Transport Canada   Transports Canada

TP 13566E

VICTORIA & ESQUIMALT HARBOURS ENVIRONMENTAL PROGRAM

ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT OF TRANSPORT CANADA ADMINISTERED & CONTROLLED HARBOUR FLOOR IN UPPER VICTORIA HARBOUR

Final Draft

December, 2007

Prepared for:

Transport Canada
Victoria & Esquimalt Harbours Environmental Program
Suite 620
800 Burrard Street
Vancouver, BC
V6Z 2V8

Prepared by:

UMA Engineering Ltd.
200-415 Gorge Road East
Victoria, British Columbia
V8T 2W1

Morrow Environmental Consultants Inc.
8648 Commerce Court
Burnaby, BC
V5A 4N6

Doug A. Bright, Ph.D., RPBio
Senior Environmental Scientist

Ross Wilson, M.Sc., DABT
Senior Toxicologist

Canada

EXECUTIVE SUMMARY

This report provides an assessment of the ecological and human health risks associated with contaminants in harbour floor sediments within the submerged lands (both intertidal and subtidal) under Transport Canada's Administration and Control within the Upper Basin of Victoria Harbour, southern Vancouver Island, British Columbia. The Upper Basin includes the area of the Harbour to the north of the Johnson Street Bridge and south of the Selkirk Trestle. Environmental Baseline Study (**EBS**) volumes completed between 1998 and 2005 at Transport Canada properties within the Upper Basin identified the presence of chemicals in harbour sediments in excess of relevant sediment criteria. The EBS volumes recommended that a risk assessment/risk management approach be implemented to further address harbour floor sediment quality issues.

This Ecological and Human Health Risk Assessment (**EHHRA**) was completed to assist with the following three overall goals:

(i) Address federal requirements for assessing and managing contaminant risks, where federal to federal land transfer/re-development is being considered;

(ii) Fulfill provincial requirements for assessing and managing contaminant risks, where federal to provincial land transfer/re-development by a non-federal entity is being considered. It should be noted, however, that provincial requirements do not directly apply to federal property, but may be discussed in this report simply as a guideline for consideration of some of the possible implications of any future change in jurisdiction; and

(iii) Provide the basis for ongoing management by Transport Canada of active contaminant releases, contaminated sediments, environmental risks, and for environmental stewardship such as development of best management practices (**BMPs**).

In addition to Transport Canada, multiple other entities own harbour floor in Victoria Harbour. Areas of harbour floor which are not under the Administration and Control of Transport Canada are not included within the scope of this study (Map 1-2). It should also be noted that Rock Bay is excluded from this Upper Basin EHHRA since it is the subject of an extensive environmental assessment and remediation project being undertaken by Transport Canada and BC Hydro.

For practical purposes, we have further divided the Upper Basin into the following two sub-areas:

- "Upper Harbour", comprising the area between the Johnson Street Bridge and Bay Street Bridge; and
- "Selkirk Waterway", comprising the area between the Bay Street Bridge and Selkirk Trestle.

The following substances were identified as "Contaminants of Potential Concern" (**COPCs**) for the purpose of this EHHRA:

- aroclor polychlorinated biphenyls (**PCBs**);
- all unsubstituted polycyclic aromatic hydrocarbons (**PAHs**);
- antimony;
- arsenic;
- chromium;
- copper;

- lead;
- mercury;
- selenium;
- silver; and
- zinc.

Dioxins/furans and dioxin-like PCBs were of special interest even though the maximum observed concentration in sediments (259 pg/g 2,3,7,8-TCDD TEQ, including both PCBs and dioxins/furans) did not exceed BC *Contaminated Sites Regulation*[1] (CSR) Schedule 9 Criteria for Managing Contaminated Sediment ("Typical" habitat). This was based on: (i) presence of elevated concentrations of these substances in dungeness crab hepatopancreas in the study area; and, (ii) strong tendency of these substances to biomagnify and potentially affect higher predators.

Four major exposure/effects scenarios are the focus of this EHHRA:

(i) Direct contact with contaminated sediments and/or pore water or at the sediment/water interface by typically small, resident marine organisms (infauna and epifauna);

(ii) Possible loss due to chemically induced impairment of important near-shore spawning, nursery and recruitment areas for various commercially and economically important fish and mobile shellfish (crabs, shrimp);

(iii) Exposures in higher predators, including many fish and wildlife species, based on dietary intake; and

(iv) Human exposures to persistent and/or bioaccumulative substances based on:

    (a) dietary exposures; and

    (b) recreational exposures (during swimming, boating, beachcombing etc) to intertidal sediments and surface water.

