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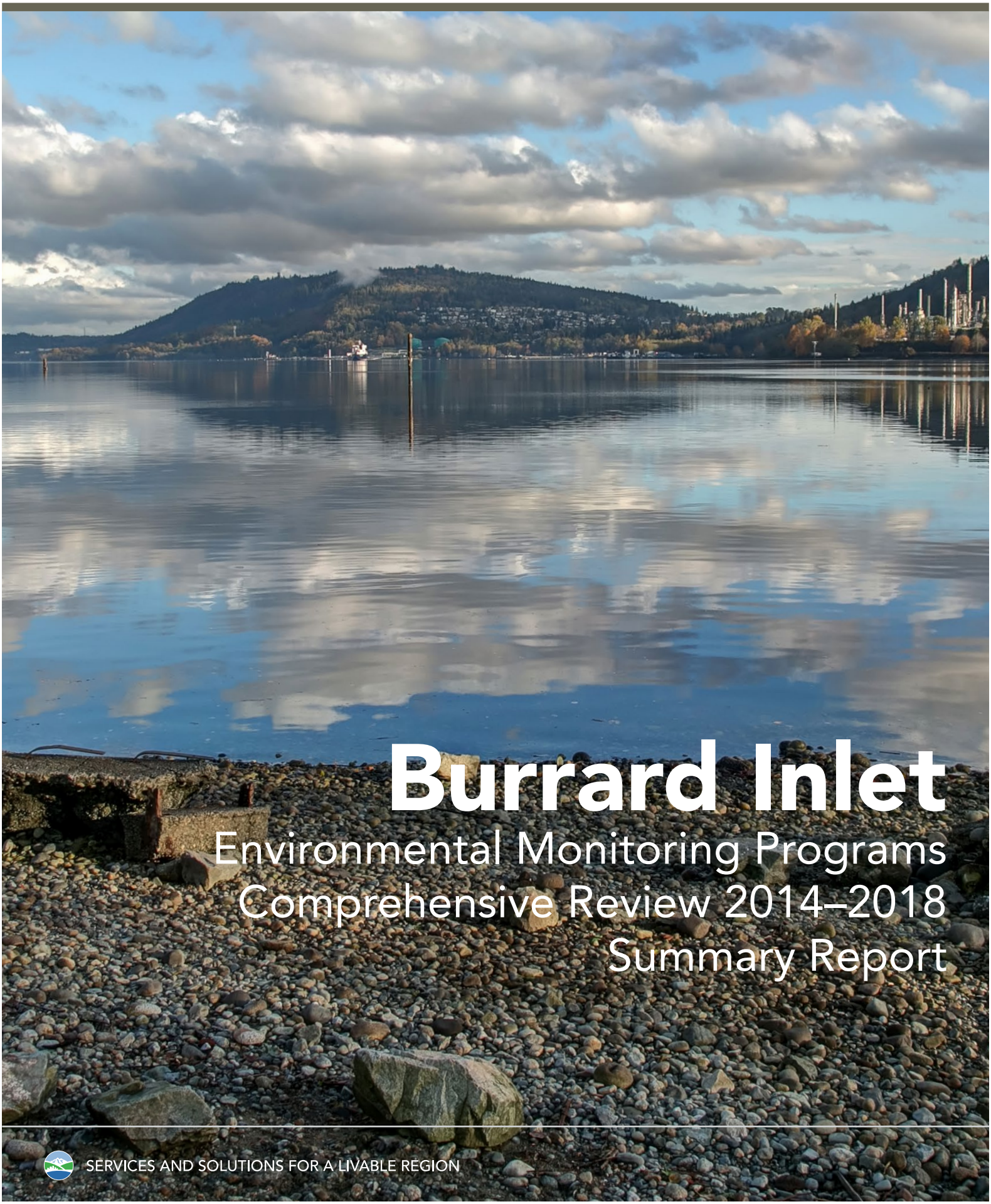

Burrard Inlet

Environmental Monitoring Programs Comprehensive Review 2014–2018 Summary Report

SERVICES AND SOLUTIONS FOR A LIVABLE REGION

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COVER: BURRARD INLET FROM NORTH SHORE

