. This portion of the harbour has several known bedrock outcrops that have been incorporated into the design, with only sediment above the bedrock considered for removal. No structures or shoreline modifications are included in the project scope. Contingency redredging and RMC placement will occur if post-dredging sediment concentrations, determined via testing, warrant these actions.

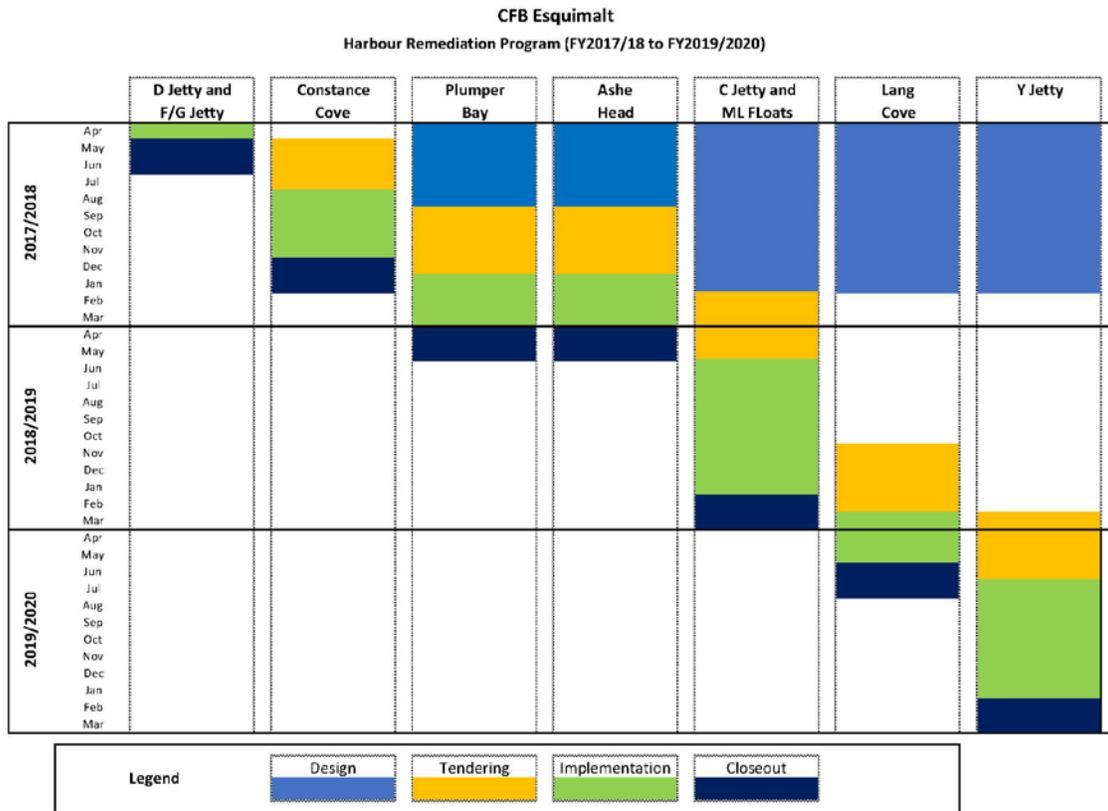
The Ashe Head and Plumper Bay Remedial Planning Areas are both currently in the 60% design stage. It is currently assumed that these projects will be combined into a single project for tender purposes. These projects will consist of remedial dredging, with subsequent material placement to restore pre-construction bathymetry and like surface material conditions to facilitate permitting conditions. The projects are smaller in size than the other sediment remediation sites and are being completed without structural modifications. Both sites are within the Esquimalt and Songhees First Nations waterlot and as such, additional coordination is underway with the First Nations regarding project elements.

### **Lessons Learned from Remediation Completed to Date**

As noted above, the initial phase of remediation at the A/B Jetty site, the Open Water A Jetty project has been completed, and the remediation at the D Jetty and F/G Jetty sites is currently nearing completion. As a result of completing these initial sediment remediation projects, several lessons learned have been captured and incorporated into remedial designs and planning for the remaining sediment remediation projects. In general, specification language has been tightened around several recurring issues, particularly regarding items such as discharge requirements of water back to the harbour, reporting of contractor sample results, and general flow of information between the contractor, contractor's subcontractors, the contracting authorities, and the owner. One major adaptation is the discovery of scrap munition during the Open Water A Jetty project in the dredge material. As part of that project, the contractor elected to sort the dredge material as a pilot test of a material processing plant. As a result, numerous scrap munitions were encountered, well beyond what was anticipated by DND and the design team in advance of the project. This resulted in requiring material processing at subsequent projects in active or former DND jetty areas to segregate potential scrap munitions or suspected unexploded explosive ordnance (UXO) from the dredge material. The processing has also led to additional requirements for archaeological monitoring to manage encountered artifacts.