An extensive data set of environmental information collected by Transport Canada and others between 1998 and 2004 was compiled and reviewed at the initiation of this study. Following a detailed review of the existing data, a sampling and analysis plan was developed to address data gaps and provide additional information for these major assessment endpoints and the many measurement endpoints that were derived from them. A field sampling program was conducted in the Upper Basin over three periods: (i) March 21 to 24, 2005 (sediment grabs, sediment cores and water column samples); (ii) July 19 to 28, 2005 (collections at focus sites for sediment chemistry, toxicity testing, benthic community analysis and benthic organism tissue; intertidal sampling for organisms and sediment; intertidal biomass surveys; beach seining for small forage fish; and trawls for fish, shrimp and crabs); and, (iii) March 24-26, 2006 (herring samples, collected during their return to spawn).

<u>Contaminant Distributions and Uptake</u>

Concentrations of the major COPCs in subtidal sediments generally increased in concentration from the Selkirk Waterway southward through the Upper Harbour. COPC concentrations in intertidal sediments were consistently lower than subtidal sediments, with the exception to

[1] *Contaminated Sites Regulation (CSR)*, B.C. Reg. 375/96, including amendments up to B.C. Reg. 239/2007.

dioxins/furans, which were higher in intertidal sediments of the Selkirk Waterway than in the subtidal sediments.

Sediment cores were collected from three locations in each of the Upper Harbour and Selkirk Waters. Contaminant concentrations generally showed a decreasing trend with increasing depth. COPC concentrations in seawater samples were generally low or below analytical detection limits, with detectable concentrations consistently below British Columbia Water Quality Guidelines for Marine and Estuarine Life.

On a basin-wide scale, the highest sub-tidal COPC concentrations were typically encountered in areas adjacent to the Point Hope industrial area on the west shore of Upper Harbour, and near an historical metal foundry and forging site in the Upper Harbour just east of the Bay Street Bridge and in the Selkirk Waters in vicinity of South Bay. With respect to near-shore areas, there is evidence that sediment COPC concentrations near major wharves and jetties, and municipal stormwater outfalls are elevated in comparison with the harbour floor as a whole. These locally elevated concentrations suggest enhanced inputs (historical and/or recent).

Concentrations of COPCs in subtidal sediment samples were generally significantly correlated with the concentration of coronene, a seven-ring PAH assessed in this study as an indicator compound of tail-pipe emissions, road runoff and subsequent stormwater inputs.

Regardless of the sources and mechanisms of contaminant re-distribution within sediments of the Upper basin, the net result is that virtually all of the Upper Harbour and the majority of the Selkirk Waterway exhibits levels of one or more COPCs in near-surface sediments that exceed their respective BC CSR sediment quality criterion for "Typical" habitat types. Small portions of the Selkirk Waterway near the western shore do not have substances at concentrations in excess of BC CSR for Typical habitat types.

In biota, a variety of trends were noted. Most COPCs exhibited a positive correlation between concentrations in benthic biota soft tissues and sediments from the same focus site. Higher levels of COPCs were observed in the soft tissues of benthic infauna from the Upper Harbour area compared to the Selkirk Waters area, a pattern that was similar to that of sediment COPC distributions. With regard to more mobile epifauna, most COPCs were elevated in Upper Basin Dungeness crab tissues and pooled whole body flatfish samples relative to reference site crabs, with a few notable exceptions.

Stable isotopic analysis ($\delta N15$) was used to re-construct trophic status of various marine biota sampled from the study area and analyzed for COPC concentrations. No relationship between apparent trophic status and tissue concentrations of COPCs with biomagnification potential was found, however. Biomagnification of PCBs, dioxins/furans and methyl mercury in the study area is likely occurring; however, the biota collected did not span a sufficient range of trophic positions to confirm this.

In addition to the chemicals that historically reside in the harbour floor sediments and those that are introduced to the study area from current sources (small spills, storm sewer inputs, etc.), there are various other physical stressors that likely affect the ecological status of the Transport Canada-Administered and Controlled portions of the Upper Basin. Such stressors include: past modification of intertidal areas consisting of substantial hard armouring; physical disturbance and sediment re-suspension as a result of propeller wash; and wood waste deposition from past log booming practices.