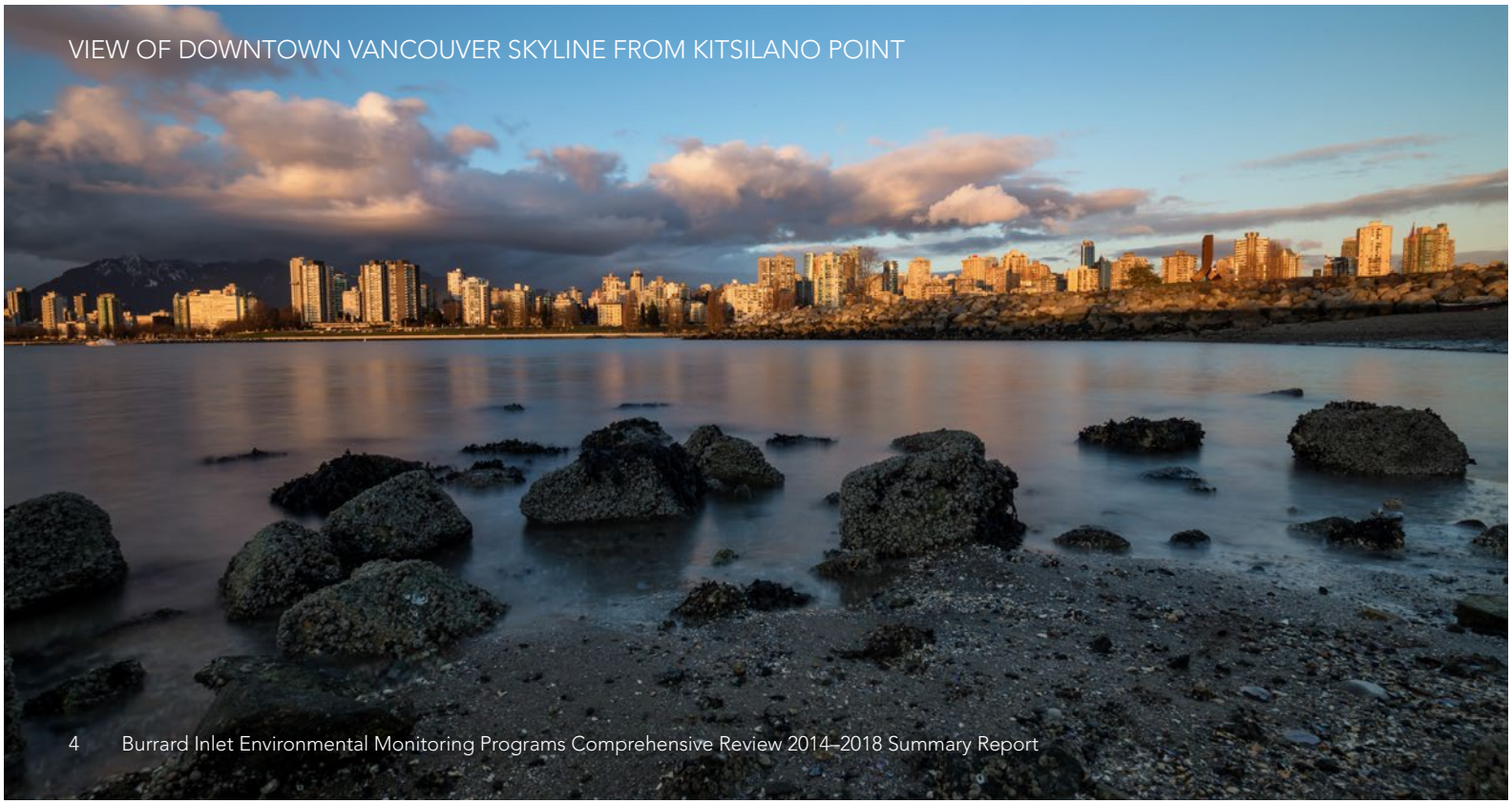
Contents

Overview

In 2020, Metro Vancouver undertook a review of its environmental monitoring programs within Burrard Inlet to better understand the potential influence of primary treated wastewater discharges from the Lions Gate Wastewater Treatment Plant (WWTP), in addition to the discharges from its eight combined sewer overflows (CSOs) and three sanitary sewer overflows (SSOs). The review focused primarily on environmental monitoring programs conducted between 2014 and 2018.

The overall objective of this program review was to provide a comprehensive and integrated analysis of Metro Vancouver's Burrard Inlet environmental monitoring program results during this five-year period and determine whether there were any significant environmental impacts on Burrard Inlet from the Metro Vancouver WWTP, CSO, and SSO discharges.

