Portland Harbor Stormwater Strategy Update – Status of Recontamination Prevention

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In December 2000, Portland Harbor was added to the National Priorities List as a Superfund Site due to unacceptable levels of contamination in sediment in an approximate ten mile reach of the Lower Willamette River in Portland, Oregon. In February 2001, a Memorandum of Understanding was signed to provide a framework for cooperation in the investigation and cleanup of the Portland Harbor Superfund Site that would optimize federal, state, tribal and trustee expertise and available resources. EPA was designated as the lead agency for investigating and cleaning up contamination in the river sediment, using federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) authorities. DEQ was designated as the lead agency for identifying and controlling upland sources of pollution adjacent to or near the river, using state cleanup program authority under ORS 465 et. seq. DEQ and EPA jointly developed a mutually acceptable source control strategy, which was finalized in December 2005 as the Portland Harbor Joint Source Control Strategy.

As part of the strategy for identifying and controlling upland pollution sources, and in response to recontamination by unevaluated stormwater at remediated sites in the Pacific Northwest and the nation, DEQ spearheaded development of an overarching stormwater strategy for all drainage to Portland Harbor. In preparation for design of in-water sediment remediation, DEQ's investigation and control of contaminated stormwater focused on remediation of legacy contaminated sites, control of on-going industrial stormwater discharges and adaptively managing stormwater discharges of contaminants at levels that could recontaminate sediment. Over the past 20 years, DEQ comprehensively implemented the stormwater strategy, significantly minimizing potential for continuing stormwater discharges to recontaminate EPA's planned sediment remedy. DEQ is now nearing completion of control of legacy contamination, continues to implement iteratively more stringent controls for on-going industrial stormwater discharges and presents in this document the results of an evaluation of the effectiveness of these combined efforts.

As a component of the adaptive management expectations of the overall Portland Harbor stormwater strategy, DEQ prepared this report summarizing the effectiveness of the strategy in preventing sediment recontamination. The report adds a quantitative component to the qualitative lines of evidence approach to evaluation of recontamination potential, by including an evaluation of contaminant loads through stormwater discharges into Portland Harbor. The evaluation confirms that DEQ's source control programs are effective, contaminant concentrations and loads in stormwater discharged into Portland Harbor have been significantly reduced and large-scale threat of sediment recontamination via stormwater following cleanup is improbable. These conclusions are predicated on the unique stormwater circumstances that exist in Portland Harbor, the need for completion of stormwater source control underway at remaining sites and on-going adaptive management with actions as warranted by cooperative monitoring conducted by multiple agencies and responsible parties.

1. Introduction

DEQ's 2016 updated Portland Harbor Upland Source Control Summary Report presented a qualitative evaluation of the potential for recontamination and unacceptable in-water risk in Portland Harbor. This update to EPA on implementation of the Portland Harbor stormwater strategy to prevent recontamination adds a quantitative line of evidence to support the effectiveness of the collective work in the uplands to identify, remediate and control stormwater sources of contamination to prevent fouling of EPA's remedy after its implementation. Consideration of the comprehensive upland and in-water investigation, source controls and remedial design planning occurring in tandem with stormwater investigations and controls, gives confidence that in-water remediation can move forward without threat of recontamination. And, though unlikely to be needed, coordinated strategies are in place or in process for timely detection and effective response to any undiscovered recontamination sources, should any materialize post-remediation.

1.1 Background and purpose

Superfund sediment remediation sites in the Pacific Northwest and other regions of the county have been recontaminated following cleanup (ASTSWMO 2013). Reviews of dozens of case studies where sediment became recontaminated identified the following causes:

1) Incomplete contaminant removal or discovery of unknown upstream sediment contamination, which became redistributed over remediated areas;
2) Undiscovered adjacent bank contamination, which eroded onto remediated in-stream sediment; uninvestigated groundwater sources promoting advection to clean surfaces from deeper residual contamination; and
3) Uncontrolled combined sewer overflows or unaddressed legacy sediment laden stormwater pipe discharges, which settled onto remediated sediment (ASTSWMO 2013 & 2017).

Because the environmental, economic and political consequences of recontamination and re-remediation are substantial, EPA and DEQ have kept prevention of recontamination in the forefront of the approach to in-water and upland source control in Portland Harbor.

Evaluation and action on the known recontamination causes listed above occur at varying stages of the CERCLA process, preferably prior to remedy implementation. EPA's two decades of work continues with responsible parties on in-water investigation and remedy selection and design, and is anticipated to prevent sediment recontamination by undiscovered in-water sources. DEQ oversaw some investigation and stabilization of contaminated banks and EPA's 2017 Record of Decision and 2019 Guidance for River Bank Characterization and Evaluations designated bank areas to be further investigated and potentially included in remedy designs, which is anticipated to address bank recontamination potential. DEQ's decades long oversight of groundwater remediation at upland sites, under the 2005 EPA/DEQ Joint Source Control Strategy, is anticipated to address any sediment recontamination potential from groundwater. And application of the comprehensive Portland Harbor stormwater strategy and overarching JSCS, and the City of Portland's 2001-2011 control of combined sewer overflows and comprehensive investigation of the 39 City outfalls into Portland Harbor are anticipated to address any potential for sediment recontamination from the stormwater pathway. Finally, EPA and DEQ developed an area-by-area Source Control Sufficiency Assessment process, by which to evaluate completeness of identification and control of all potential upland and in-water sources during remedial design of each active remedy area. This will allow another layer of source discovery and control, either prior to or as part of, the remedy to be implemented in each discrete in-water and bank area, if needed.

However, in addition to all pre-remediation work and evaluation described above, development of an adaptive management approach is a critical piece of effective recontamination prevention. DEQ and EPA staff have discussed adaptive management for sediment recontamination prevention in Portland Harbor with the following aims:

1) Designing post-remedial monitoring to detect any recontamination that begins to occur;
2) Conducting evaluations to identify and differentiate, as possible, between in-water and upland sources;
3) Taking actions to stop and reverse recontamination, to prevent or minimize the need for any re-remediation.

The purpose of this Portland Harbor Stormwater Strategy Update is to document the development and implementation of the comprehensive stormwater strategy, led by DEQ, to demonstrate achievement of effective stormwater controls and stormwater contaminant load reductions to prevent recontamination of sediments via the stormwater pathway, following implementation of EPA's site-wide sediment remedial actions. Information is presented on DEQ's evaluation of reductions in contaminant loads into Portland Harbor through stormwater. And this load evaluation can be revisited as a component of the comprehensive adaptive management approach, should stormwater sources of sediment recontamination be detected post-remediation.

1.2 Portland Harbor stormwater strategy

To ensure that recontamination through stormwater would not occur, DEQ began development of a comprehensive stormwater strategy soon after Portland Harbor was designated a Superfund site in 2000.

1.2.1 Chronological overview of stormwater strategy development

DEQ partnered with the City of Portland, beginning in 1999, to investigate and control potential contamination from the City's 39 stormwater outfalls. Knowledge gained during planning for these investigations of stormwater collected and conveyed from a mix of industries, commercial facilities, residences and open spaces into Portland Harbor informed the elements of the Harbor-wide stormwater strategy. In December 2005, the EPA/DEQ Portland Harbor Joint Source Control Strategy was finalized, which included as Appendix D, a Framework for Portland Harbor Stormwater Screening Evaluations. Between 2005 and 2007, DEQ convened an internal stormwater work group, sought EPA input and formalized an interagency stormwater work group (DEQ, EPA, and City of Portland with assistance from GSI Water Solutions, Inc.) focused on expanding Appendix D. By 2009, DEQ published Guidance for Evaluating the Stormwater Pathway at Upland Sites. The stormwater group worked intermittently through July 2010, when the group collectively settled on a three part stormwater strategy for Portland Harbor.

Elements of the comprehensive Portland Harbor stormwater strategy include:

1. Control of upland legacy stormwater contaminant sources – by implementing the Joint Source Control Strategy and DEQ Cleanup program authorities to remediate more than 150 sites within the Portland Harbor drainage boundaries, specifically following DEQ's Guidance for Evaluating the Stormwater Pathway at Upland Sites;
2. Development and implementation of a Portland Harbor-specific NPDES stormwater permit – administered by DEQ's Water Quality program and the City of Portland as DEQ's agent, for on-going control of stormwater discharges from cleanup sites and/or other industrial sites within Portland Harbor; and,
3. A monitoring and adaptive management component – to ensure that remediation of legacy sites and on-going stormwater permit implementation continue to be effective in preventing sediment recontamination, following implementation of EPA's sediment remedy.

In response to an EPA request during stormwater group discussions, DEQ created a tool to standardize interpretation of significant contamination in stormwater, as opposed to more typical levels of pollutants found in stormwater, which are a lower priority for source controls since these are unlikely to pose recontamination risk. The tool was included in DEQ's 2009 update to the Guidance for Evaluating the Stormwater Pathway at Upland Sites, as Appendix E. The tool consists of rank-order curves of 12 contaminants and total suspended solids measured in stormwater and stormwater solids at heavy industrial sites throughout Portland Harbor. The curves are used to identify contaminant concentrations in samples that are atypically elevated. Concentrations falling within the upper/steeper portion of the curve are an indication that uncontrolled contaminant sources may be present at the site and that additional evaluation or source control measures may be needed. Concentrations that fall on the lower/flatter portion of the curve suggest that stormwater is not being unusually impacted by contaminants at the site, and while concentrations may exceed the risk-based Portland Harbor Cleanup Levels, they are within the range found in stormwater or solids from active industrial sites in Portland Harbor. DEQ updated the tool in 2015, with significantly more data, which enhanced its robustness.

1.2.2 Summary of implementation of the stormwater strategy

As detailed in DEQ's Portland Harbor Upland Source Control Summary Report (2016), DEQ has been investigating and controlling stormwater at sites in Portland Harbor since 1999 and comprehensively implementing the Portland Harbor stormwater strategy since 2005. Implementation highlights of the three components of the strategy are summarized below.

1) For legacy site control, DEQ screened in excess of 500 sites for the potential for stormwater discharge to the Harbor and actively evaluated the need for stormwater controls at about 173 sites found to contribute stormwater discharges to the Harbor. Sites range in size from dozens of acres to a few tenths of an acre and have varying levels of potential for legacy or current contaminants to come into contact with stormwater. Sampling and analysis indicates that some sites do not require stormwater control measures beyond typical practices, while others require removal of legacy sources, significant reorganization of site infrastructure or installation of sophisticated, multi-component active stormwater treatment systems. Post-implementation monitoring, which may include permit monitoring, is required to demonstrate that control measures in place at sites are effective in reducing stormwater volumes or contaminant concentrations and loads to levels that are not anticipated to cause sediment recontamination or unacceptable in-water risk to river-related receptors. In addition, the City of Portland separated industrial wastewater discharges in most of Portland Harbor's industrial areas in the 1950s, achieved control of combined sewer overflows into the Harbor in 2000 through 2011, and conducted comprehensive investigations over 20 years up the pipes from their 39 outfalls into Portland Harbor. DEQ and the City also partnered on two stormwater site discovery projects. In 2007, DEQ and the City sampled catch basin solids at six sites within the densely industrialized Guilds Lake georegion, which drained stormwater through City outfall 18. And in 2013, DEQ and the City sampled catch basin solids at 11 sites in the Swan Island/Mocks Bottom, Guilds Lake and Albina georegions. These and other City investigations brought more than a dozen sites into DEQ's source control program for investigation and control of site stormwater discharges and also under regulation by the 1200Z permit specific to Portland Harbor. Evaluation of end-of-pipe data collected between 2007 and 2018 demonstrate that investigation within the City's 39 stormwater outfall basins has been comprehensive and effective controls are in place to support DEQ's source control decision, proposed for early 2020. DEQ has now achieved stormwater source control at most individual sites, with stormwater recontamination potential initially ranging from minimal to high, and will continue to oversee implementation of needed controls to completion.

2) On the Portland Harbor-specific stormwater permit, the City of Portland, as DEQ's agent, continues to implement the NPDES 1200Z (and 1200A) Industrial Stormwater general permits, including maintenance of No Exposure Certifications, at hundreds of sites within Portland Harbor and the Columbia Slough (which is tributary to the furthest downstream end of the Harbor). DEQ issued stricter iterations of the 1200Z permit as renewals in 2012 and 2017, which now require monitoring of most Portland Harbor contaminants of concern, geographic area-specific benchmarks, TSS reductions for discharges into Portland Harbor (and the Columbia Slough), and expanded the need for coverage to additional sites that discharge to Portland Harbor (and Columbia Slough). In total, sites with permit-regulated stormwater source controls cover approximately 70 percent of the developed land area draining to the Harbor. Permitted sites are inspected annually and NEC sites are expected at least once every five years. Exceedance of permit benchmarks and reference concentrations require corrective action, including engineered solutions, and continued monitoring. Many sites with completed stormwater source control decisions continue to monitor stormwater discharges under the 1200Z. DEQ periodically compiles and evaluates this data, specific to Portland Harbor.

3) DEQ anticipates continuing implementation of site-specific stormwater controls and subsequent effectiveness monitoring through both the source control and stormwater permit programs to fulfill the need for adaptive management specific to stormwater discharging into Portland Harbor. As explained in Section 2 of this report, DEQ evaluated the effectiveness of these programs in 2017, by estimating contaminant loads in stormwater discharged to Portland Harbor and reductions in those loads over time. This work adds more quantitative evaluation to support the largely qualitative lines of evidence approach to evaluations of recontamination potential in Portland Harbor undertaken before 2017. DEQ is committed to completing source control for all pathways at all relevant sites and in crafting any needed actions to address stormwater sources of recontamination, during participation with EPA in the overall approach to adaptive management of recontamination from all pathways, as described in Section 1.1 above.

2. 2017 DEQ Portland Harbor stormwater contaminant load study

In Section 5.4 of DEQ's 2016 Portland Harbor Upland Source Control Summary Report, DEQ committed to undertaking addition stormwater evaluations, including qualitative aspects of stormwater contaminant loads, as warranted. Although specific threat of recontamination via stormwater has not emerged, DEQ improved on this commitment by undertaking a quantitative stormwater contaminant load study in 2017, specific to stormwater discharging into Portland Harbor. As a continuation of DEQ's comprehensive implementation of the Portland Harbor stormwater strategy and part of the planning for the adaptive management component of the overall strategy for recontamination prevention, DEQ hired an engineering graduate for an eight month duration to: update DEQ's Portland Harbor stormwater database; set up and conduct calculations using standard methodology to estimate contaminant loads to Portland Harbor through annual stormwater discharges; and compare estimated loads over time periods before and after implementation of stormwater source control measures. DEQ staff guided the analysis and compiled and interpreted the results.

Chief aims of the stormwater contaminant load study were to estimate contaminants loads in stormwater discharging to Portland Harbor and evaluate reductions in loads over time, following implementation of source control measures and other aspects of the Portland Harbor stormwater strategy. In addition, load estimates provide a better understanding of the potential for recontamination through stormwater than concentration trends alone. Hence, stormwater-specific load estimates on a georegion scale provide support for EPA-led Source Control Sufficiency Assessments, in preparation for EPA's in-water remedy design and implementation. The approach and results of this stormwater contaminant load study are presented in the sections of this report that follow.

2.1 Limitations of stormwater contaminant load study

At the time DEQ embarked on this study in 2017, very few examples of stormwater-specific contaminant load studies could be found. While studies on estimated loading of PCBs in portions of waterway systems can be found for New York's Hudson River (2017), New Jersey's Passaic River (2014), Washington's Lake Washington (2013) and Maryland's Potomac and Anacostia Rivers (2007), these studies evaluated in-stream loads of PCBs in various media from contaminated areas to downstream areas. While stormwater inputs undoubtedly contributed to downstream areas, due to uncontrolled combined sewer overflows and other stormwater discharge outfalls, loads specific to stormwater inputs were not contemplated in any of these studies. Similarly, a comprehensive evaluation of PCBs loading within the Green-Duwamish watershed (2014) was underway in Washington, for understanding of delivery of PCBs loads from the upper watershed to the lower reaches where the Lower Duwamish Waterway CERCLA sediment site is located. While stormwater inputs are anticipated to be a component of that study, stormwater discharges directly into the Lower Duwamish were not uniquely evaluated. Finally, EPA Region 10 completed an evaluation of surface water quality that estimated Portland Harbor loads of some contaminant classes, which was presented as Appendix K in the June 2016 Portland Harbor RI/FS Feasibility Study. As with the previously mentioned studies, stormwater discharges were not included in this evaluation, though sampling during "stormwater-influenced flows" was evaluated. The study was further "limited by a single sampling event conducted over three seasons" during 2006 and 2007, which occurred at one transect location upstream, one downstream and four locations within the Portland Harbor reach (USEPA 2016). The most relevant study available was the 2007 Spokane River PCBs TMDL Stormwater Loading Analysis – Final Technical Report. There are numerous differences between conditions within the Spokane River and the Portland Harbor reach of the Lower Willamette River, including uncontrolled combined sewer overflows in Spokane and far less data abundance in Spokane. However, for devising the stormwater contaminant load analysis methodology, DEQ found it valuable to reference the Spokane study.