Risks to Human Health

The methods used to estimate human health risks were based on risk assessment procedures commonly used by regulatory agencies such as the BC Ministry of the Environment (**MoE**), Health Canada, World Health Organization (**WHO**), US Environmental Protection Agency (**US EPA**) and US Food and Drug Administration (**US FDA**). Briefly, exposures to chemicals were estimated based on a variety of assumptions relating to how persons may spend time in the vicinity of the Lower Basin. The toxicological literature was then reviewed to identify exposure rates that have been determined to be acceptable or "safe" (or more specifically, exposure rates without unacceptable risks of adverse effects to humans). In all cases, toxicological reference values were obtained from recognized health agencies that included Health Canada, US EPA, WHO and US FDA. The final step in the risk assessment was a comparison of the doses from the hypothetical exposure scenarios to the dose rates considered to be "safe" for humans. Standards provided in the Health Canada (2004b) approach to country foods assessment and the BC CSR provided the primary measures of acceptable levels of risks quantified as, Hazard Quotient values of 1 and Incremental Lifetime Cancer Risk (**ILCR**) estimates of 1×10^{-5}.

Overall, no unacceptable human health risks were estimated from foods or contact with intertidal sediments in the Upper Basin. From a HHRA perspective, there appears to be no need to complete remediation of the harbour floor under the Administration and Control of Transport Canada. Instead, it is anticipated that a risk management plan can be developed to ensure that environmental conditions within the Upper Basin remain acceptable to persons using the area. The key elements of such a risk management plan would be ensuring that the current uses and environmental concentrations remain similar to those assumed in the HHRA.

Ecological Risks

An ecological risk assessment was conducted to assess the possible adverse effects of contaminants of potential concern to wildlife foraging in the study area, bottom-dwelling fish, and invertebrates that live in close contact with the sediments. The ecological risk assessment considered risks to:

(i) benthic infauna (invertebrates that live in close contact with the sediments);

(ii) fish and large marine invertebrates that live and feed in close association with the Lower Basin harbour floor; and

(iii) avian and mammalian wildlife that might use the Lower Basin area for foraging.

Benthic Infauna

Sediments from eight focus stations were assessed using three laboratory toxicity tests. The Upper Basin sediment samples did not result in decreased survival or growth of juvenile polychaetes in comparison with responses in control beach sand collected from Mackenzie Beach, near Tofino, BC. There was no statistically significant difference between the survival or percent normal development of bivalve larvae between Upper Basin samples and the controls. Finally, burrowing amphipod survival was significantly lower than in uncontaminated control sediment in only two of eight Harbour samples; however, the percent decrease from the controls was ≤ 19%. An effect size of 20% for single species laboratory toxicity tests is often used as a threshold of ecologically significant (as opposed to statistically significant) effects.

The relative lack of apparent toxicity of Upper Basin surface sediments was also borne out by the benthic infaunal analysis. Overall, average taxon richness was reduced by 20% or more of the expected lower range (10^{th} %ile) for reference sites at 3 of 8 Upper Basin sites (37.5% of stations sampled). Since this comprises less than 50% of the sampled areas, risks are concluded to be acceptable over the entire study area.

The Upper Basin data were also examined in concert with similar data for 12 Lower Basin Stations and 2 Saxe Point reference site stations. The diversity (as taxon richness) was statistically significantly lower in sites from Selkirk Waterway, Upper Harbour, and Inner Harbour (range of 15 to 83 different types of organisms/0.1 m^2 grab sample), compared with sites near or beyond the Harbour mouth (range of 37 to 107 different types of organisms/0.1 m^2 grab sample). The taxon richness was negatively correlated with the concentrations of several harbour floor COPCs; however, taxon richness was also strongly positively correlated with silt content of the sediments. The concentration of silt in the sediment was, in turn, inversely correlated with COPC concentrations.

It should be noted that the methods used here do not lend themselves to an unequivocal interpretation of cause-effect relationships based on harbour floor COPCs. Rather, the analysis indicates that both sediment texture and some of the COPCs are correlated with reductions in benthic infaunal species richness throughout the Harbour, and that the inter-correlations between sediment texture and COPCs make it very difficult to accurately assess the relative influence of the two. The major point; however, is that measured variation within sediment benthos was not clearly related to gradients of sediment contamination by COPCs.

Overall, the available evidence indicates that although there has been an anthropogenic influence on sediment-associated biota within the study area, the degree of departure from the expected reference state is within an acceptable range, as interpreted from BC MoE policy.

Fish and Large Macroinvertebrates

The study area is frequented by juvenile flatfish and other sub-adult life stages of larger epifaunal invertebrates (e.g., crabs) and fish. Various fish, whole shrimp, Dungeness crabs, bivalves and other taxa were collected and their tissues were analyzed for COPCs.

Risks to juvenile or other fish and large, transient macrofauna were considered to be unacceptable if (i) tissue concentrations of non-polar organics (PAHs + PCBs) might lead to non-polar narcosis (i.e., > 3 µmol/g lipid); or (ii) tissue concentrations of total (Aroclor) PCBs were greater than the documented threshold of effects (0.6 mg/kg ww).