This report provides a summary of findings and recommendations from the *Burrard Inlet Environmental Monitoring Programs Comprehensive Review 2014–2018,* prepared for Metro Vancouver by Hatfield Consultants LLP (2020). This information will be considered when making updates to the region's Integrated Liquid Waste and Resource Management Plan (ILWRMP), which guides Metro Vancouver and its member municipalities on ways to protect the region's outstanding livability and manage liquid waste in a manner that protects human health and enhances environmental quality.



VIEW OF DOWNTOWN VANCOUVER SKYLINE FROM KITSILANO POINT

Background

Wastewater Treatment Plants, CSO Outfalls, and SSO Outfalls Located Along the Shores of Burrard Inlet

Treated wastewater is discharged from the Lions Gate WWTP into the First Narrows area of Burrard Inlet through a diffuser located just to the west of the Lions Gate Bridge in West Vancouver. This plant currently provides primary or chemically enhanced primary wastewater treatment, which uses various mechanical and chemical (when needed for the enhanced treatment) processes to remove materials that settle or float. In general, primary treatment removes about 50 to 60 per cent of total suspended solids (the solid particles present in wastewater) and about 30 to 50 per cent of biochemical oxygen demand (the amount of oxygen consumed by organic materials in water as they biodegrade). The mechanical processes are chemically enhanced seasonally to maintain or improve solids reduction rates.

In addition, Metro Vancouver manages sanitary sewers that carry domestic and industrial wastewater to WWTPs and combined sewers that carry stormwater runoff and wastewater in a single pipe to the WWTPs. During periods of heavy rainfall and snowmelt, the wastewater volume can exceed the capacity of the sewer collection system or the WWTPs. Sewer systems are designed to overflow when inputs exceed conveyance capacity. When these overflows occur, excess untreated, stormwater-diluted wastewater is discharged directly into nearby water bodies through outfall pipes, also known as outfalls.

There are currently three SSO and eight CSO outfalls owned by Metro Vancouver that have potential to discharge into Burrard Inlet. These CSO and SSO outfalls release wastewater diluted with stormwater into Burrard Inlet. Metro Vancouver has monitored CSO discharges since 1996 and conducted SSO characterization from 2010 to 2017.

The Lions Gate WWTP, CSO outfalls, and SSO outfalls located along the shores of Burrard Inlet are shown in the map on the next page (Figure 1). Quantities of total, average annual, and average daily wastewater discharges from the Lions Gate WWTP from 2014 to 2018 have been described in Table 1.

BURRARD INLET AND THE LIONS GATE BRIDGE

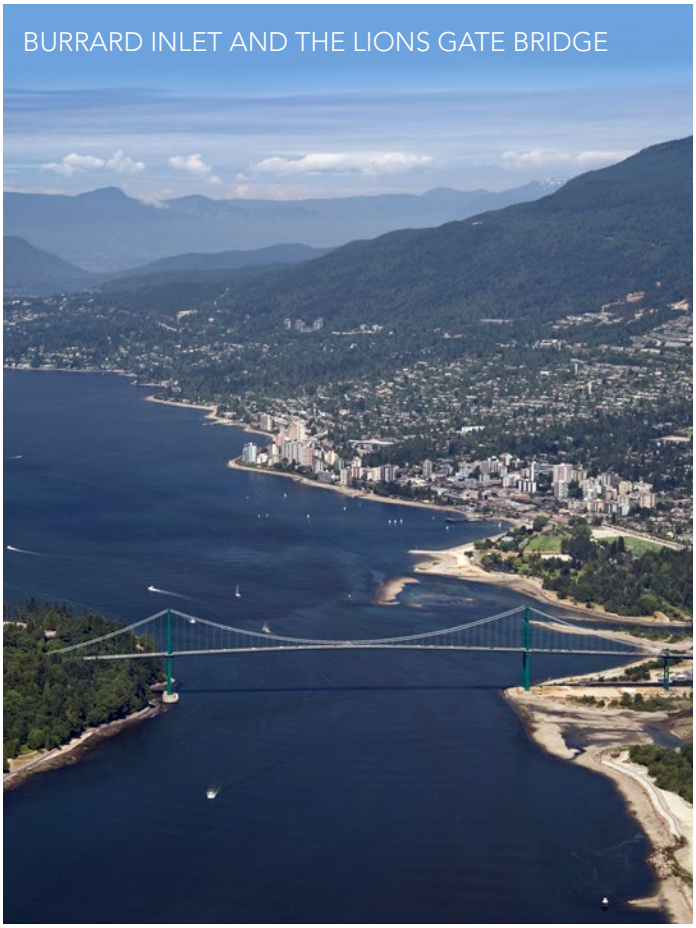


FIGURE 1: MAP SHOWING THE LIONS GATE WWTP AND THE METRO VANCOUVER CSO AND SSO OUTFALLS LOCATED ALONG THE SHORES OF BURRARD INLET