While DEQ's Portland Harbor stormwater database included about 70,000 data points at the time of this 2017 study, the majority of the data employed are from 2012 through 2017. It is also important to note that the available stormwater data for this study is comprised predominantly of grab samples, rather than continuously collected samples spanning the total storm event. These grab samples varied in volume and season collected, as well as in duration and intensity of rain events. The National Academy of Sciences found that flow- or time-weighted continuous data collected throughout the full duration of storm provides the most accurate estimates of contaminant loading in urban stormwater (NAS 2009). Therefore, DEQ's study is limited by the varied grab sample data available. Regardless of these limitations, and although the available data may lack precision, they do allow for useful interpretations to be made.

Solids captured using sediment trapping devices from stormwater flowing through conveyance lines may also provide more accurate estimates of recontamination potential than stormwater grab samples of contaminants. This is because many contaminants associate with solids that could settle onto remediated sediment potentially causing recontamination, of which sediment traps provide a more direct measurement. However, DEQ's database contains very little inline sediment trap data and even less direct flow volume measurements for pipes sampled. Therefore, DEQ employed grab sample contaminant concentrations, averaged by area, and estimated flow volumes to calculate estimates of average contaminant loads. In this way, the richest datasets were used in order to most conservatively evaluate recontamination potential by area.

Finally, it is important to note that DEQ's Portland Harbor stormwater contaminant load study only evaluated contaminant inputs to the river from stormwater discharges, generated within the areas draining to the approximately 10 river miles reach of the Lower Willamette that makes up the Superfund site. DEQ's stormwater contaminant load study does not include evaluation of surface water contaminant loads, which would include unknown load contributions of contaminants leaching from contaminated sediment, in addition to any contaminant load contributions from stormwater and wastewater discharge. Due to the very high river sediment volumes and contaminant concentrations found in Portland Harbor sediment, as opposed to the volumes and concentrations of contaminants in stormwater solids, in-water contaminant loads are a critical missing component for making overall conclusions regarding the potential for sediment recontamination and in-water risk in Portland Harbor.

2.2 Overall stormwater contaminant load study approach

In the simplest terms, DEQ used the richest datasets available to conservatively estimate average concentrations of representative contaminants in stormwater generated in selected areas of interest, and associated these with averaged suspended solids concentrations and conservatively estimated average annual stormwater discharge volumes to calculate estimated contaminant loads into a ten mile stretch of the Willamette River between River Mile 1.9 to 11.8 (referred to as Portland Harbor in this report) via stormwater.

2.2.1 Geographic considerations

In consultation with EPA, five geographic areas of interest were identified as having the greatest potential for recontamination of sediment via stormwater discharges due to: 1) density of industrialization; 2) magnitude of land or sediment contamination; and 3) quiescence of receiving water locations. As shown in Figure 2.2.1, these five areas are:

1. International Slip – quiescent area with little potential for flushing of contaminants
2. River Mile 11-East – farthest upstream end of Superfund site with high concentrations of PCBs in sediment
3. River Miles 6-8 West – large fuel distribution and former pesticides manufacturing facilities with high concentrations of PAHs, DDx and other contaminants
4. Swan Island Lagoon – quiescent area with little potential for flushing of contaminants
5. River Mile 9 West – densest industrialization in the Superfund site

Together, these areas constitute the majority of the land area with stormwater discharges into Portland Harbor. Because these areas are also considered to have the greatest potential for recontamination via stormwater discharges, evaluation of these areas lends conservatism to the stormwater contaminant load study.

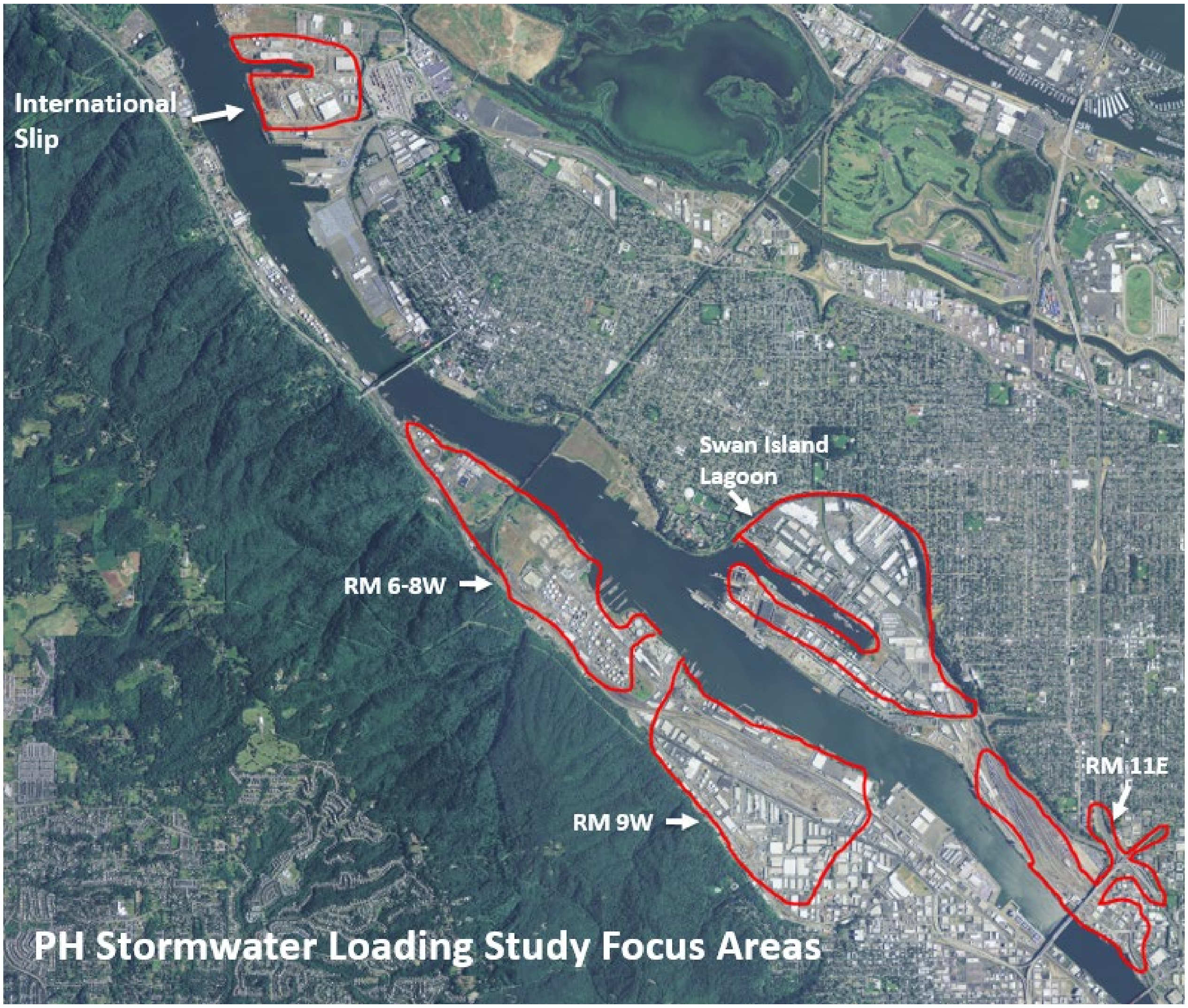

Figure 2.2.1. Five focus areas for Portland Harbor stormwater contaminant load study.

2.2.2 Stormwater data considerations

In 2009, DEQ created a Portland Harbor stormwater sampling results database, from which rank-order curves of concentrations measured at Portland Harbor sites were developed for several contaminants in both stormwater and stormwater solids. These curves were presented in Appendix E of DEQ's Guidance for Evaluating the Stormwater Pathway at Upland Sites, published in 2009 and updated with additional data in 2015. In mid-2017, the database was updated to include all available stormwater and stormwater solids sampling data collected until that time at sites within areas that drain to Portland Harbor. Sources included data collected by: the Lower Willamette Group for the Portland Harbor Remedial Investigation; individual sites undergoing source control evaluations (including City of Portland and Oregon Department of Transportation); and sites regulated under NPDES (individual and general) stormwater permits with requirements to monitor discharges.

DEQ's Portland Harbor stormwater database does not contain data for all contaminants of interest in Table 17 of the January 2017 EPA Record of Decision for Portland Harbor. Many of the Table 17 contaminants are not expected to be present in stormwater, were not evaluated for the stormwater pathway to Portland Harbor as part of site-specific conceptual site models and are not required to be monitored under NPDES general (or most individual) stormwater permits.

Five focus contaminants were selected for evaluation in the Portland Harbor stormwater contaminant load study. These are commonly monitored and detected in stormwater discharges and have chemical and physical properties generally representative of the various families of chemical compounds that are of most concern in Portland Harbor sediment. The five focus contaminants are:

1. Total polychlorinated biphenyls or PCBs
2. Total polycyclic aromatic hydrocarbons or PAHs
3. Zinc or Zn
4. Bis(2-ethylhexyl)phthalate or BEHP
5. Total suspended solids or TSS

Only stormwater data, on the five focus parameters, collected at sites that discharge into the five focus areas, were extracted from the database and evaluated in the study. DEQ recognizes that, during evaluation of sampling results for remedial design planning subsequent to publication of EPA's Portland Harbor Record of Decision in 2017, dioxin/furans have emerged as a contaminants of potential concern for sediment recontamination in some areas of Portland Harbor. Adequate dioxins/furans stormwater data is not available in DEQ's database for a load evaluation of dioxins/furans. However, DEQ expects results to be similar to those for PCBs because these compounds are frequently associated, behave similarly in the environment and respond similarly to stormwater treatment mechanisms.

2.3 Stormwater volume estimates

Precipitation data gives insight into the volume of water that is available to infiltrate into the ground surface, evaporate or runoff as stormwater. For this study, the interest was the volume of precipitation considered to be stormwater runoff.

A combination of focus area calculations and precipitation estimates were used to estimate the annual stormwater runoff volume from each of the five focus areas. The total stormwater runoff volume was calculated using the equation below.

$$Stormwater\ Runoff\ Volume = Impervious\ Area * Annual\ Precipitation$$

The calculation provides a rough estimate of the total stormwater runoff to the Portland Harbor reach of the Willamette River. The equation does not take into consideration potential evaporation or infiltration, resulting in a larger calculated stormwater volume, which is a conservative approach, since larger volumes can amplify estimated contaminant loads.

The calculation was originally preformed using the average annual rainfall for the Portland Harbor and the total estimated impervious areas. Due to the simplicity of the equation there is likely to be error. To minimize error, DEQ calculated a range of potential average runoff volumes, including a worst case scenario using an average annual rainfall of 60 inches (an unusually high but possible value based on historical data) and the total Portland Harbor Area (pervious and impervious), as well as comparing range values to those calculated for other studies of the area.

2.3.1 Annual average precipitation determination

To improve accuracy, annual precipitation for the project site was determined by comparing precipitation data from two different sources: US Geological Survey City of Portland Hydra Rainfall gauge system and database; and National Oceanic and Atmospheric Administration data. Rainfall estimates were further verified using City of Portland precipitation values associated with Combined Sewer Overflow Asset Management.

The USGS Portland Hydra Rainfall network includes numerous gauges across the Portland-Metro area, including several gauges within the project reach that were used to determine rainfall volume ranges for stormwater runoff calculations. The Albina Rainfall Gauge is located approximately 0.7 miles north of the Broadway Bridge (~River Mile 11.8), so its data was used to represent the south end of the Portland Harbor Superfund site. The Shipyard Gauge is located approximately 1.0 miles upstream of the north end of the project site (~River Mile 1.9), so its data was used to represent the north end of the Portland Harbor Superfund site.

NOAA data consists of rainfall volumes from two locations, the Downtown Portland Gauge and the Portland Airport Gauge. The Downtown Portland Gauge data is in close proximity to the project area and was used to verify the precipitation range determined by the USGS gauges. Due to its relatively far distance from the site of interest, the Portland Airport gauge data was only used to verify the wettest months and acknowledge differences in rainfall based on gauge location.

These datasets were used to determine a range of values representing total annual precipitation in inches for the area draining to Portland Harbor. Two ranges were used during this study: a conservative range, which included the maximum and minimum precipitation values obtained from all gauges evaluated; and average annual precipitation values from the two sources, excluding the maximum and minimum values.

2.3.2 Land area calculations

In order to determine the volume of stormwater runoff that is discharged into the Willamette River using the annual rainfall data, the land area of the sites of interest must be determined. Within each of the five focus areas are numerous sites engaged with DEQ on source control efforts, as well as other commercial, residential or open space areas. All land within the areas of interest was denoted as impervious or pervious. Impervious areas were associated with specific stormwater outfalls, as possible, and were used to determine stormwater runoff volumes. When little information was available on an area, the area was deemed impervious. This adds conservatism because additional impervious area results in larger runoff volumes, which can amplify contaminant load estimates.

2.3.3 Impervious surface estimates

Given the large area of interest, areas for each zone were calculated using numerous sources. Stormwater infrastructure maps from site specific documents were used to determine impervious and pervious areas in ArcGIS for individual, private outfalls. City outfall drainage areas were determined using the City's Municipal Source Control Report (CoP 2013a). The Municipal Report splits land use into seven main categories: Heavy Industrial, Light Industrial, General Employment, Commercial, Residential, Parks and Open Space, and Major Transportation. With the exception of Parks and Open Space, all categories were assumed to be 100 percent impervious.

Where stormwater infrastructure maps were not available, sites did not contribute to City outfall basins, or areas were not associated with a specific site, the default categorization was impervious light industrial/commercial/residential.

Sites areas that drain to the city sanitary sewer or the Columbia Slough were identified and not included in runoff volume calculations, as the stormwater is not received by the Willamette River.

The following precautions were taken to ensure accuracy and that calculations were conservative:

1. When available, each outfall area rendered in ArcGIS was compared to values found in individual site reports or the City Municipal Report.
2. After the area of every site was calculated, the areas were summed to determine the total acreage of the zone. This calculated sum was then compared to an ArcGIS area measurement of the entire zone to minimize error.

3. Percent error calculations were performed to determine the variation in ArcGIS measurements and values found in reports. In some cases only the total area or the impervious area could be compared to ArcGIS measurements.

$$Percent\ Difference = \frac{Report\ Area - ArcGIS\ area}{Report\ Area}$$

4. If the percent error was determined to be less than 5%, the values from individual site reports was used because these calculations were performed by scientists and engineers responsible for the site and were assumed to be more accurate.
5. If the percent error was greater than 5%, ArcGIS areas were double checked. If the areas were still over 5% different, the larger impervious area was used, unless a specific reason could be determined for the differences between values.

2.4 Average contaminant concentration estimates

For each focus area, DEQ first created lists of sites within each area and confirmed those that discharge stormwater to the Willamette River. Site discharges occur either directly through private outfalls or indirectly into City of Portland or ODOT conveyance systems, which may comingle with other site discharges prior to discharge into the river. Sites without discharge to the river or without stormwater data collected were excluded for purposes of determining average contaminant concentrations. However, once calculated, average contaminant concentrations for a focus area were applied to all sites within that focus area.

Average annual concentrations of each contaminant of interest (zinc, total PAHs, TSS, BEHP and total PCBs) in stormwater were calculated in Excel spreadsheets using all available stormwater data measured between 2003 and 2017 within each focus area. Data richness proved to be limited prior to 2012, when renewal of the NPDES 1200-Z Industrial Stormwater general permit included expanded data collection of most Portland Harbor contaminants of interest. All available data was analyzed and some was excluded during interpretation of the changes in concentrations over time within each of the various focus areas.

To make use of the richest datasets for the stormwater contaminant load evaluation, average focus area concentrations were calculated using only available data collected between 2012 through 2017. Averaging the concentrations from 2012-2017 is a more conservative approach then using only the last data year, because there is a higher data density and representation across facilities when a five year span is used. Using the entire 2012-2017 data also reduced error when trends were unclear and allowed for higher concentration data in downward trending areas to be included. Because higher data points likely increased calculated contaminant concentration averages, this also served to create more conservative load estimates.

Each focus area average was calculated as follows:

$$\sum \frac{all\ concentrations\ from\ 2012 - 2017}{number\ of\ data\ points}$$

In calculating focus area average concentrations, no data was excluded from the average. All non-detects were represented by their method detection limits or method reporting limits and no high outliers were excluded.

2.5 Contaminant load estimates

Annual loads of zinc, PAHs, BEHP, PCBs and TSS were estimated in stormwater from each of the five focus areas. With the exception of TSS, annual loads for the focus contaminants were also calculated, based on land use types, for the remaining land areas not captured within the five focus areas, but still within the hydoboundary draining to Portland Harbor.