### **Project Schedule**

As previously noted, the various Remedial Planning Areas are at differing stages of completion. Individual project dates are typically driven by funding availability and berthing constraints and are sequenced in an effort to minimize overlap of construction of multiple projects at the same time. The sequencing was established to minimize impacts to RCN operations and facilitate competitive bids from qualified contractors. Figure 4 provides a high-level summary schedule of the various harbour sediment remediation project sites. Note that since the A/B Jetty Remedial Planning Area is tied to operational upgrades as part of the A/B Jetty Recapitalization Project, those are not included in this figure since they are being managed separately from the rest of the harbour remediation sites.



**Figure 4. Esquimalt Harbour sediment remediation projects schedule.**

As previously mentioned, the D Jetty and F/G Jetty sites are nearing completion and will enter closeout shortly. The remediation of the eastern portion of Constance Cove is the next project to go to construction, and is prepared to go out to tender as of the writing of this paper. Subsequently, the Plumper Bay and Ashe Head Remedial Planning Areas will be constructed. The Constance Cove, Plumper Bay, and Ashe Head Remedial Planning Areas all have funding restrictions that require the projects to be completed prior to March 31, 2018. C Jetty, Lang Cove, and Y Jetty are all slated to occur in 2018 through March 2020. The EHRP has a project closeout date of April 2020. This closeout date is driven by the sunset of the primary source of funds for this project, the FCSAP, on March 31, 2020 with closeout in April 2020.

**Challenges and Opportunities**

Every large remediation program has several challenges and opportunities that can significantly affect the probability of delivering a successful project. Some of the challenges and opportunities that apply to the sediment remediation projects in Esquimalt Harbour include the following:

- Completing a risk management and remedial strategy in an active naval base with adjacent industrial uses.
- Establishing appropriate remedial and risk management objectives in a largely industrial working harbour (e.g., How clean is “clean”?)
- Working with numerous stakeholders.
- Accessing a time-limited funding source (i.e., the FCSAP will sunset in 2020).
- Constraints on funding sources and the impact on the ability to remediate sites.

- Sequencing multiple projects within a limited timeframe while encouraging competitive bids and qualified contractors.
- Developing remedial strategies adjacent to older infrastructure (e.g., a drydock that is more than 125 years old).
- Working within shallow bathymetry.
- Challenging dredging conditions due to irregular bedrock and the potential for an increase in generated residuals.
- Dredging in an active harbour with limited berthing while the A/B Jetty Recapitalization Project has a main jetty out of service.
- Conducting nearshore remediation to adjoin upland contamination sources and remediation sites.
- Managing potentially ongoing sources of sediment contamination consistent with Esquimalt Harbour being a working and largely urbanized waterbody.
- Producing synchronization and integration with multiple marine infrastructure renewal projects within Esquimalt Harbour (e.g., recapitalization of A/B Jetty).
- Coordinating with multiple contracting authorities and consultants.
- Developing appropriate cost estimates and contingencies in the context of an aquatic contaminated site.
- Learning from similar completed projects (e.g., Open Water A Jetty Dredging, D Jetty, F/G Jetty, PWGSC Esquimalt Graving Dock Waterlot Remediation Project, and Transport Canada sediment-related projects in Victoria Harbour).

### CONCLUSIONS

Historical activities within Esquimalt Harbour have resulted in the contamination of sediments in areas of the harbour. The presence of this contaminated sediment has resulted in potentially significant risks to human health and the environment. To mitigate these potentially significant risks, multiple sediment Remedial Planning Areas have been, or are being, executed to implement a remediation and risk management strategy. The remediation and risk management strategy currently includes the remediation of nine prioritized hotspots within Esquimalt Harbour, as well as the design and implementation of a harbour-wide risk management plan prior to April 2020.

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### CITATION

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