TABLE 1: TREATED WASTEWATER DISCHARGED INTO BURRARD INLET FROM THE LIONS GATE WWTP 2014–2018

WASTEWATER TREATMENT PLANT	TOTAL AMOUNT OF TREATED WASTEWATER DISCHARGED INTO BURRARD INLET 2014–2018	AVERAGE ANNUAL AMOUNT OF WASTEWATER DISCHARGED INTO BURRARD INLET 2014–2018	AVERAGE DAILY AMOUNT OF WASTEWATER DISCHARGED INTO BURRARD INLET 2014–2018
Lions Gate WWTP	151,034 ML	30,207 ML	80 MLD

Environmental Monitoring Programs

The ILWRMP commits Metro Vancouver to monitor, assess, and forecast the impacts of liquid waste discharges from the region's WWTPs, CSOs, and SSOs on receiving water bodies. In doing so, Metro Vancouver is able to gather the information needed to effectively manage liquid waste discharges, set priorities for improvement, and design system upgrades.

Between 2014 and 2018, Metro Vancouver's environmental monitoring programs for Burrard Inlet included:

- **Wastewater Treatment – Effluent Monitoring Programs,** which measure the quantity and quality of effluent (treated wastewater that flows out of the WWTP), identify any compounds of potential environmental concern, assess regulatory compliance, and assist in the future development of effluent discharge objectives;
- **The Lions Gate WWTP Receiving Environment Monitoring (REM) Program,** which monitors water quality at the edge of the initial dilution zone (IDZ) where the effluent mixes with water in the receiving environment, sediment quality, and the health of aquatic organisms surrounding the WWTP outfall;
- **The Burrard Inlet Ambient Monitoring Program (BIAMP),** which assesses environmental conditions in areas of Burrard Inlet that are not directly affected by wastewater discharges. This program is designed to operate in five-year cycles, with water quality monitoring occurring each of the five years, sediment monitoring every other year, and one fish community and fish health survey within the five-year cycle;
- **The 2018 Burrard Inlet Water Column Monitoring Program,** an amalgamation of Metro Vancouver's previous Lions Gate WWTP REM and BIAMP water column programs designed with the aim of addressing knowledge gaps, increasing the efficiency of sampling and analysis, and using an integrated approach to interpreting data;
- **CSO and SSO Characterization and Receiving Environment Monitoring,** which assesses the possible effects of CSO and SSO discharges on Burrard Inlet. The data provides a scientific basis for informing management decisions regarding operations and infrastructure enhancements; and
- **Recreational Water Quality Monitoring,** which assesses the bacteriological quality of local recreational waters on a weekly basis throughout the beach season from May to September and outside of this season as required.

Approach

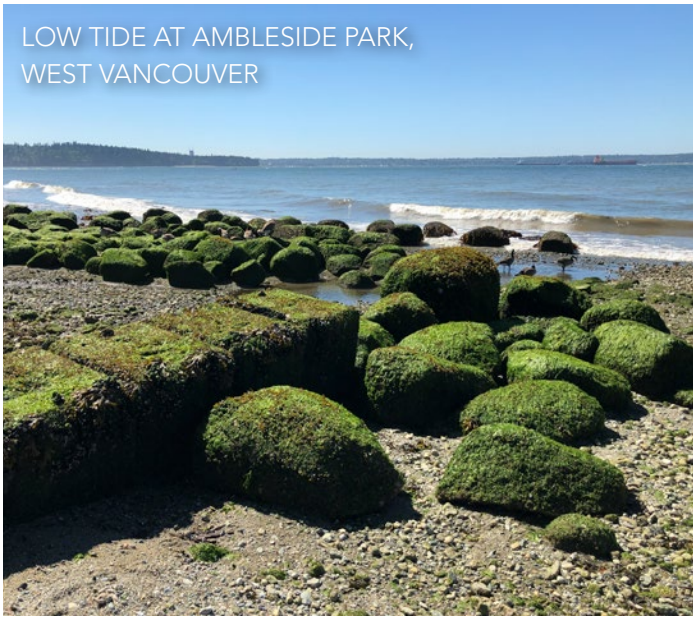
The approach to completing the 2014–2018 program review of the Burrard Inlet environmental monitoring programs included four components:

1. **Review of 2014–2018 environmental monitoring reports and summary of findings:** Reviews were undertaken on 27 reports of environmental monitoring studies conducted between 2014 and 2018. These reviews resulted in a short summary of the study objectives for each report, evaluation of sampling methods and data analytical tools, and key findings.

2. **Data compilation, analysis, and screening of regulatory guidelines:** Data compilation and assessment were conducted using standard protocols and data were analyzed using appropriate and meaningful statistical tools. All relevant data were compared with site-specific Burrard Inlet objectives and provincial and federal environmental quality guidelines.

3. **Weight of Evidence (WOE) analysis:** A WOE approach was applied to aggregate the findings of various ecosystem component monitoring programs to assess the probability and magnitude of potential effects from Metro Vancouver discharges.

4. **Critical assessment of monitoring programs and recommendations:** After completion of statistical analyses and WOE-based environmental risk assessment, a technical assessment of the Burrard Inlet environmental monitoring programs was prepared, and based on the monitoring results improvements to the design of the monitoring programs were recommended.



LOW TIDE AT AMBLESIDE PARK, WEST VANCOUVER

ELSJE POINT IN VANCOUVER

Summary of Key Findings and Recommendations

According to the *Burrard Inlet Environmental Monitoring Programs Comprehensive Review 2014–2018*, Metro Vancouver's Burrard Inlet environmental monitoring programs are effective at describing environmental conditions in the vicinity of Metro Vancouver's discharges and provide useful information to identify potential effects of these discharges on Burrard Inlet. The following key findings were presented:

- Effluent from the Lions Gate WWTP met the compliance requirements of its Operational Certificate with a few exceptions.
- Water quality guidelines were typically met throughout Burrard Inlet, and for those that were not met, the cause was not linked to MV discharges.
- Sediment concentrations of many metals, PAHs, PCBs, and other persistent organic substances exceeded guidelines throughout Burrard Inlet. These elevations were likely the result of a combination of background sources and point source contributions.
- Concentrations of some substances in fish tissues, including arsenic, selenium, and PBDEs, exceeded guidelines. However, there was no consistent pattern in these concentrations across Burrard Inlet, which may implicate background conditions rather than direct effects of Metro Vancouver discharges as the cause.

The WOE approach aggregated the key findings from all the monitoring programs to assess the probability and magnitude of potential environmental effects from Metro Vancouver discharges during the review period. The WOE integration found that effects from Metro Vancouver discharges in Burrard Inlet were low overall. The largest effects of Metro Vancouver discharges on the marine environment of Burrard Inlet are the discharge of PBDE compounds by the WWTP, CSOs, and SSOs, and the local-scale effects associated with discharges from CSO outfalls.

The comprehensive review identified that some programs, such as the Recreational Water Quality Monitoring program, are effective in their current design, while other programs would benefit from adjustments to their overall designs or specific methods to better achieve Metro Vancouver's monitoring goals.

The specific recommendations included in the report have been listed in the table on the following pages, along with the rationale that support them. In order to address these recommendations, Metro Vancouver has prepared responses and proposed actions, which are listed in the right-hand column.

Definitions of technical terms used herein have been included in the Appendix.