2.5.1 Estimating loads from the five focus areas

The Schueler Simple Method (Schueler 1987), a common method used in stormwater contaminant load determinations for urban areas, was employed with a combination of precipitation, concentration and area data to estimate the load for a given contaminant. Using the 2012-2017 average concentrations of each focus contaminant in each focus area, as described in Section 2.3 above, and the ranges of annual runoff volumes and focus area land area calculations, as described in Section 2.2 above, a range of loads were calculated in Excel spreadsheets. The following equations were used in Excel in the order listed below:

List of variables
Ia = percent impervious/total area in decimal form
Rv = Runoff Coefficient
R = Annual Runoff in inches
P = Annual rainfall in inches
Pj = Fraction of annual rainfall events that produce runoff (assumed to be 0.9)
A = Total area in acres
C = Pollution Concentration in mg/L
L = Annual load in lbs/year

Step 1: Determine Ia.

Ia = Impervious Area/Total Area

Step 2: Calculate Rv.

Rv = 0.05*0.9Ia

Step 3: Calculate R.

R = P*Pj*Rv (Where Pj = 0.9)

Step 4: Calculate the load in lbs/year.

L = 0.226*R*C*A

Step 5: Convert the load from lbs/year to kg/year.

2.5.2 Estimating loads for remaining land areas draining to Portland Harbor

Loads from areas within the Portland Harbor hydroboundary that were not included in the five focus areas estimates were calculated as follows:

Step 1: Estimate the remaining area within the Portland Harbor hydroboundary that was not included in the five areas of interest.

As shown in Table 2.5.2.1, the measurable area within the Portland Harbor hydroboundary includes: river surface area, highway transportation, open space, and light industrial/residential/commercial areas, and totals approximately 13,785 acres.

Table 2.5.2.1. Portland Harbor Area Acreages

Area Type	Acres
River Surface	2350
Highway Transportation	300
Industrial, Commercial, Residential and Roadways	4165
Open Space	6970
Total Area	13785
Source: DEQ Portland Harbor Source Control Summary Report 2016	

Acreages were further refined into impervious and pervious areas to better estimate stormwater loads. Pervious areas consisted of open space and impervious areas included highway transportation, light industrial, commercial and residential areas. Table 2.5.2.2 shows the estimated impervious and pervious areas in the Portland Harbor. The river area was not included because it does not contribute to the load.

Table 2.5.2.2. Portland Harbor Impervious and Pervious Acreages

Area Type	Acres
Impervious	4465
Pervious (Open Space)	6970
Total Area	11435

Finally, the following determinations were made:

a. Sum the total impervious areas from all five areas of interest.
b. Sum the total pervious areas from all areas of interest.
c. Subtract the impervious and pervious areas from the five areas of interest from the total impervious and pervious areas.

Step 2: Estimate the loads for the remaining areas not included in the five focus areas. The Lower Willamette Group's February 2016 Final Portland Harbor Remedial Investigation Report used the following five land use categories: Heavy Industrial, Light Industrial, Parks and Open Spaces, Residential and Commercial, and Major Transportation. DEQ considered the five focus areas for this study as Heavy Industrial areas, due to the relatively high industrial densities and greatest risk for recontamination. To estimate loads for the areas not included in the focus areas, DEQ used the average loads calculated for the focus areas and used ratios to proportionally adjust the load for the other land uses. DEQ created ratios using the following equation and load percentages from stormwater and solids provided in Tables 6.1-3a and 6.1-3b from the LWG's 2016 RI. These tables are provided in Appendix B of this report. Because TSS data was not used in the LWG RI tables, proportions were not available to adjust TSS loads by category, so TSS was not included in the Portland Harbor-wide stormwater contaminant load summary.

$$Avearge\ percent\ of\ load\ for\ each\ area\ type = \frac{(percent\ from\ stormwater\ total\ load) + (percent\ from\ total\ solids\ load)}{2}$$

DEQ calculated an average load for each contaminant of interest for the Heavy Industrial focus areas using approximately 4,979 total data points of concentration data measured in stormwater at the sites within each specific area in the following equation:

$$Average\ heavy\ industrial\ load\ for\ each\ contaminant = \frac{(RM\ 6-8\ W) + (RM\ 9W\ ) + (Swan\ Island\ Lagoon\ ) + (RM\ 11E) + (International\ Slip\ )}{5}$$

Using contaminant load percentages by land use type found in Tables 6.1-3a and 6.1-3b of the LWG RI, DEQ calculated ratios of the Heavy Industrial loads determined in DEQ's five focus areas for the simplified additional categories of Open Space and the combined Light Industrial, Commercial, Residential and Transportation.

Open Space: $Open\ Space\ Load = Heavy\ Load\ *$ (%open/%heavy)

Light Industrial/Commercial/Residential/Transportation Load: $Light\ industrial\ etc..load = Heavy\ Load\ *$ (%light industrial_etc.)/%heavy)

2.6 Stormwater contaminant load study results and discussion

2.6.1 Assumptions, caveats and factors of conservatism

2.6.1.1 Rainfall and runoff volumes

Comparisons between the NOAA Portland Airport and Downtown Portland gauges indicate that rain gauge location can have an effect on rainfall volume measurements. Areas that drain to Portland Harbor cover a large area around a ten mile stretch of the Willamette River. To ensure accuracy of precipitation values used to determine runoff volumes, data from two USGS Hydra Rainfall Network gauges within the Portland Harbor drainage area were analyzed for annual averages, maximums and minimums. Based on this data a range of precipitation values was determined to represent the total project reach. Using a range of values helps reduce the error when estimating precipitation rates for the entire Portland Harbor area. However, there are limitations to this method since rainfall may vary from site to site effecting runoff volumes for a specific site within the Harbor.

The equation used to estimate runoff volumes used a range of values from a combination of the two available historical records and did not account for evaporation or infiltration, resulting in higher runoff volumes than actually occur. Because higher volumes amplify contaminant load estimates, this is a conservative approach.

2.6.1.2 Area calculations

When little information was available on a subarea within one of the five focus areas, the subarea was deemed impervious to produce a conservative estimate. Also, because the areas chosen discharge stormwater to quiescent areas off the main channel, comprise the most densely developed industrial areas or have measured concentrations of contaminants in site soils, groundwater, stormwater or adjacent river sediment that are the highest concentrations found within Portland Harbor, these five focus areas are considered to have the highest potential for recontamination. Therefore, extrapolating contaminant load estimates to the broader Portland Harbor area from the information specific to these five areas, biases high the contaminant load estimates for Portland Harbor in its entirety.

2.6.1.3 Contaminant concentration

Averaging together stormwater data from multiple facilities within a focus area can introduce error into the analysis. However, concentrations were averaged over each focus area. A focus on these areas with the highest potential recontamination risk and which are much smaller than the entire 10 river mile stretch, reduces error. In addition, using measured data from facilities actively undergoing remediation of the stormwater pathway biases toward higher concentrations for the entire focus area, which adds conservatism to the approach.

2.6.1.4 Datasets

While DEQ's PH Stormwater Database included more than 70,000 data points in mid-2017, the stormwater data on the focus contaminants that was collected in the areas of interest amounted to more than 6,000 data points. Data richness varied by parameter, location and year. Data in order of decreasing richness by parameter was zinc, TSS, PCBs, PAHs and BEHP. Data in order of decreasing richness by focus area location was RM 9W, RM 6-8W, Swan Island Lagoon, RM 11E and International Slip. Far more data was available beginning in mid-2012, due to implementation of the 2012 renewal of the NPDES 1200Z Industrial Stormwater general permit, which began requiring monitoring of all 303(d) list parameters (most of which overlap with Portland Harbor contaminants of concern) as well as additional industrial parameters (cadmium, chromium and nickel). Given the substantial increase in data richness starting in 2012, the load study was initially performed using only data from mid-2012 through mid-2017. In order to roughly evaluate downward trends following implementation of stormwater source control measures, loads from 2012-2017 were also compared to estimated loads from 2000 through 2010. Data richness over the 2000-2010 decade was significantly less than the later five year period, as well as varying by locations and parameters.

2.6.2 Average annual precipitation estimates

USGS data, analyzed between 2012 and 2016 for two gauges, gives the most accurate representation of the entirety of the Portland Harbor Superfund site, and produced an estimated precipitation range between 25 to 53 inches. This range was adjusted up in consideration of more variable historical minimums and maximums, seen in NOAA data for the Downtown Portland gauge from 1981-2014. The NOAA data indicates the range should be between 29 to 73 inches. The NOAA Downtown Portland Gauge Data recorded a precipitation event over 70 inches only once since 1871, making 73 inches per year highly unlikely and a 60 inch per year maximum reasonable. Removing maximum and minimum values from the NOAA data gives an annual average of 43 to 47 inches, which aligns with the average annual precipitation estimate from the USGS gauges of 43 inches. The 50th percentile rain year from the NOAA 1981-2014 data was 41.11 inches, so using an average value with approximately 2 to 6 inches more per year is conservative. Using the larger range 25 to 60 inches allowed for a conservative approach, as well as future consideration of potential changes in precipitation due to climate change.

A conservative range of 25 to 60 inches represents most precipitation possibilities in the Portland Harbor Superfund Site and was used to determine a stormwater runoff volume range. However, annual precipitation is typically between 43 to 47 inches and 37 inches of precipitation was the value used for annual precipitation in the area by the City of Portland to evaluate the volume of annual combined sewer overflow discharge (CoP 2013b).

2.6.3 Impervious surface estimates by focus area

2.6.3.1 River Mile 11E

As summarized below in Table 2.6.3.1, the River Mile 11E area was determined to be approximately 308 acres of half impervious and half pervious surfaces, with approximately 23.2 acres of general commercial area. Stormwater from the area discharges from City (ECSI# 2425) outfall basins (42, 43, 44, 45 and 47), four Glacier (ECSI# 5449) outfall basins, four Cargill (ECSI# 5561) outfall basins and one ODOT (ECSI# 5437) outfall (WR-306) basin, which captures half of the Broadway Bridge and the major transportation areas within the hydro boundary. To simplfy calculations, the ODOT area was assumed to drain to one outfall, even though the bridge also discharges stormwater through scuppers. As seen in Figure 2.6.3.1 below, the majority of the pervious area is composed of the UPRR Albina railyard (ECSI# 178) on the north end of the zone. Additional areas that are known to infiltrate include the decomissioned

City basin for outfall 44A, a small section of the PacifiCorp Albina (ECSI# 5117) site and various other small vegetated areas. Pervious areas are designated as solid green polygons. Impervious areas within each outfall basin are depicted as a different color. Areas without associated concentration data and not within City outfall basins were shaded with purple polygons representing general impervious commercial areas.

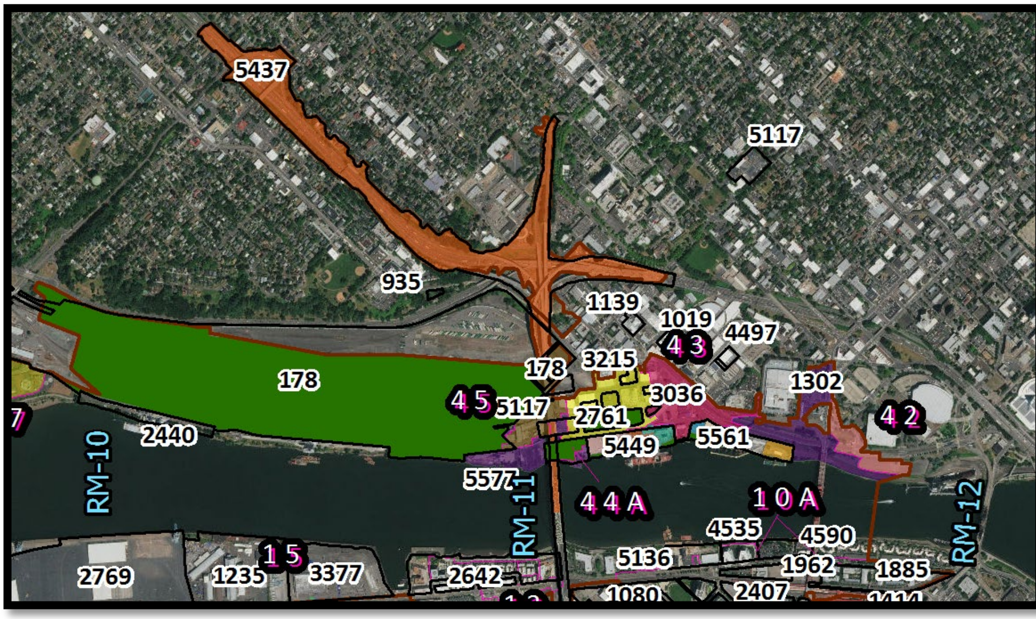

Figure 2.6.3.1. ArcGIS rendering of RM 11E focus area.

Table 2.6.3.1. RM 11E acreage summary.

Outfall Basin or Land Use	Acreage
City Outfall 42	4.0
City Outfall 47	9.5
City Outfall 45	9.9
City Outfall 44A	0.0
City Outfall 43	14.0
City Outfall 44	12.8
Commercial General	23.2
Glacier WR 352	1.6
Glacier Docs	0.4
Glacier WR 351	1.4
Glacier WR 350	2.8
Cargill Outfall 2	2.0
Cargill Outfall 4	0.1
Cargill Outfall 6	1.3
Cargill Outfall 5	1.2
Cargill CSO	0.6
Outfall WR 306 ODOT including Bridge	64.3
Total Pervious	159.1
Total Impervious	148.5
Total Area of Interest	308.2

2.6.3.2 River Mile 9W

As summarized in Table 2.6.3.2 below, the River Mile 9W area consists of approximately 1163.3 acres, most of which is Forest Park or heavy industrial areas, with approximately 46.6 acres of general commercial area. Stormwater from this area discharges through City outfall basins 18, 19 and 19A and private outfalls serving BNSF Guilds Lake Yard (ECSI# 100) and Gunderson (ECSI# 1155).

The Municipal Report was used to determine the areas and imperviousness for Basins 18, 19 and 19A. ArcGIS was used along with Google Earth, and site-specific source control evaluation documents to determine the Gunderson, BNSF Guilds Lake Yard and general commercial areas. The general commercial area was conservatively assumed impervious. The BNSF Guilds Lake areas not included within the Outfall 18 drainage area outlined in the Municipal Report were considered pervious.

The majority of the total area of interest can be seen in Figure 2.6.3.2 below. Areas shown in Green were considered pervious. Purple areas were considered commercial general impervious areas. Orange areas include impervious areas of the Gunderson site. The various shades of pink represent different City Outfall Areas. City outfall areas are not indicated as pervious or impervious in this map.

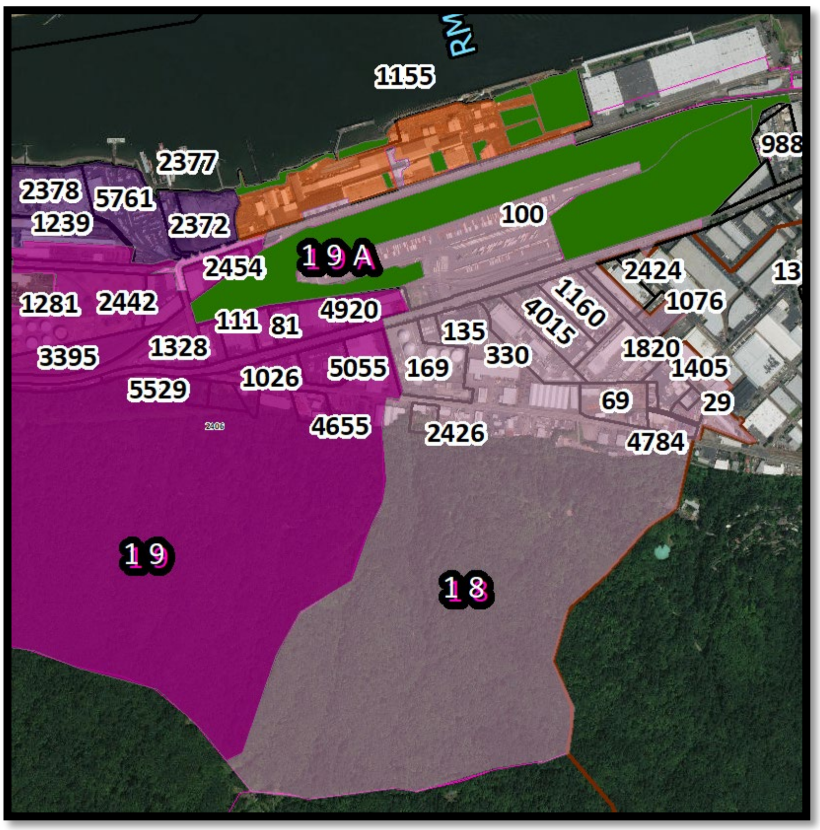

Figure 2.6.3.2. ArcGIS rendering of RM 9W focus area.

Table 2.6.3.2. RM 9W acreage summary.