The levels of PCBs, measured as Aroclors, in the tissues of marine biota from the study area were uniformly much lower than the tissue residue-based TRV, indicating acceptably low risks from PCB exposure. The levels of PAHs and PCBs (combined) measured in tissues were also much lower than would be associated with negative effects mediated through a non-polar narcosis mode of toxicity. Overall, no risks were evident from evaluation of the tissue concentrations in Upper Basin marine biota.

Avian and Mammalian Wildlife

In order to formally assess potential for risks to wildlife species, three mammal (mink, river otters and harbour seals) and six bird species (pigeon guillemots, double-crested cormorants, black oystercatcher, surf scoters, western grebes and bald eagles) were identified as appropriate surrogate species for the potential receptors of concern. These species comprise a wide range of dietary habits and exposure scenarios. Body weights, food ingestion rates, expected diets and toxicity reference values were obtained from published literature (based on surrogate species where necessary) and this information was used to predict potential risk to each of the identified species based on levels of COPC found in the study area.

Receptors were deemed to be potentially exposed at unacceptably high concentrations to the extent that calculated risk quotients strongly exceeded a value of one (1.0).

Based on the ecological risk assessment there is evidence of possible risk to some wildlife receptors associated with dioxins/furans and coplanar PCBs in dietary items. The conclusions about risks, however, should be tempered by an understanding of the uncertainties associated with the risk characterization. All calculated wildlife risk quotients were less than four (4), and the predicted risk, therefore, is low even if risks cannot be absolutely precluded without additional analysis.

The risk quotients for the remainder of COPCs (Arsenic, Chromium, Lead, Zinc, Mercury, PAHs, and Aroclor PCBs) were less than 1.0 for all receptors and therefore risks associated with these substances are considered to be acceptably low.

Major Areas of Uncertainty

The results of the EHHRA were derived through extensive collection and analysis of sediments, seawater, and marine biota, so that the COPC concentrations in relevant exposure media for humans and other living organisms were measured directly. Sufficient data exist, furthermore, to provide reasonable confidence in the substance concentration ranges likely to be encountered.

Every effort has been made through several sampling and analysis programs to anticipate areas of the harbour floor that might have become contaminated based on the various known source types and areas. In particular, the 1998 sediment sampling program was initiated after a review of the environmental status of the harbour. Each subsequent investigation (see Chapter 3) has been based on a thorough prior review of contaminant data for both the harbour floor and foreshore areas around the Upper Basin. The ecological risk assessment was intended to capture worst-case conditions for harbour floor contamination for at least a subset of samples collected and analyzed. Nonetheless, it cannot be absolutely precluded that the small areas of atypically high sediment contamination may be discovered in the future within the overall study area. The conclusions herein about degree of contamination and associated ecological risk may or may not be relevant to small sub-areas within the overall Transport Canada-Administered and Controlled harbour floor in the Lower Basin. Therefore, it may be necessary to be aware that contaminant hotspots may exist in Victoria Harbour, which may require due diligence assessments when considering management plans for sub-areas of the overall study area.

For both humans and the wildlife species assessed (either directly or by extension of analysis of similar surrogate species), one area of uncertainty is the expected particulars of dietary intake. To address this high degree of uncertainty, the exposure assumptions used were chosen as highly conservative, and very likely over-predict risks relative to the true risks.

For direct effects on sediment associated fauna, the major area of uncertainty relates less to our understanding of the degree of association between sediment concentrations of individual COPCs and biological responses, than it does to designating a point along the continuum of concentration-effects curves that can be used to designate acceptable versus unacceptable risks.

Another major area of uncertainty is the extent to which tissue concentrations in especially more mobile epifauna such as shrimps and crabs, or filter feeders such as clams and mussels, reflect active inputs into and/or processes in the water column, as opposed to contaminant mobilization from historically contaminated sediments. Contaminant concentrations and composition in intertidal versus subtidal sediments suggests different contaminant source influences, as discussed in Chapter 5.

Finally, this study does not evaluate the relative influence on the ecological status of the study area of other stressors such as the loss of intertidal habitat due to infilling, shoreline development and hard armouring, stormwater inputs, ongoing inputs from wharves and jetties, and sediment disturbances associated with physical stressors (including propeller wash and stormwater outfall discharge). Although the investigation and evaluation of these factors are outside the scope of the present study they likely have significant implications on the overall ecological health of the study area.