TABLE 2: RECOMMENDATIONS, RATIONALE, AND METRO VANCOUVER RESPONSE/ACTION

REF #	ENVIRONMENTAL MONITORING PROGRAM	RECOMMENDATION	RATIONALE	METRO VANCOUVER RESPONSE/ACTION
1	Lions Gate WWTP Effluent Monitoring	**Finalize the formal toxicity identification evaluation (TIE) for chronic toxicity.**	Some chronic toxicity to fathead minnows and water fleas was periodically observed in samples of Lions Gate WWTP effluent.	A formal, tiered TIE for chronic toxicity was initiated in 2018 to determine if there is a pattern to the observed variability and identify the potential causes of the observed toxicity. This work will be finalized and presented to the Environmental Monitoring Committee and the BC Ministry of Environment and Climate Change Strategy in 2021.
2	Lions Gate WWTP Receiving Environment Monitoring (REM) Program – Sediment Effects Survey	**Conduct a pilot program that collects replicated sediment samples for key water quality indicators (i.e., sterols and metals), along with the continued collection of replicated samples for bacteriological indicators at sites that are potentially influenced by wastewater.**	The pilot study would provide updated estimates of variation within sites and the statistics required to identify potential gradient-type effects to sediment quality. From this pilot study, the ability of the Lions Gate Sediment Effects Survey to detect potential effects along this spatial gradient could be estimated, which would support the assessment of effects and further refinements to the program.	Metro Vancouver intends to conduct a special study to examine variation within sites for Sediment Effects Surveys based on program needs.
3	Lions Gate WWTP Receiving Environment Monitoring (REM) Program – Sediment Effects Survey	**Consider developing a panel-design program, depending on the results of the replication pilot study described in Recommendation 2, to focus monitoring efforts on areas potentially affected by wastewater discharges as identified by current monitoring programs or by other studies (e.g., dye tracer studies or hydrodynamic modelling).**	Focusing monitoring efforts on key areas would increase the ability of the monitoring program to detect potential effects, whereas the use of panel designs would maintain regular sampling across the entire monitored area.	Metro Vancouver intends to evaluate panel designs and their relative value for improved understanding of variation and the potential extent of effects.
4	Lions Gate WWTP Receiving Environment Monitoring (REM) Program – Sediment Effects Survey	**Conduct research into alternative monitoring programs using different endpoints where exposure and biological effects can be assessed.**	Sediment-triad type studies are not practical near the outfall because of the bottom and water current conditions. Monitoring in the Inner Harbour is confounded by influences from human activities, variation in the sediment environment, and operational challenges from shipping and industrial activities. Alternative studies that consistently characterize effects in the near-field of the outfall and in the Inner Harbour could be considered.	Metro Vancouver intends to continue to explore alternate endpoints that may better address the potential for near-field effects. This may include a special study on the assessment of potential alternate endpoints and subsequent pilot field testing.

REF #	ENVIRONMENTAL MONITORING PROGRAM	RECOMMENDATION	RATIONALE	METRO VANCOUVER RESPONSE/ACTION
5	Lions Gate WWTP Receiving Environment Monitoring (REM) Program – Sediment Effects Survey	**A pilot study measuring sediment toxicity using standard marine amphipod assays is recommended for sediments at an Inner Harbour site and the sites selected to characterize variation within sites.**	The inclusion of marine amphipod assays would support sediment-triad type analyses, which would be valuable in supporting the analyses of potential effects and variation within sites.	Metro Vancouver intends to conduct a pilot study at a limited number of sites to assess the suitability of standard marine amphipods and determine its utility for future Metro Vancouver Burrard Inlet Sediment Effects Surveys.
6	Lions Gate WWTP Receiving Environment Monitoring (REM) Program – Sediment Effects Survey	**Apply caution for the interpretation of Stations 45 and 49 as reference sites because analytes (e.g., metals) are sometimes elevated in their sediments. It is recommended that these sites continue to be classified as influenced/ uninfluenced using multivariate analyses, which reduces the importance of reference site data on the assessment of effects. If a panel-design program is considered, then reduced sampling frequency at Stations 45 and 49 is recommended.**	Stations 45 and 49 provide useful information on background conditions and spatial variation but Station 49 has shown trends not observed at other locations. These differing trends suggested other processes may be affecting sediment chemistry but the source was not clear.	Metro Vancouver reviews site selection, including Reference Stations for representing background conditions in Burrard Inlet, on an ongoing basis. Identifying good reference sites is challenging in this dynamic environment and classifying sites using multivariate analysis as influenced or uninfluenced based on how similar or different the sites are from each other is a strategy currently used. Past results and ongoing statistical analysis are used to confirm suitability of sites, and once available, the updated model for the Lions Gate WWTP outfall plume dispersion may further improve site selection. A dye tracer study is planned for 2021 to aid in updating the plume dispersion model.
7	Sanitary Sewer Overflow (SSO) Monitoring Program	**Manage these data in a standardized database.**	A standard data management approach would add efficiencies to the management, review, and interpretation of the results.	This recommendation will be considered as part of the development of a consistent and comprehensive data management and quality assurance and quality control (QA/QC) plan (see Recommendation 11 below).
8	Combined Sewer Overflow (CSO) Characterization and Receiving Environment Monitoring Program	**Develop a pilot program to characterize discharge quality throughout a CSO event.**	By measuring the concentration of water quality indicators from the first flush through the end of the event, the pilot study would provide information regarding the degree of variation in the characteristics of the discharge, which would help validate the assumption that first flush is the critical period to be monitoring events and provide the data needed for a more accurate integration of loading into the environment.	Metro Vancouver intends to determine the feasibility of CSO characterization throughout an overflow event with a pilot study planned for Heather CSO after sampling infrastructure upgrades are completed in 2021. If the pilot study is successful, Metro Vancouver will review results of the CSO comparative risk assessment and separation plans to determine the need, feasibility, and suitability of conducting a similar study at an additional site.