Land Use	Acreage
Heavy Industrial	339.9
Commercial	0
Residential	2.7
Parks and Open Space	599.5
Major Transportation	16.1
Gunderson Impervious	41.0
General Commercial (assumed impervious)	46.6
Total Pervious	717.0
Total Impervious	446.4
Total Area of Interest	1163.3

2.6.3.3 Swan Island Lagoon

As summarized in Table 2.6.3.3 below, the Swan Island Lagoon area includes approximately 555 acres of mostly impervious area, with approximately 48 acres of general commercial area. All impervious areas were separated according to which outfall the area discharges through. As shown in Figure 2.6.3.3 below, stormwater discharges from the area to the Lagoon from five City outfall basins (M1, M2, M3, S1 and S2), as well as four US Coast Guard (ECSI# 1338) outfalls and 54 Vigor (ECSI# 271) outfalls. The private outfall areas owned by Vigor were separated into substantially similar outfall groups for ease of comparing ArcGIS areas to report values and to reduce error. In addition, scuppers located on Vigor's Pier C and Pier D were considered to be one outfall area per pier. Pervious areas for this zone consist of the end of the Swan Island Lagoon (ECSI # 3901), portions of the river bank and specific pervious areas on the Vigor site. Pervious areas are designated as solid green polygons. Impervious areas within each outfall basin are depicted as a different color. Areas without associated concentration data and not within City outfall basins were shaded with purple polygons, representing general impervious commercial areas. Areas that were known to drain to the sanitary sewer were marked in solid blue and not included in area calculations.

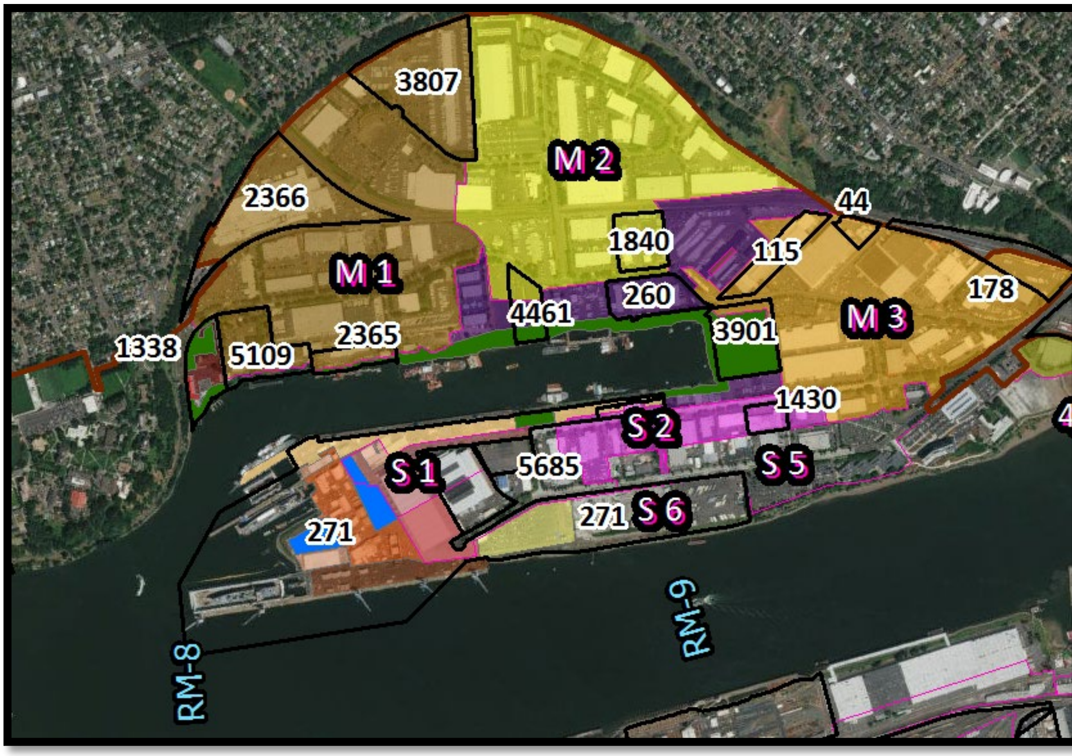

Figure 2.6.3.3. ArcGIS rendering of Swan Island Lagoon focus area.

Table 2.6.3.3. Swan Island Lagoon acreage summary.

Outfall Basin	Acreage
City Outfall M-1	162.4
City Outfall M-2	134.0
City Outfall M-3	104.0
City Outfall S-1	23.3
City Outfall S-2	27.1
US Coast guard Outfalls 1-4	3.6
Vigor Outfall G+L	12.7
Vigor Outfall LD-1B	8.5
Vigor Outfall M	17.4
Vigor Outfall P	8.5
Vigor Outfall Q	12.2
Vigor Outfall R	4.1
Pier C	1.3
Pier D	4.6
Commercial General	47.8
Total Pervious	28.4
Total Impervious Including Overlap	559.5
Total Area of Interest	588.0

2.6.3.4 River Mile 6-8W

This is the largest of the five focus areas, at approximately 1552.1 acres. As summarized in Table 2.6.3.4 and Figure 2.6.3.4 below, the area is mainly pervious due to the large portion of City outfall basin 22C that drains Forest Park. The remainder of the zone is composed of bulk fuel terminals, large former chemical and gas manufacturing plants, major transportation areas and approximately 19.4 acres of general commercial area. Stormwater discharges from the area from three City outfall basins, four Siltronic (ECSI# 183) outfall basins, two Gasco (ECSI# 84) outfall basins, one GS Roofing (ECSI# 117) outfall basin, three US Moorings (ECSI# 1641) outfall basins, three Kinder Morgan (ECSI# 1549) outfall basins, two McCall Oil (ECSI# 134) outfall basins and a handful of other impervious areas that drain into the Willamette. The Siltronic, US Moorings, McCall Oil and Gasco sites also contain large infiltration areas. Other pervious areas include an old covered landfill, and small vegetated areas.

Due to incomplete site stormwater infrastructure maps, the Chevron (ECSI# 25), Unocal (ECSI# 177) and Conoco Philips (ECSI# 160) site areas that do not contribute directly to City outfall basins were considered impervious. The areas were modeled as contributing to one outfall each. This approach is conservative and can be modified at a later date.

For this analysis, DEQ source control project managers conservatively estimated impervious areas of Arkema and Rhone Poulenc to be 60% and 20%, respectively. For future iterations of this study, more accurate estimates from permitted effluent flow volumes from the Arkema and Rhone Poulenc sites should be utilized.

Pervious areas are designated as solid green polygons. Impervious areas within each outfall basin are depicted as a different color. Areas without associated concentration data and not within City outfall basins were shaded with purple polygons representing general impervious commercial areas.

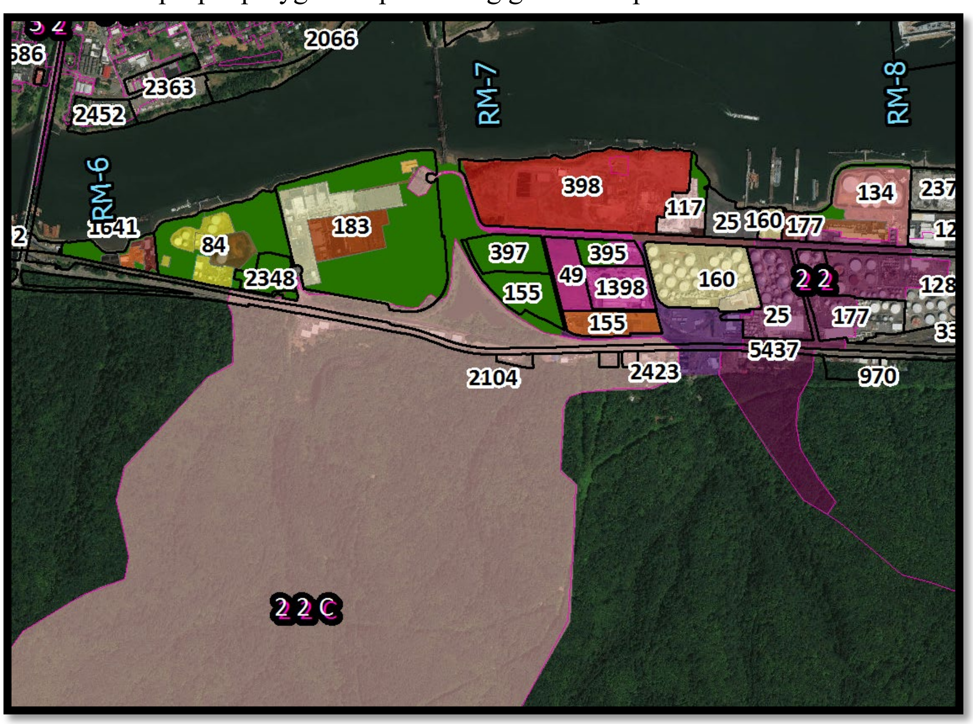

Figure 2.6.3.4. ArcGIS rendering of RM 6-8W focus area.

Table 2.6.3.4. RM 6-8W acreage summary.

Outfall Basin of Land Use	Acreage
Siltronic 001	17.6
Siltronic 002	0.4
Siltronic 003	11.6
Siltronic 004	0.6
Gasco Outfall 107	9.1
Gasco Outfall 001	5.0
City Outfall 22B	25.8
City Outfall 22	69.9
City Outfall 22C	69.2
GS Roofing Outfall B	5.8
GS Roofing to city	0.8
US Moorings Area 1: Outfall A	1.6
US Moorings 2: Outfall B	2.0
US moorings 3	0.7
Rhone Poulnec (8.59 total area)	Use Volume
Arkema (60.04 total area)	Use Volume
ODOT	3.6
Kinder Morgan Dock Area	1.6
Kinder Morgan Outfall 1	2.8
Kinder Morgan Outfall 3	22.6
Chevron Bank Side	7.6
Unocal Bank Side	2.5
McCall Oil Outfall S-3	5.0
McCall Oil S-4	15.7
Commercial General	19.4
Total Pervious	1182.4
Total Impervious	301.1
Total Area of Interest(need to include volumes)	1552.1

2.6.3.5 International Slip

As noted in Table 2.6.3.5 and Figure 2.6.3.5 below, this focus area comprises approximately 287 acres, approximately 2/3 of which is impervious. Six outfalls drain the Schnitzer-Burgard Industrial Park (ECSI# 5324)), Lampros Steel (ECSI# 2441) and Northwest Pipe (ECSI# 138) sites. Two additional outfalls drain the former Time Oil (ECSI# 170) and Premier Edible Oils (ECSI# 2013) sites. In addition, stormwater drains to the International Slip from a small City outfall basin 52D and some portions of the area drain to the Columbia Slough. The majority of pervious area consists of undeveloped acerage on the Time Oil and Premier Edible Oil sites. Additional pervious area is found throughout the SBIP areas, these areas are usually gravel storage areas. The basins specified in the SBIP report have some uncertainty as to infrasturcture locations and connectivity. However, all impervious area was accounted for and minor discrepencies between exact discharge locations doesn't change contaminant load results. Pervious areas are designated as solid green polygons. Impervious areas within each outfall basin are depicted as a different color. Areas without associated concentration data and not within City outfall basins were shaded with purple polygons, representing general impervious commercial areas. Areas that were known to drain to the sanitary sewer were marked in solid blue and not included in area calculations.

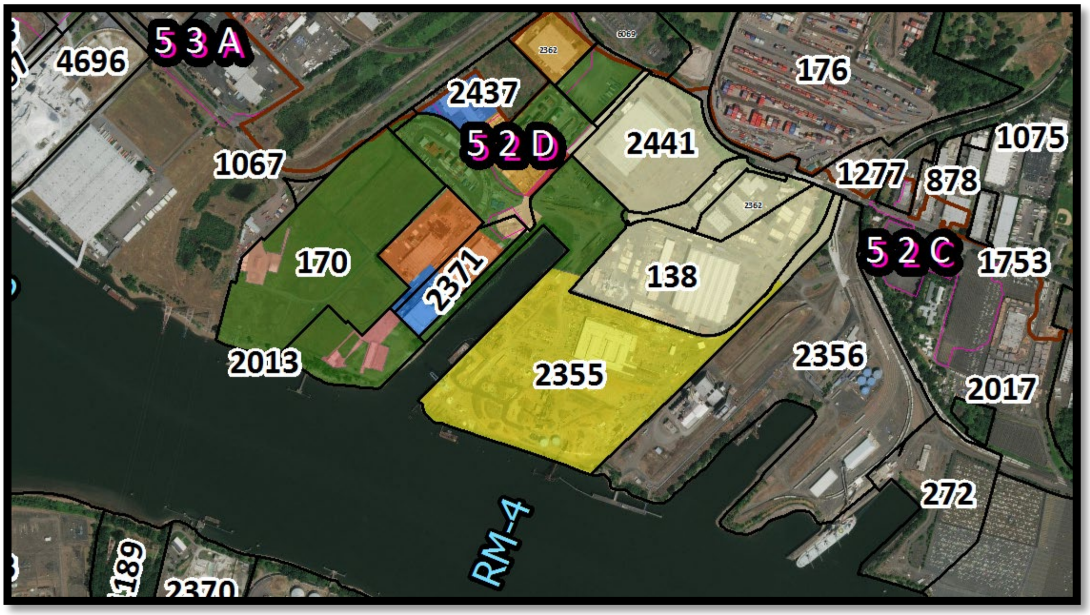

Figure 2.6.3.5. ArcGIS rendering of International Slip focus area.

Table 2.6.3.5. International Slip acreage summary.

Outfall Basin	Acreage
Premier Edible Oils	3.2
Time Oil WR-151	2.3
Outfall 22	13.0
Sewer	5.0
Slough (City OF52D)	4.5
Outfall 20	2.1
Outfall 21 (City OF52D)	12.0
River Mile 9W WR123	78.9
Outfall 20A	0.8
Outfall 1	64.2
Total Pervious	100.5
Total Impervious	176.5
Total Area of Interest	286.5

2.6.4 Contaminant concentration estimates by focus area

Average annual concentrations were calculated for each facility and for each focus area over the five year timespan from 2012-2017. In addition to providing focus area averages to be used in the contaminant load estimates, facility-specific averages were evaluated for changes over time. This provided insight into the effects of source control measure and permit implementation to help identify facilities that may need further stormwater controls. Insight on effectiveness of control measures was also gained by evaluating trends over a longer time period. Average concentrations of available data from 2003 through 2011 were compared to the average concentration calculations from 2012 through 2017, roughly representing before and after implementation of control measures through the source control program and the 2012 renewal of the NPDES 1200-Z Industrial Stormwater general permit. See Appendix A for data richness tables by focus area.

2.6.4.1 River Mile 11E

As shown in Figure 2.6.4.1.1, a modest downward trend in average annual zinc concentrations was seen for data collected between 2012 and 2016 from stormwater discharges from the RM 11E focus area, with all concentration averages below the flat portion of DEQ's rank-order curve for zinc measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009). Due to data limitations and lack of complete representation, data prior to 2012 and after 2016 were excluded. Due to limited data collected prior to 2012, a comparison plot of data prior to and after 2012 was not supported.

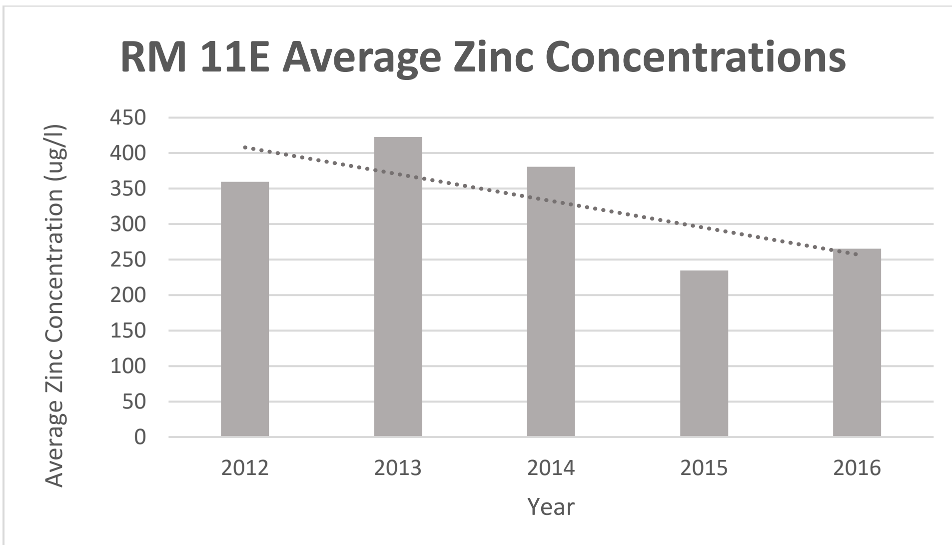

Figure 2.6.4.1.1. Shows the change in average annual zinc concentrations from 2012-2016. Data prior to 2012 was limited and so excluded. Data from 2017 was also excluded because there was no data from Cargill, which contributed the largest data set for other years.

As shown in Figure 2.6.4.1.2, the trend for total PAHs concentrations in the River Mile 11E area was not clear. In part, this is complicated by increasing concentrations of PAHs found in UPRR Albina stormwater discharges, shown in Figure 2.6.4.1.3. This further complicates contaminant load estimates because, while the UPRR facility comprises the largest land area in the RM 11E focus area, the gravel ballast covering the site was classified as pervious.