Management Implications

The human or ecological health risk assessment documented herein addresses the three major study goals as follows:

- **Federal requirements for assessing contaminated sediments:** The information contained herein provides an environmental baseline study per federal and Treasury Board requirements, and assists Transport Canada with an understanding of the extent of contaminant-related liabilities on a basin-wide basis.

  Federal statutes were reviewed in detail as a pre-requisite to the formulation of ecological protection goals in support of the human health and ecological risk assessment component of the EHHRA. No concrete formal guidance on ecological protection goals is available within federal environmental acts, regulations or other formal guidance that is applicable to sediments and biota of the harbour floor in Victoria Harbour. It should be noted that the Fisheries Act (specifically Section 35(2) - HADD) could become relevant in the event of activities that could re-suspend contaminated sediments.

  The methods used to conduct the EHHRA were generally consistent with CCME[2] guidance, as well as guidance provided by Health Canada and Environment Canada for federal contaminated sites.

- **Provincial requirements for assessing and managing contaminant risks**: Should the Transport Canada-Administered and Controlled portion of the Upper Basin harbour floor be transferred to an entity under provincial jurisdiction, BC CSR numerical standards might apply. the majority of the Upper Basin harbour floor sediments exceed BC CSR Schedule 9 SedQC-typical values for several of the COPCs and would be formally defined as contaminated.

  The study area is not currently under British Columbia provincial jurisdiction; however, the assumptions and methods used were intended to be consistent with provincial guidance on the conduct of human health risk assessments. Overall, no unacceptable human health risks were estimated. No remediation would be required, therefore, from the perspective of human health risks.

  The evaluation of ecological risks was based on ecological protection goals that were intended to be consistent with policies and guidance arising from the British Columbia *Environmental Protection Act* and *Contaminated Sites Regulation*, especially as described in the *Criteria For Managing Contaminated Sediments in British Columbia, Technical Appendices.*

[2] *Canadian Environmental Quality Guidelines (CEQG)*, Canadian Council of Ministers of the Environment (CCME), Winnipeg MB, 2006. .

Based on the above-discussed provincial guidance, there is evidence of possible risk to some wildlife receptors associated with dioxins/furans and coplanar PCBs in dietary items. The conclusions about risks, however, should be tempered by an understanding of the uncertainties associated with the risk characterization. All calculated wildlife risk quotients were less than four (4), and the predicted risk, therefore, is low even if risks cannot be absolutely precluded without additional evaluation. It should also be noted that measured sediment concentrations of these parameters do not exceed BC CSR Schedule SedQC values for "typical" habitat types.

The risk quotients for the remainder of COPCs (Arsenic, Chromium, Lead, Zinc, Mercury, PAHs, and Aroclor PCBs) were less than 1.0 for all receptors and, therefore, risks associated with these substances are considered to be acceptably low.

The available evidence indicates that although there has been an anthropogenic influence on benthic infauna within the study area, the degree of departure from the expected reference state is within an acceptable range, as interpreted from BC MoE policy.

- **Developing and implementing best management practices:** This study provides a basis for ongoing management by Transport Canada of active contaminant releases, contaminated sediments, environmental risks, and for environmental stewardship such as development of best management practices.

  This study provides preliminary indications about the possible importance of current contaminant sources to the study area via point-source inputs (e.g., storm sewers) and non-point source inputs (e.g., releases of metals and petroleum hydrocarbons from vessels). These current sources are of direct relevance when considering and evaluating potential areas for sediment management. With respect to the development and implementation of future best management practices, this study provides information that will assist in future source identification and reduction initiatives.

  Recognizing that human health risks are currently low, risk management actions are prudent to ensure that the current uses and environmental concentrations remain similar to or improve on those assumed in the HHRA.

  Based on the above-discussed ERA, there is evidence of possible risk to some wildlife receptors associated with dioxins/furans and coplanar PCBs in dietary items. However all calculated wildlife risk quotients were less than four (4), and the predicted risk, therefore, is low even if risks cannot be absolutely precluded based on the currently available knowledge. Development of best management practices to address these potential risks is complicated by the uncertain relationship between observed patterns of these substances in sediments versus tissues of sampled biota. Additional study is required to develop a better understanding of dioxin/furan and coplanar PCB sources to marine biota prior to developing future best management practices.

  Based on the above-discussed ERA, risks to wildlife, bottom-dwelling fish and macroinvertebrates, and benthic infauna from the remainder of COPCs (Arsenic, Chromium, Lead, Zinc, Mercury, PAHs, and Aroclor PCBs) are concluded to be acceptably low.

The baseline information presented herein and the results of the EHHRA form the basis for examining future conditions within the study area. Such baseline information will be useful for concretely assessing the degree of change relative to future environmental management actions and implementation of BMPs in the study area.