REF #	ENVIRONMENTAL MONITORING PROGRAM	RECOMMENDATION	RATIONALE	METRO VANCOUVER RESPONSE/ACTION
9	Combined Sewer Overflow (CSO) Characterization and Receiving Environment Monitoring Program	**Assess the benefit of the CSO receiving environment monitoring programs once the results of Metro Vancouver's CSO risk assessments are complete and the expected operational modifications are implemented.**	CSO receiving environment monitoring programs are well-designed but currently undertaken on an irregular basis. Metro Vancouver is conducting a comparative risk assessment of all CSOs, including the CSOs discharging to Burrard Inlet.	The intention of the current CSO Receiving Environment Monitoring Program was to collect enough data in the receiving environment to provide inputs for modelling and to complete a comparative risk assessment of Metro Vancouver CSOs to inform operational and infrastructure CSO reduction options. The CSO Receiving Environment Monitoring Program completion is expected in 2022. The need for future receiving environment monitoring will be assessed once operational and infrastructure improvements are implemented. To date Metro Vancouver has completed conceptual plans to separate its regional combined trunk sewers for three CSO catchments which discharge to Burrard Inlet: Cassiar, Heather, and Canoe Creek (via Clark). A CSO Elimination Working Group was formed in 2018 to ensure the CSO elimination initiatives of the cities of Burnaby, New Westminster, Vancouver, and Metro Vancouver are aligned. Objectives for this group include improved clarity on combined sewer lateral separation, defining the context for green infrastructure in CSO elimination, and coordinating regional and municipal sewer separation activities. To support sewer separation planning work, dynamic sewer models were developed in 2019 for the Vancouver Sewerage Area and the north part of the Fraser Sewerage Area and are now in use as operational tools. The models are currently being used to complete system assessments and will be used to evaluate combined sewer separation strategies and inform the prioritization of work in both sewerage areas.
10	Burrard Inlet Ambient Monitoring Program (BIAMP)	**Validate the suitability of sole as the sentinel species with other fish or shellfish.**	The fish monitoring component is focused on a single species (English sole). Validating the suitability of sole as the sentinel species with other fish or shellfish is recommended. Dungeness crab has been used as a sentinel species for persistent organic substances studies in Howe Sound, for example.	Metro Vancouver intends to investigate the feasibility of including crab or another sentinel species with the intent to incorporate this recommendation into the future Burrard Inlet Environmental Monitoring Program, if feasible and appropriate.

REF #	ENVIRONMENTAL MONITORING PROGRAM	RECOMMENDATION	RATIONALE	METRO VANCOUVER RESPONSE/ACTION
11	Data Management and Quality Assurance/ Quality Control (QA/QC) – All Programs	**Continue the development of consistent data quality objectives, QA/QC plans, and data management processes across all monitoring programs.** This unified plan should provide a consistent framework for the acquisition, quality review, revisions and corrections, and storage of environmental monitoring data and metadata, and include the following characteristics: • Workflow for the management of existing and new monitoring programs, with consistent conventions of program data and metadata monitoring; • Detailed QA/QC processes defined for existing programs; and • Workflows for the entry, management, storage, and tracking of monitoring data.	This framework would ensure consistency and comparability of data among programs, protect data quality, improve reproducibility and transparency of data, and better identify data quality issues.	To date Metro Vancouver has developed a Standard Operating Procedure for data verification and validation using data quality objectives from BC Ministry of Environment and Climate Change Strategy field manuals and/or analytical laboratory data quality objectives. Metro Vancouver will look for opportunities to engage a consultant to develop a data management framework and processes for development of program appropriate data quality objectives, workflow, storage, and tracking of monitoring data in the future.
12	Modelling to Support Study Design Improvements	**Use modelling outputs (e.g., from hydrodynamic models) to refine monitoring programs, as described in Recommendation 3. Much like the IDZ studies were designed around modelled effluent mixing, hydrodynamic models of water movement within Burrard Inlet could be used to refine the monitoring design and identify areas with higher potential for exposure to WWTP or CSO effluents.**	Burrard Inlet is a large, physically complex water body with tidal influences and complex circulation patterns. Modelling could improve understanding of these influences and patterns and guide improvements to the positioning of monitoring site locations.	Metro Vancouver is currently using modelling to understand the extent and potential effects of SSO, CSO, and WWTP discharges in receiving water bodies and to refine monitoring programs to confirm or better target the appropriate exposure areas. Metro Vancouver is planning a dye tracer study in 2021 for the Lions Gate WWTP outfall that will be used to support current modelling efforts.