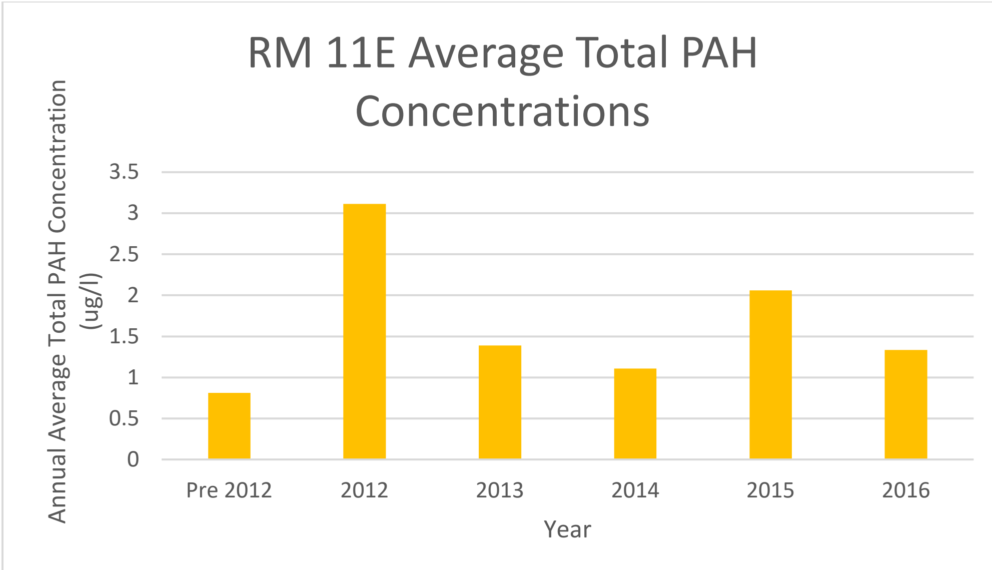

Figure 2.6.4.1.2. RM 11E average annual total PAHs concentrations.

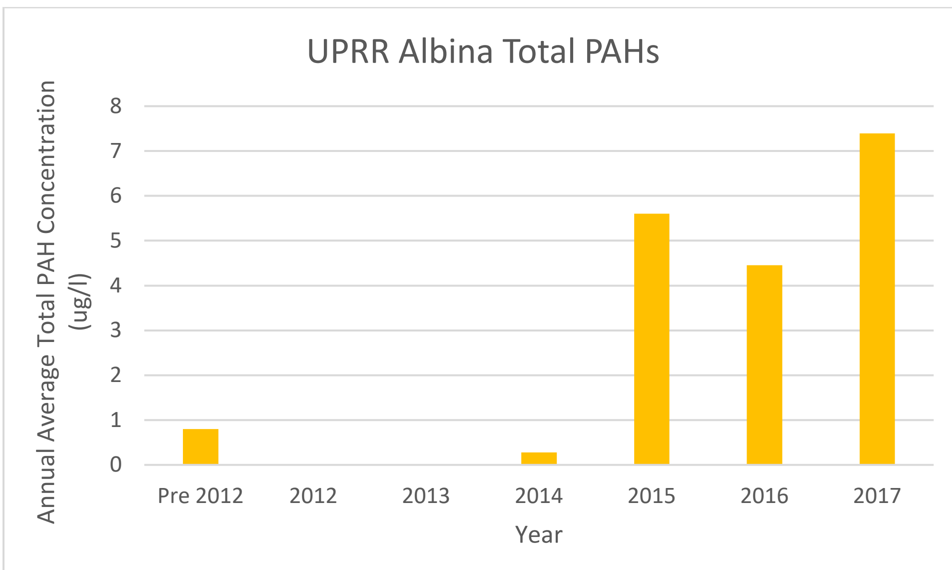

Figure 2.6.4.1.3. Increasing total PAHs concentrations at the UPRR Albina facility.

A plot of average annual BEHP data was not created, due to limited overall data and several years being comprised of data from just one site. The overall average of BEHP from the data collected between 2009 and 2017 was 5.44 ug/L. Highest individual data points range between 11 ug/L to 21 ug/L and a single point at 104 ug/L. Although a plot of annual average concentrations was not supported by the data, it should be noted that these are among the highest concentrations of BEHP measured for any stormwater discharges into Portland Harbor.

As shown in Figure 2.6.4.1.4, after a decline in 2012, potentially due to implementation of source control measures and best management practices, average annual total PCBs concentrations for all available data from stormwater discharges from the RM 11E focus area are relatively stable at concentrations below the flat portion of the DEQ rank-order curve for PCBs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

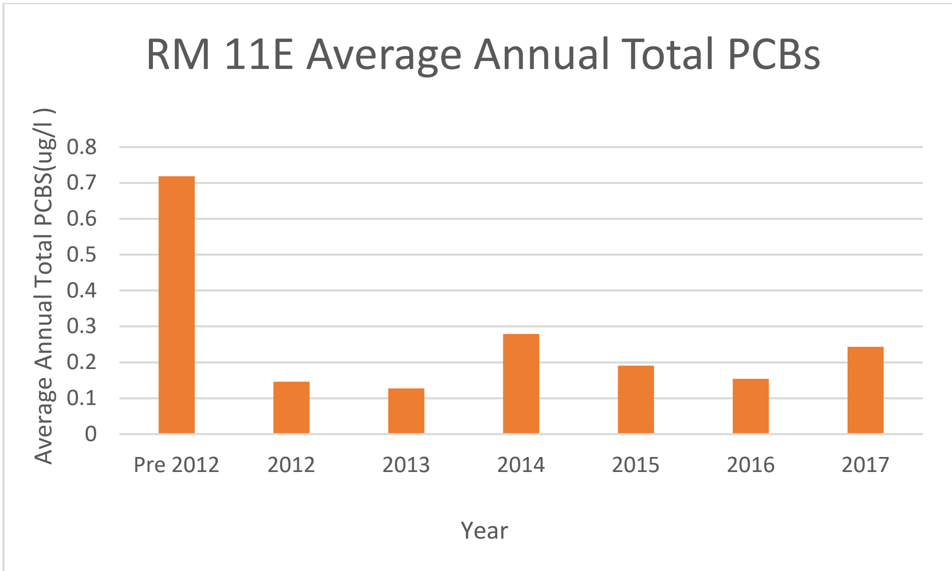

Figure 2.6.4.1.4. RM 11E average annual total PCBs concentration with combined Pre-2012 data.

Comparison of total PCBs average concentrations of data collected prior to and after 2012 for stormwater discharges from the RM 11E focus area indicates significant reductions, as shown in Figure 2.6.4.5.

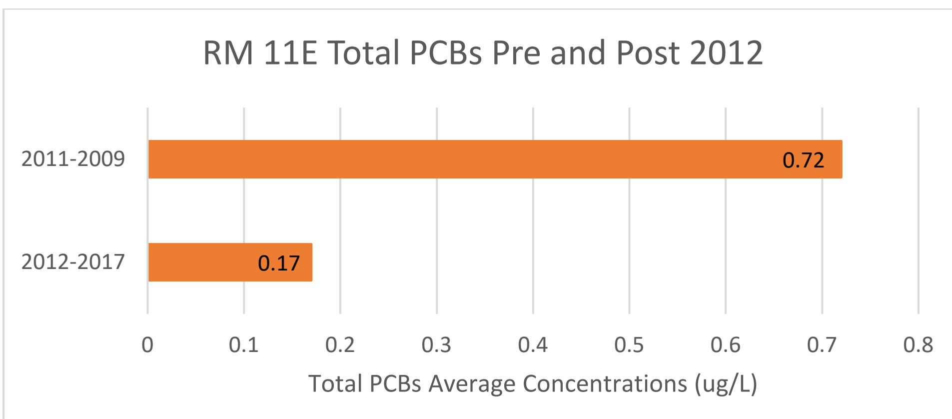

Figure 2.6.4.1.5. RM 11E difference in the average concentration of Pre-2012 data and data collected after 2012.

A general downward trend in TSS concentrations in stormwater discharges from the RM 11E focus area is shown in Figure 2.6.4.1.6. Due to limited data on TSS collected from stormwater discharges from the RM 11E focus area, a comparison plot for pre and post 2012 data was not supported.

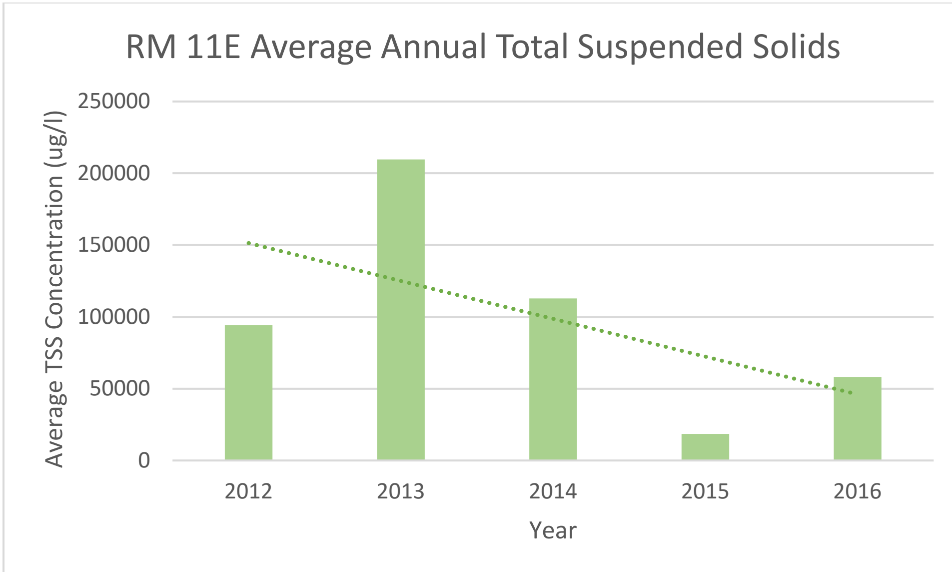

Figure 2.6.4.1.6. RM 11E average annual TSS concentration trend, excluding limited data from pre-2012 and 2017.

2.6.4.2 River Mile 9W

As shown in Figure 2.6.4.2.1, the overall trend in average annual zinc concentrations in stormwater discharges from the RM 9W focus area is not clear. However, there appears to be a steady decrease in concentrations over the last three years of data available during this study, with all average concentrations since 2012 below the flat portion of DEQ's rank-order curve for zinc measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

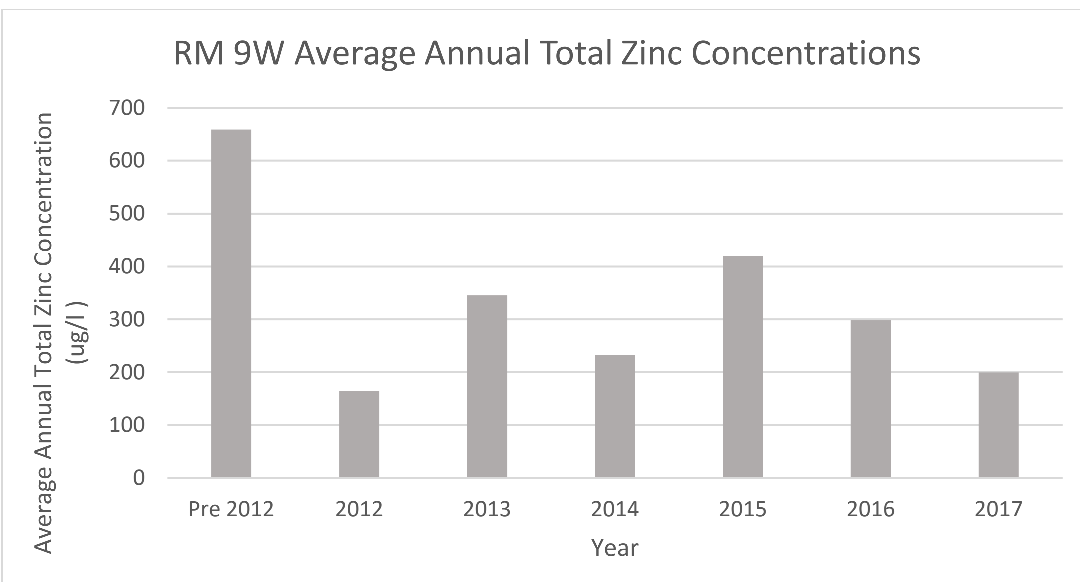

Figure 2.6.4.2.1. RM 9W average annual zinc concentrations with combined Pre-2012 data and exclusion of the outlying Univar data point in 2017.

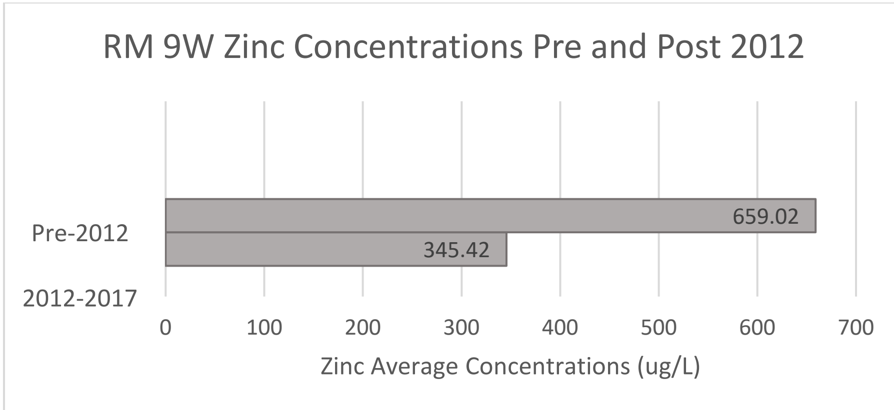

Figure 2.6.4.2.2. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012.

As shown in Figure 2.6.4.2.3, the highest concentrations of total PAHs were measured in stormwater discharges from the RM 9W focus area in 2012. Since then, concentration averages were significantly lower and generally below the flat portion of DEQ's rank-order curve for total PAHs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009). Due to limited data and the concentration spike of 2012, a comparison plot of data collected prior to and after 2012 was not supported.

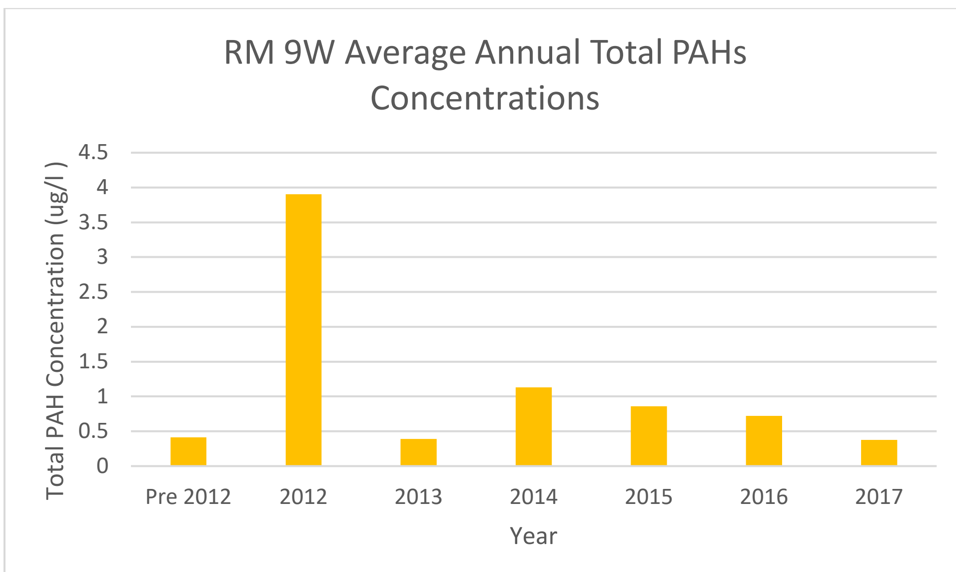

Figure 2.6.4.2.3. RM 9W average annual total PAHs concentrations with combined Pre-2012 data.

As shown in Figure 2.6.4.2.4, data gaps exist for 2010 and 2014 in BEHP measured in stormwater discharges from the RM 9W focus area. In addition, data richness is limited and not spread across all sites within the area. As a result, no clear trend is apparent. Highest individual concentrations were measured at the Univar site (which is undertaking source control under EPA oversight) and range from 8 ug/L to 23 ug/L with outliers ranging from 83 ug/L to 120 ug/L. As with the RM 11E focus area, it should be noted that these are among the highest concentrations of BEHP measured for any stormwater discharges into Portland Harbor.

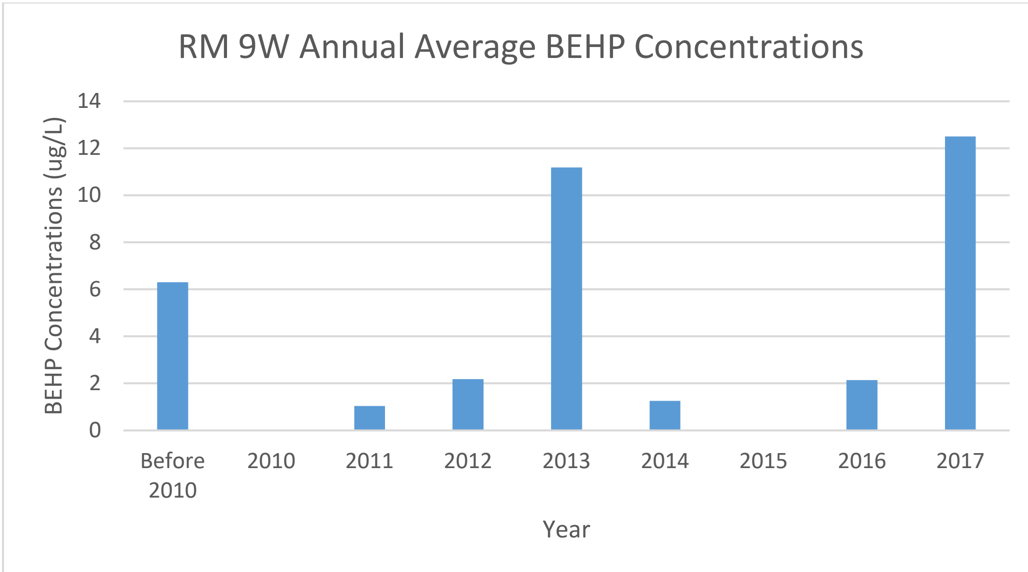

Figure 2.6.4.2.4. RM 9W average annual BEHP concentrations.

As shown in Figure 2.6.4.2.4, a downward trend in total PCBs concentrations is noted in stormwater discharges from the RM 9W focus area, with all average annual concentrations below the flat portion of DEQ's rank-order curve for PCBs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009). Figure 2.6.4.2.5 shows a significant reduction following implementation of source control measures and best management practices.

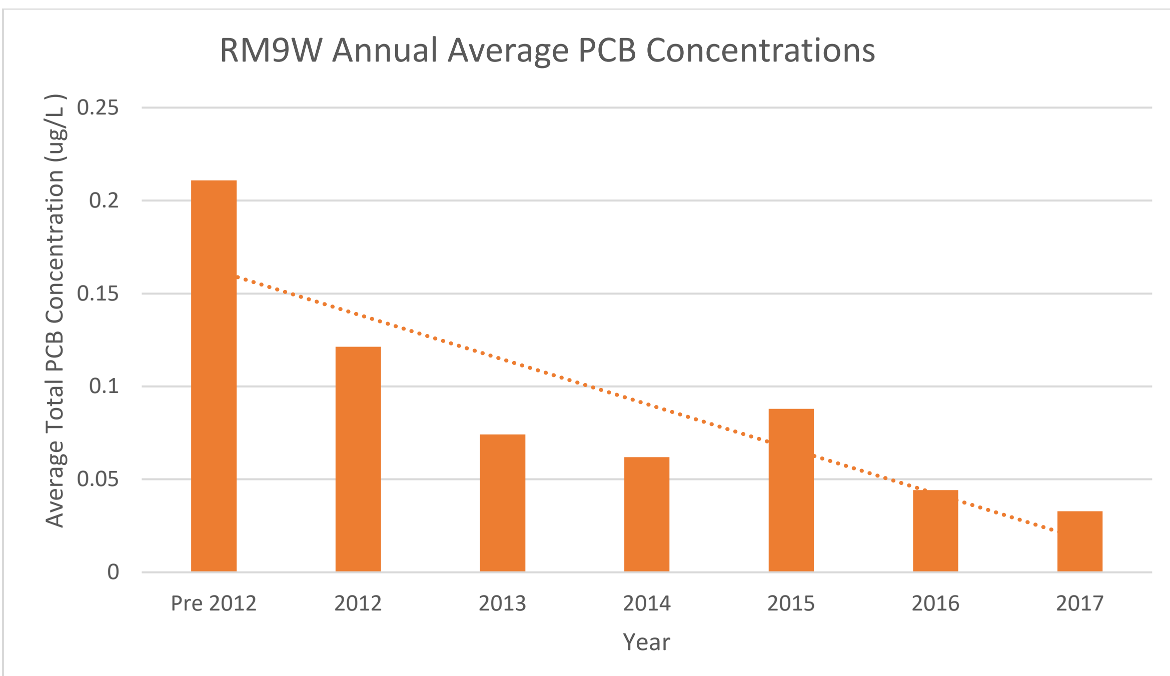

Figure 2.6.4.2.5. RM 9W average annual total PCBs concentrations with combined Pre-2012 data.

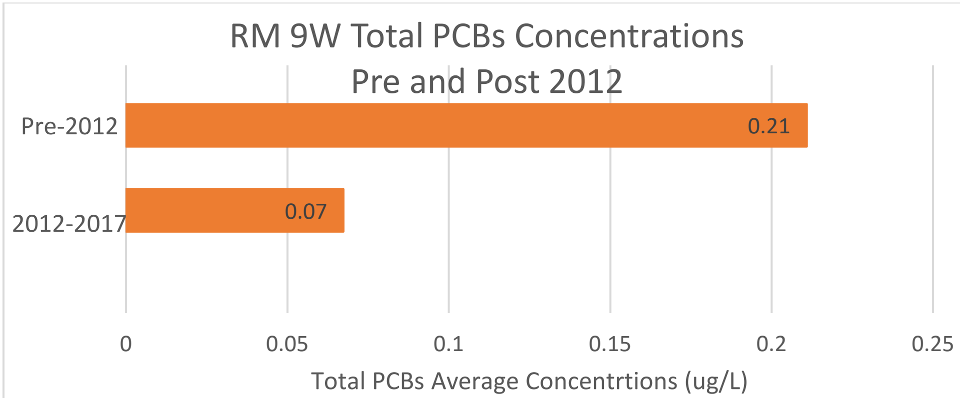

Figure 2.6.4.2.6. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012.

As shown in Figure 2.6.4.2.7, on average, TSS concentrations measured between 2002 and 2017 in stormwater discharges from the RM 9W focus area remained relatively constant, with all but the 2012 annual average concentration below the flat portion of DEQ's rank-order curve for TSS measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

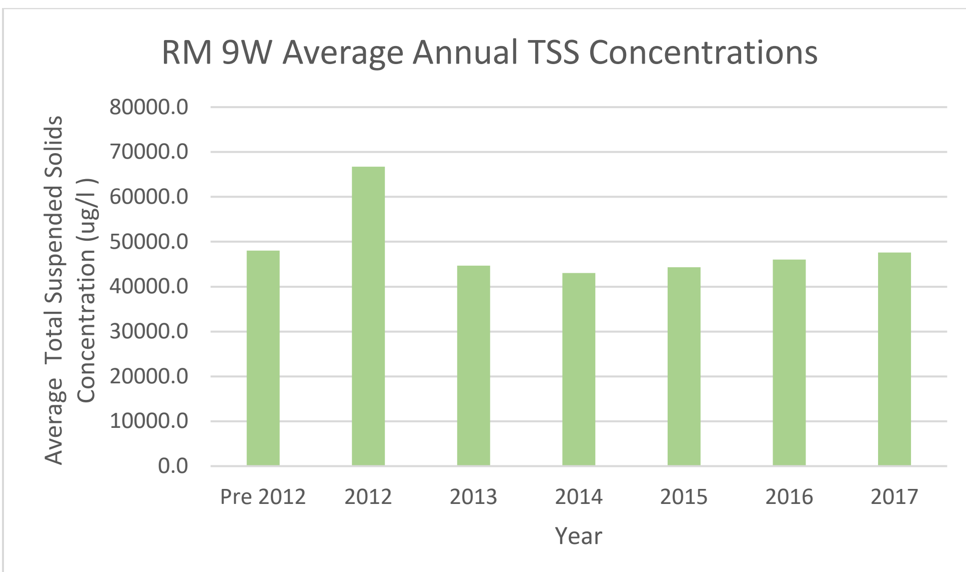

Figure 2.6.4.2.7. RM 9W average annual TSS concentrations with combined Pre-2012 data.

2.6.4.3 Swan Island Lagoon

As shown in Figure 2.6.4.3.1, average zinc concentrations measured between 2007 and 2017 in stormwater discharges into the Swan Island Lagoon remained relatively steady. Data prior to 2012 is limited, including no data for 2010, so a comparison plot of data prior to and after 2012 was not prepared. Highest individual concentrations ranging from 1,000,000 ug/L to 4,000,000 ug/L were measured in discharges from the Vigor site in 2012 and 2013. All annual average concentrations are below the flat portion of DEQ's rank-order curve for zinc measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

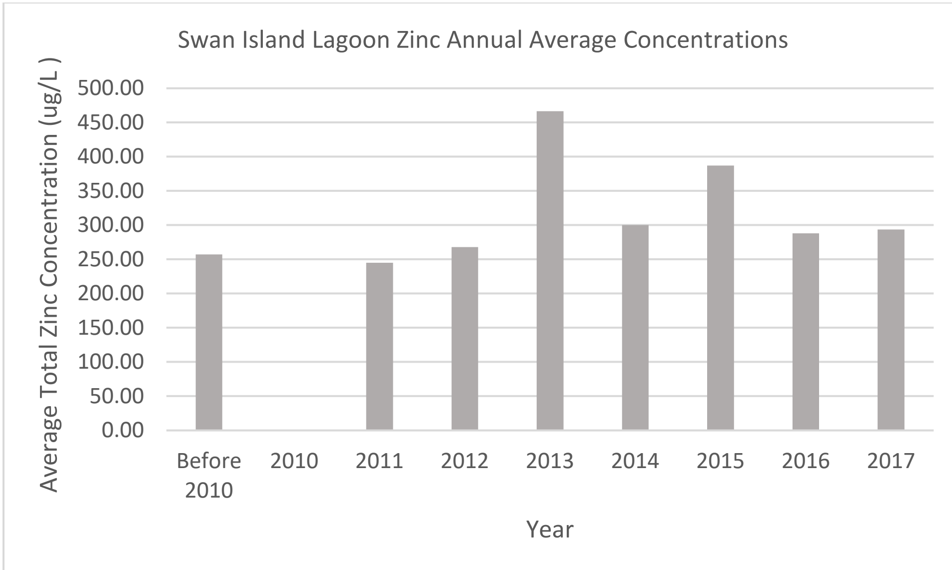

Figure 2.6.4.3.1. Swan Island Lagoon average annual zinc concentrations.

As shown in Figure 2.6.4.3.2, data gaps for 2010, 2012 and 2013 exist for total PAHs concentrations measured in stormwater discharges into Swan Island Lagoon. In addition, only limited data is available for the other years between 2007 and 2017, and only from about half the sites. While no clear trend can be determined from this limited dataset, all but four of the individual measurements and all of the average annual concentrations fall below the flat portion of the DEQ rank-order curve for total PAHs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009). The four highest measurements ranged from one in 2015 at 2 ug/L to three in 2009 between 3 ug/L to 7.6 ug/L.

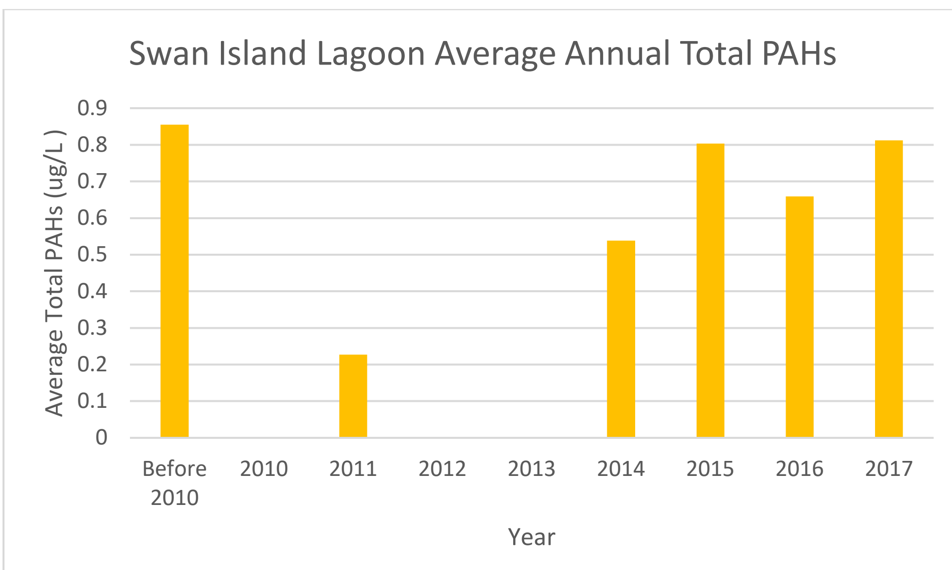

Figure 2.6.4.3.2. Swan Island Lagoon average annual total PAHs concentrations.

As with other focus areas in this study, BEHP data measured in stormwater discharges to Swan Island Lagoon is limited, including no data for 2010 and 2012 and only 58 data points for 2007 through 2017 spread across less than half of the sites in the focus area. Little value is provided in developing a plot for these data. The majority of individual measurements are below the flat portion of DEQ's rank-order curve for BEHP measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ

2009). However, the highest individual measurements were 19 ug/L prior to 2009 and 28 ug/l in 2013 and 14 measurements fall in or above the knee of the curve ranging from 4 ug/L to 14 ug/L.

Though Figure 2.6.4.3.3 indicates a downward trend in total PCBs concentrations in stormwater discharges into Swan Island Lagoon, the small magnitude of the concentration range indicates concentrations are relatively steady between 2007 and 2017 and all annual average concentrations fall below the flat portion of DEQ's rank-order curve for PCBs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

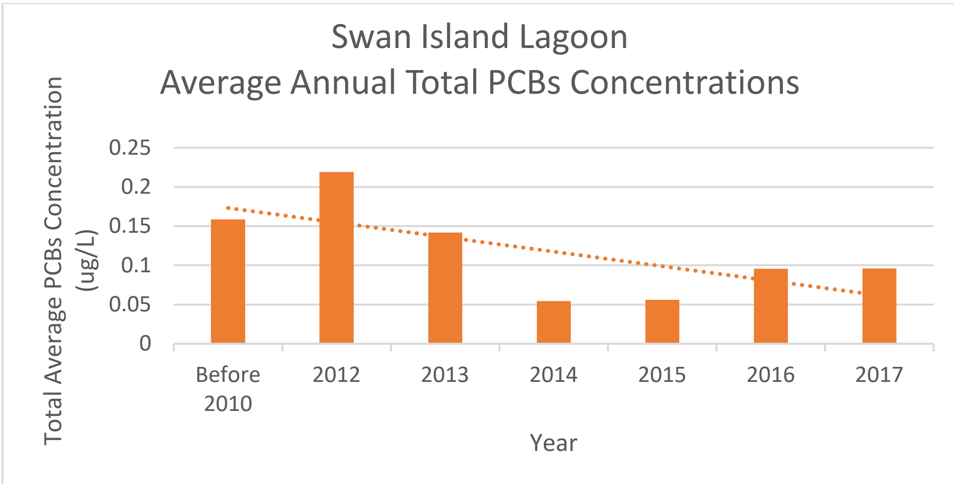

Figure 2.6.4.3.3. Swan Island Lagoon average annual total PCBs concentrations.

As shown in Figure 2.6.4.3.4, TSS concentrations in Swan Island Lagoon discharges appear to have increased in 2013 and then generally are stable to decreasing, with all average annual concentrations below the flat portion of the DEQ rank-order curve for TSS measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

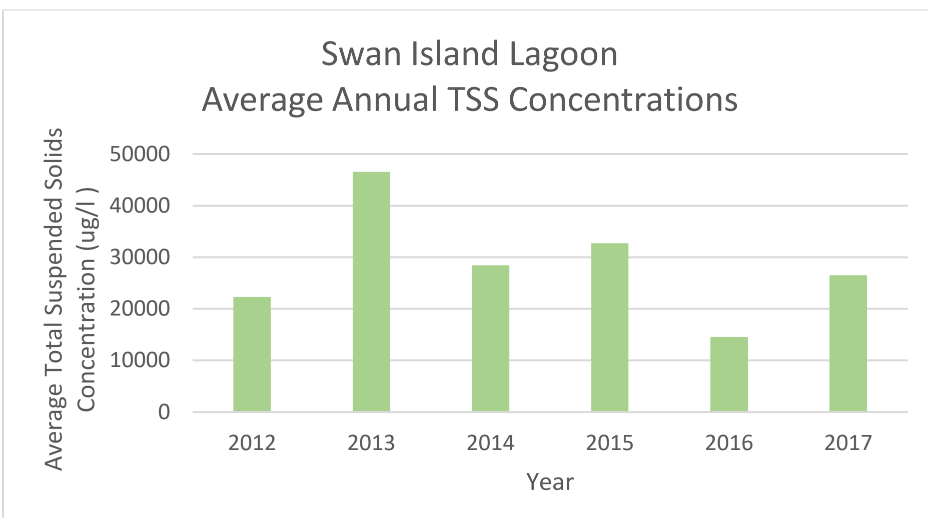

Figure 2.6.4.3.4. Swan Island Lagoon average annual TSS concentrations with combined Pre-2012 data.