REF #	ENVIRONMENTAL MONITORING PROGRAM	RECOMMENDATION	RATIONALE	METRO VANCOUVER RESPONSE/ACTION
13	Sediment Coring Study	**Conduct a sediment coring program focused on PBDEs.**	Sediment cores may be valuable for assessing the relative importance of dispersion, deposition, and burial of PBDEs from Metro Vancouver discharges to Burrard Inlet, and may also provide information on sedimentation rates. It could be easily extended to organic carbon, metals, and other persistent organic compounds of interest. The information from a coring program on deposition and burial rates would provide critical information for a mass-balance model.	Sediment cores were collected in the outer Harbour and near the Iona Island WWTP outfall and analyzed in 2018. Following review and interpretation of the results, future needs and anticipated benefits will be assessed.

Appendix: Key Definitions of Technical Terms

Analytes: chemical substances that are the subject of chemical analysis

Bacteriological indicators: types of bacteria that are measured and compared with baseline concentrations and regulatory guidelines as part of the environmental monitoring process

Chronic toxicity: refers to the impacts on an organism's life cycle when exposed to an effluent sample for an extended period of time

CSO catchment: an area from which water drains into a particular CSO outfall

Dye tracer study: a fluorescent dye is injected at a discharge location of interest and the resulting "dye cloud" is measured at various locations in the receiving environment to determine the mixing and transport patterns of the discharge in the environment

First flush: the phase of initial surface runoff during a rainstorm or snowmelt, where wastewater discharges from CSOs are typically the most concentrated

Hydrodynamic modelling: computer simulation studies of the way fluid moves, with the aim of determining the mixing and transport patterns of wastewater effluent within a large body of water

Loading: the amount of a compound in wastewater or other sources that is discharged into a body of water over a period of time

Marine amphipod assays: small, flat-bodied crustaceans (e.g., beach fleas and sand hoppers) that are studied as part of the process of sediment toxicity testing

Mass-balance model: a consideration of the input, output, and distribution of a substance in a given area over a given time

Near-field: an area close to an outfall where effluent initially mixes with a body of water and where mixing is typically more turbulent than that which occurs further from the outfall

Panel designs: sampling designs that focus studies on different specific areas in each iteration of a program on a rotating schedule, with the aim of reducing the frequency of sampling at individual sites while providing thorough coverage of a large study area

PAHs: polycyclic aromatic hydrocarbons, a class of substances originating from coal or oil deposits that may also be produced when burned in engines and incinerators or in forest fires

PBDEs: polybrominated diphenyl ethers, a class of substances that are used commercially as flame retardants

PCBs: polychlorinated biphenyls, a class of organic chlorine substances that were once widely used for insulating and cooling purposes in electrical equipment, in carbonless copy paper, and in heat transfer fluids

Replicated samples: multiple samples at the same site

Sediment coring: the process of obtaining a vertical sample of sediment that contains layers, with the most recent sediment deposition layer at the top and the oldest layer at the bottom

Sediment-triad studies: an assessment of sediment chemistry, sediment toxicity, and communities of sediment-dwelling aquatic species to determine sediment quality

Sentinel species: animals and plants that help with the proactive detection of potential impact to human health and the environment

Spatial gradients (sediment): change in the concentration of a compound of interest in the sediment over a specific area

Toxicity identification evaluation (TIE): studies that identify causes of toxicity in water and sediment samples

Water quality indicators: substances that are measured and their concentrations compared with baseline concentrations and regulatory guidelines as part of the environmental monitoring process