2.6.4.4 River Mile 6-8W

As shown in Figure 2.6.4.4.1, average annual zinc concentrations measured in stormwater discharges from sites within the RM 6-8W focus area appear to have increased from 2000 to 2013 and then trend downward through 2017. Data richness and the spread across sites increased after 2012, increasing confidence in the downward trend from 2013 through 2017. The highest data points range from 770 ug/L to 1540 ug/L and were measured at GS Roofing in 2015 through 2017. But all average annual concentrations fall below the flat portion of the DEQ rank-order curve for zinc measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

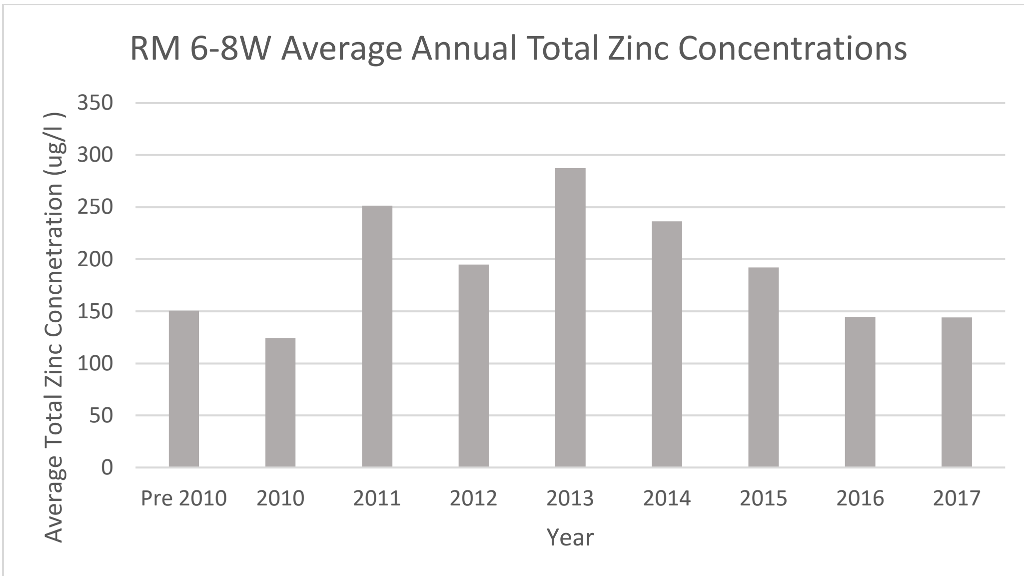

Figure 2.6.4.4.1. RM 6-8W average annual zinc concentrations.

As shown in Figure 2.6.4.4.2, there appears to be a general downward trend in average annual total PAHs concentrations in stormwater discharges from sites in the RM 6-8W focus area. Annual datasets are each limited in sample number with data in 2012 from a single facility and from 2013 from just three facilities. Although these data limitations limit confidence in the downward trend, confidence is increased by the fact that 60 of the 68 individual data points from 2013 through 2017 fall below the flat portion of the DEQ rank-order curve for PAHs measured at heavy industrial sites within Portland Harbor (DEQ 2009). The eight exceptions were four samples from Chevron – Willbridge in 2016 and 2017 ranging from 2.8 ug/L to 5.3 ug/L, three samples from Unocal – Willbridge at 2 ug/L in 2016 and one sample from GS Roofing at 36 ug/L in 2015.

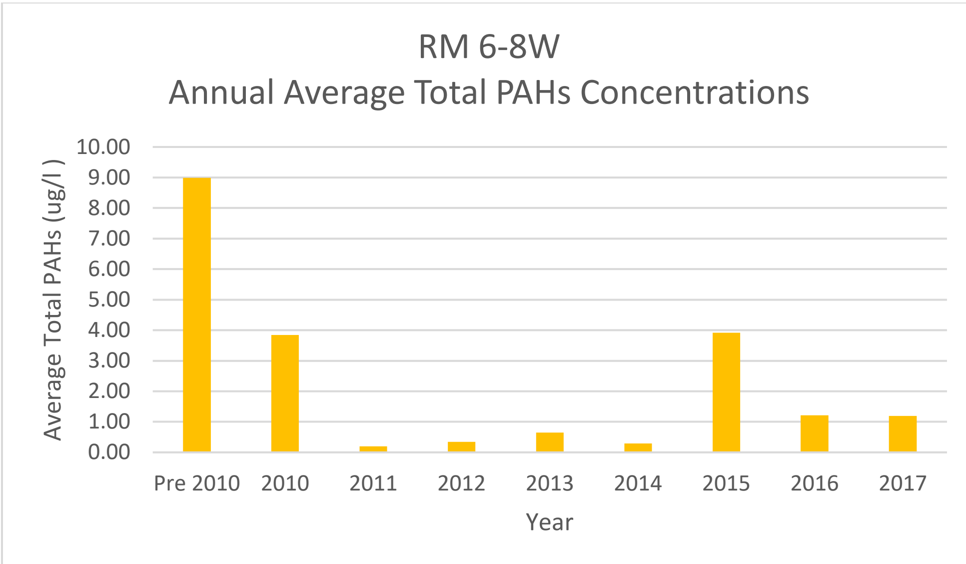

Figure 2.6.4.4.2. RM 6-8W average annual total PAHs Concentrations.

As shown in Figure 2.6.4.4.3, a trend in average annual BEHP concentrations in stormwater discharges from sites in the RM 6-8W focus area is not apparent. As with other focus areas, datasets for BEHP are very limited, including the absence of data in 2016 and 2017, and data is not well spread across facilities within the focus area. While a total of 122 measurements collected between 2007 and 2015 does not support conclusions on trends, the eight most recent data points collected in 2014 and 2015, all fall below the flat part of the DEQ rank-order curve for BEHP measured at heavy industrial sites within Portland Harbor (DEQ 2009).

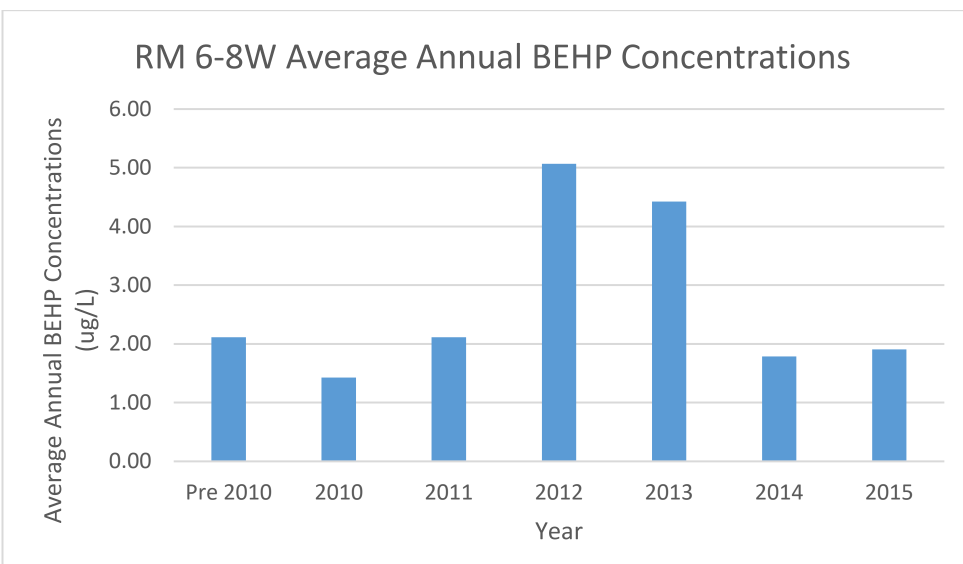

Figure 2.6.4.4.3. RM 6-8W average annual BEHP concentrations.

Despite adequate data richness and representation across facilities within the RM 6-8W focus area, trends in stormwater discharge concentrations of total PCBs are inconclusive. As shown in Figure 2.6.4.4.4, overall average annual concentrations are fairly low. In looking at the most recent data, 58 of 66 individual measurements collected between 2014 through 2017 fall on the flat part of the DEQ rank-order curve for PCBs measured at heavy industrial sites within Portland Harbor (DEQ 2009), as well as all average annual concentrations since 2010. The eight exceptions all reported at about 0.5 ug/L, six from Chevron – Willbridge (three in 2016 and three in 2017) and two from McCall Oil in 2014, which is within the inflection point of DEQ's rank-order curve.

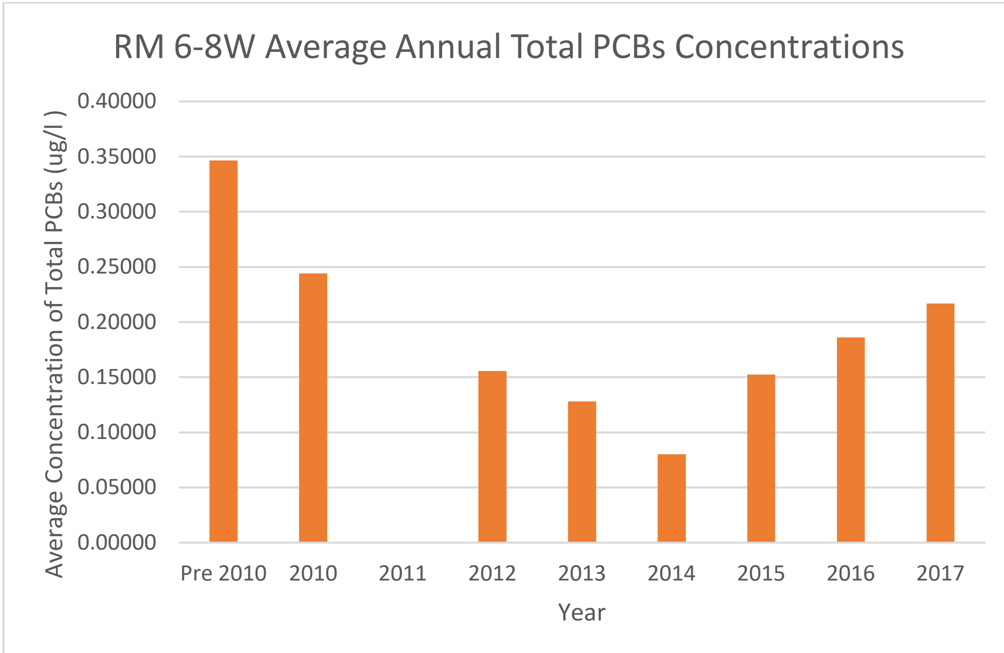

Figure 2.6.4.4.4. RM 6-8W average annual total PCBs concentrations.

The 70 TSS data points collected between 2007 and 2010 and one collected in 2011 represented only five sites within the RM 6-8W focus area, so this limited data was excluded. The remaining data is a robust set across the sites within the area and demonstrates a clear downward trend in TSS, as shown on Figure 2.6.4.4.5, with all average annual concentrations after 2012 falling below the flat portion of the DEQ rank-order curve for TSS measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

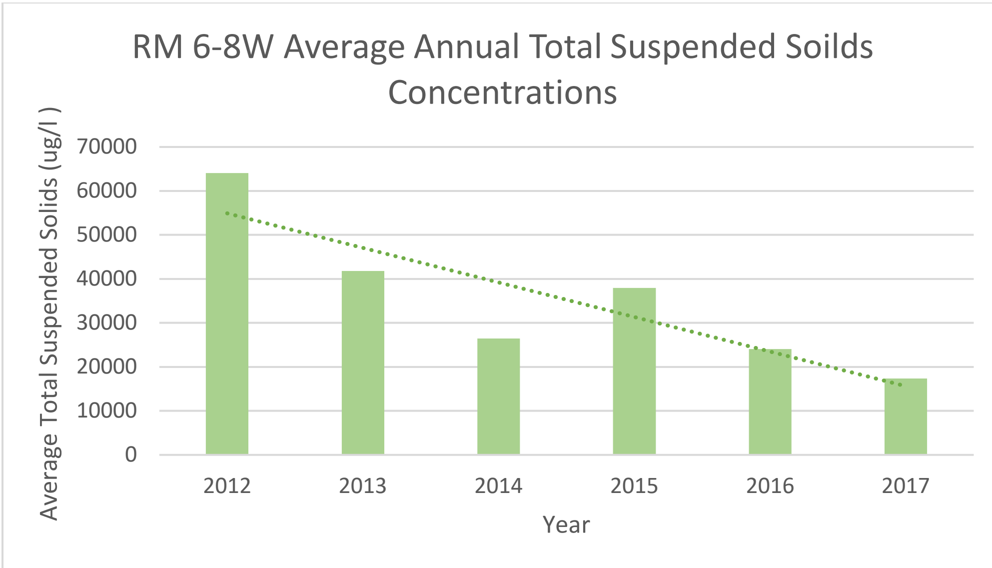

Figure 2.6.4.4.5. RM 6-8W average annual TSS concentrations with limited Pre-2012 data excluded.

2.6.4.5 International Slip

Downward trends in average annual concentrations of all five focus parameters were seen in the following plots of data from stormwater discharges into the International Slip. As noted in some plots, outliers were removed in some instances to clarify the trends. These downwards trends are potentially due to significant stormwater source control measures being put into place at the large Schnitzer Steel site between 2010 and 2014.

While Figure 2.6.4.5.1 shows a downward trend in overall zinc concentrations, only the two most recent years have average annual concentrations that fall below the flat portion of the DEQ rank-order curve for zinc measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

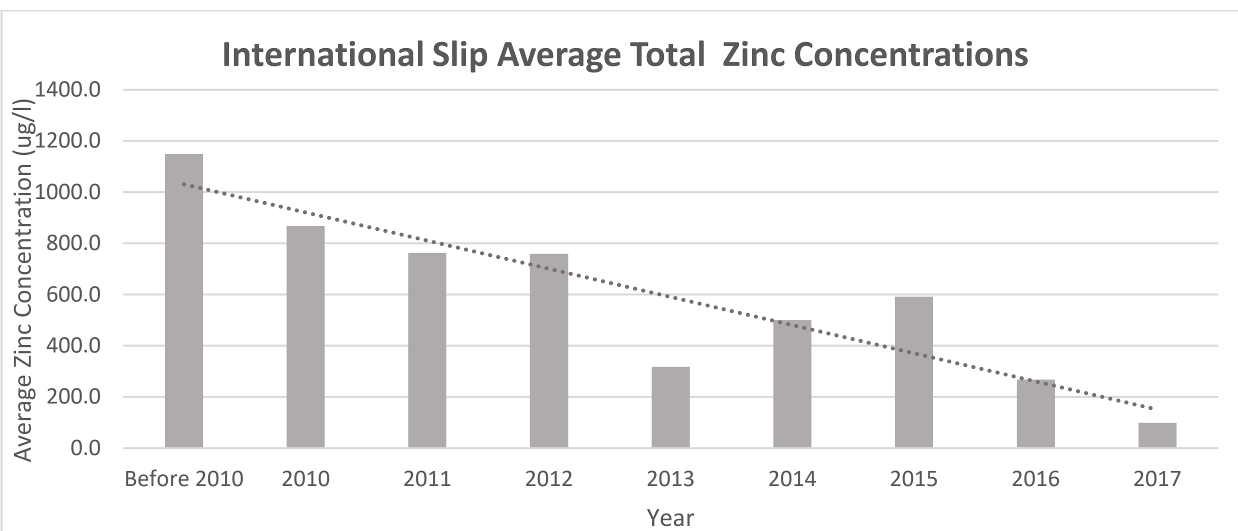

Figure 2.6.4.5.1. Shows the downward trend in average annual zinc concentration over time in stormwater discharges to the International Slip.

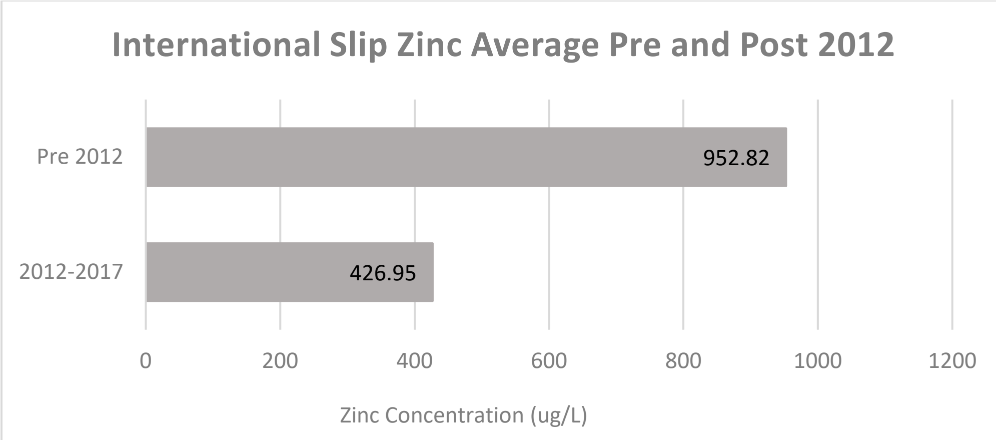

Figure 2.6.4.5.2. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012.

As shown in Figures 2.6.4.5.3, 2.6.4.5.4. and 2.6.4.5.5, average annual PAHs concentrations trend downward in International Slip stormwater discharges, data richness supports confidence in the lowest concentrations in 2012, 2013, 2014 and 2016 and a significant decrease is noted after 2012. Despite these downward trends, however, all annual average PAHs concentrations evaluated fall above the flat portion of DEQ's rank-order curve for PAHs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

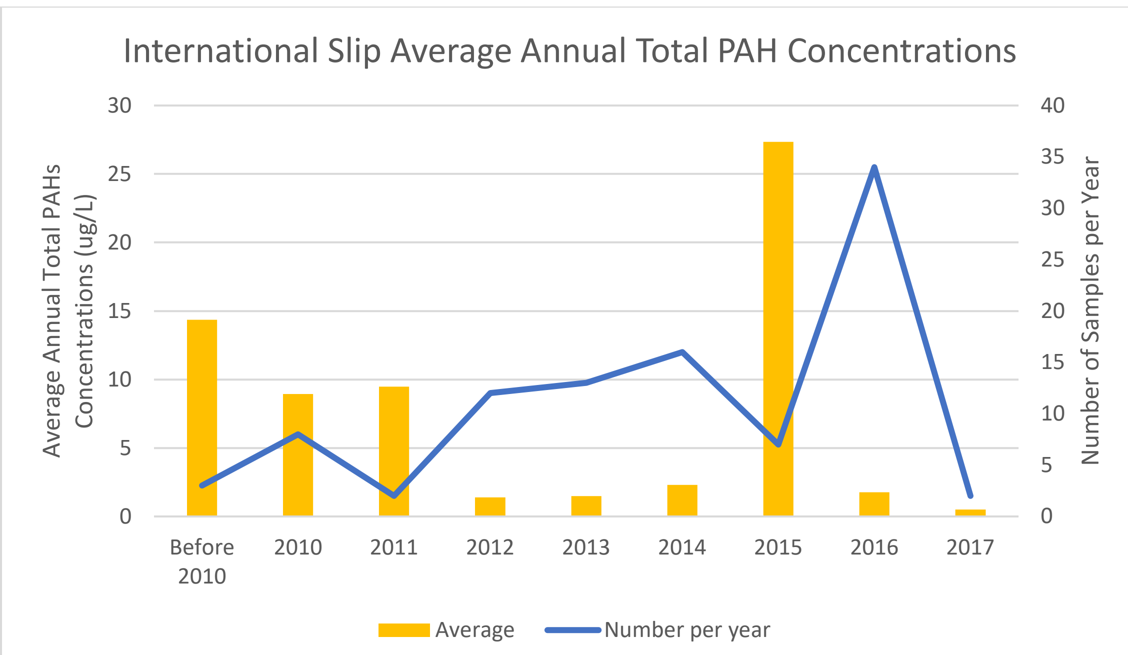

Figure 2.6.4.5.3. International Slip average annual Total PAHs are represented by the blue bars. The blue line represents the number of data points used for each year's average.

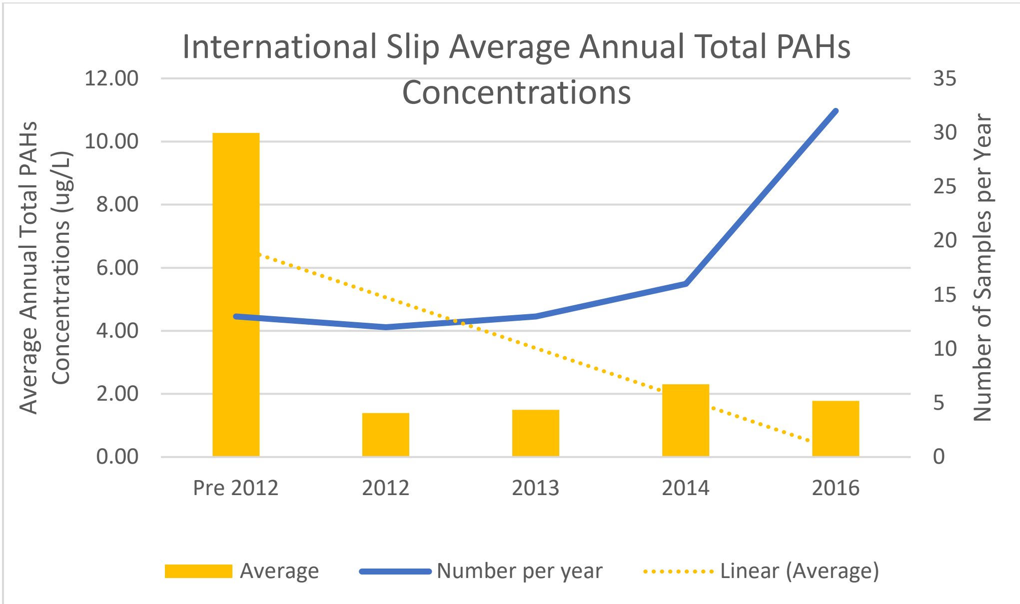

Figure 2.6.4.5.4. International Slip average annual Total PAHs are represented by the blue bars. The blue line represents the number of data points used for each year's average. This graph removed the 2015 annual average due to potential outliers from Lampros Steel. Data from 2017 was limited and so also excluded.

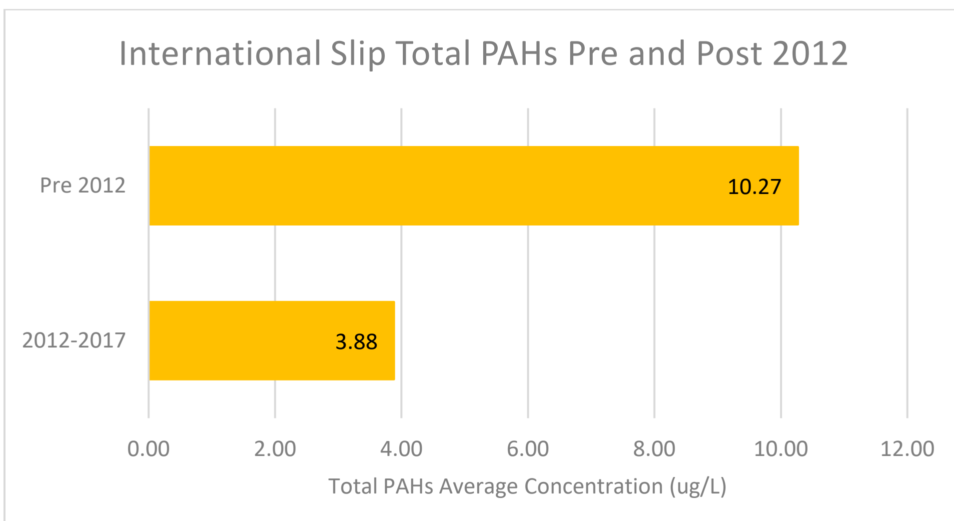

Figure 2.6.4.5.5. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012. No data was excluded.

As shown in Figures 2.6.4.5.6. and 2.6.5.4.7, BEHP average annual concentration trends are less clear, but appear to be declining in the more recent data. While more recent average annual concentrations are approaching the flat portion of curve, all averages remain above the flat portion of DEQ's rank-order curve for BEHP measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

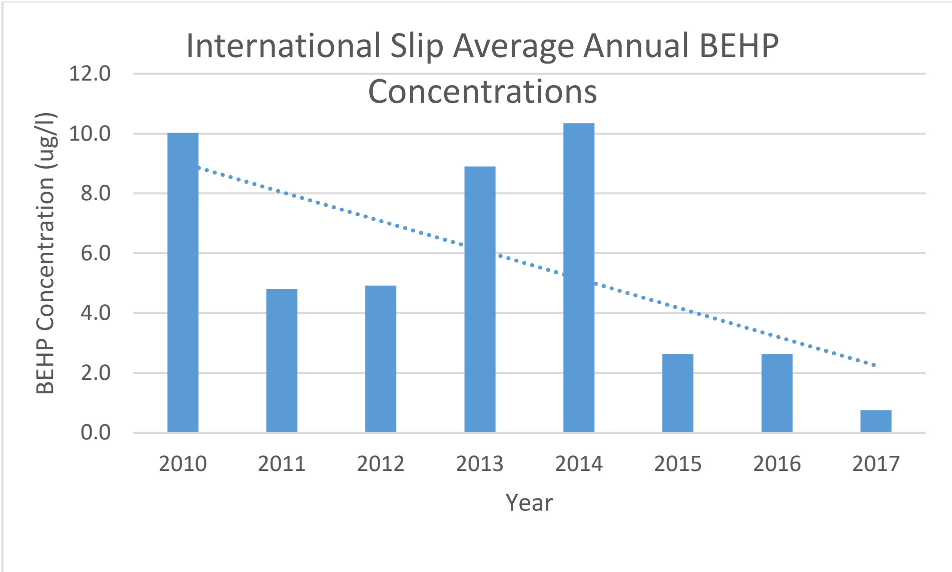

Figure 2.6.4.5.6. Shows the average annual BEHP concentration for the International Slip.

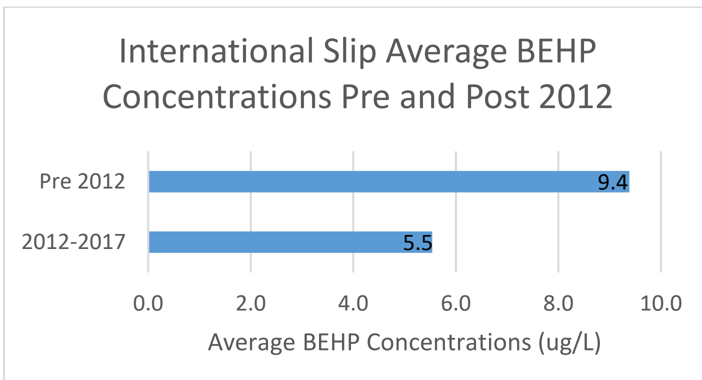

Figure 2.6.4.5.7. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012. No data was excluded.

As shown in Figures 2.6.4.5.8. and 2.6.4.5.9, average annual PCBs concentrations generally trend down and show a significant reduction after 2012. With the exception of 2015, average annual concentrations since 2012 fall below the flat portion of DEQ's rank-order curve for PCBs measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

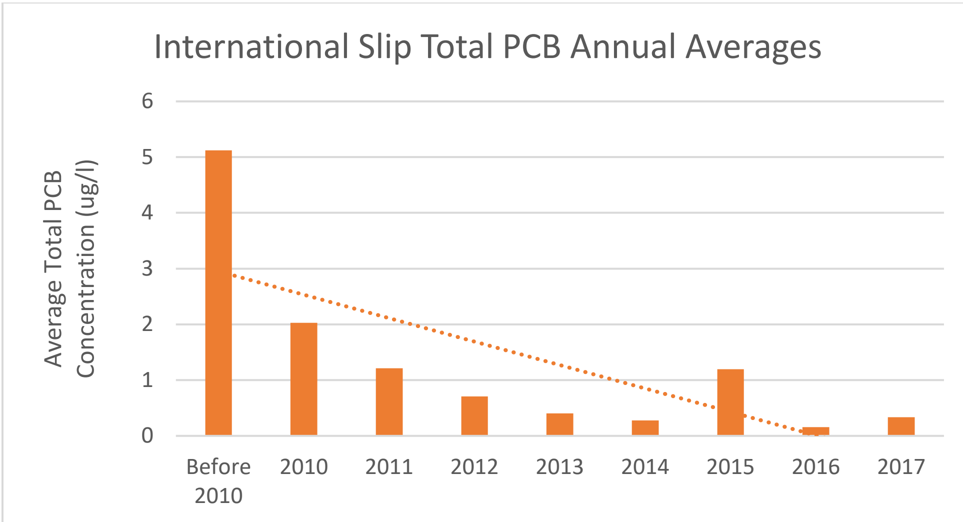

Figure 2.6.4.5.8. Shows a decreasing trend in average annual PCB concentrations in the International Slip.

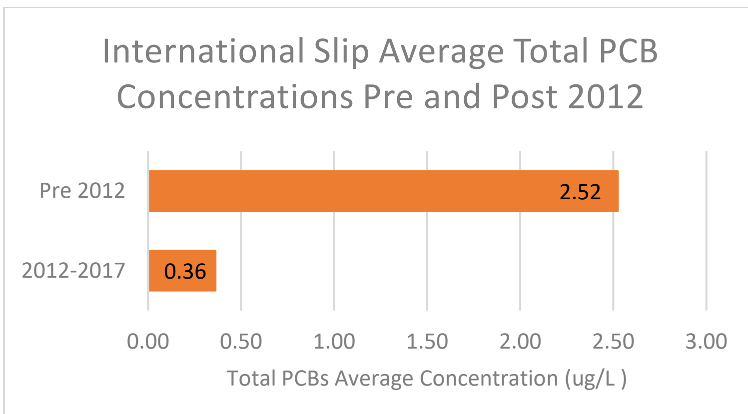

Figure 2.6.4.5.9. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012. No data was excluded.

As demonstrated by Figures 2.6.4.5.10. and 2.6.4.5.11, average annual TSS concentrations are declining and have significantly decreased since 2012. However, all average annual concentrations remain above the flat portion of the DEQ rank-order curve for TSS measured in stormwater discharges at heavy industrial sites within Portland Harbor (DEQ 2009).

Figure 2.6.4.5.10. Shows the average annual TSS concentration for the International Slip excluding City of Portland 2016 data and all 2017 data.

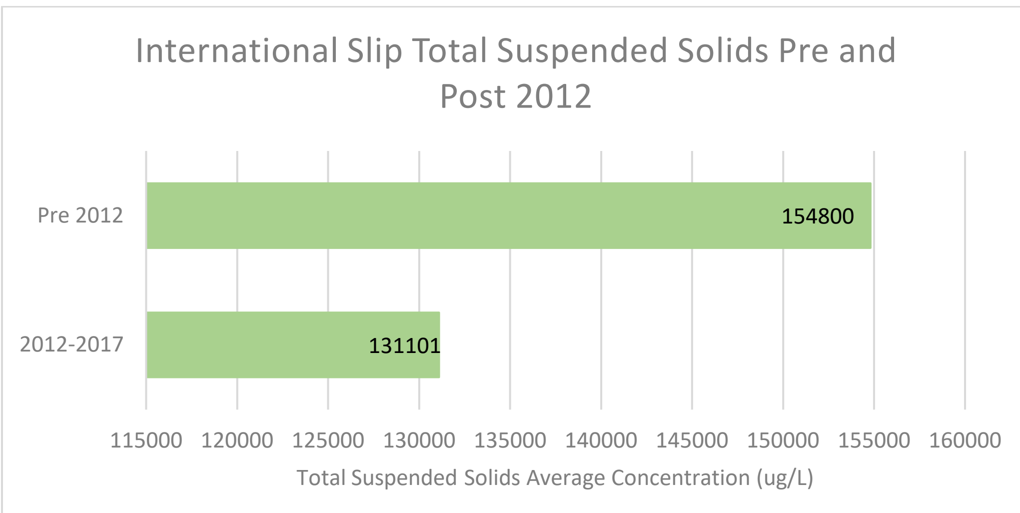

Figure 2.6.4.5.11. Shows the difference in the average concentration of Pre-2012 data and data collected after 2012. No data was excluded.

2.6.5 Stormwater contaminant loads by focus area

Due to the variability of precipitation in the historical record, variability demonstrated in gauges from site to site within the large land area of interest and uncertainty about future rainfall in the region in response to climate change, contaminant load estimate spreadsheets were set up to calculate loads at various ranges of precipitation. These annual precipitation estimate values included: “low” at 25 inches per year; “average” at 45 inches per year and “high” at 60 inches per year. As explained in Section 3.2, while possible, both the low and high ranges are unlikely and more representative of best and worst case scenarios. Instead, DEQ’s analysis focused on the more realistic average, which represents typical rainfall measured in the area. A summary of the results of the stormwater contaminant load analysis is presented below, by focus area and then basin-wide. The load analysis spreadsheets are provided in Appendix C.

2.6.5.1 River Mile 11E

Table 2.6.5.1. River Mile 11E Annual Loads (kg/year)

	Zinc	PAHS	TSS	BEHP	Total PCBs
Low	115.99	0.66	37235.43	1.43	0.06
High	278.39	1.59	89365.02	3.44	0.14
Average	208.79	1.19	67023.77	2.58	0.11

2.6.5.2 River Mile 9W

Table 2.6.5.2. River Mile 9W Annual Load (kg/year)

	Zinc	PAHS	TSS	BEHP	Total PCBs
Low	366.43	1.26	51405.40	7.05	0.07
High	879.44	3.03	123372.95	16.93	0.17
Average	659.58	2.27	92529.71	12.70	0.13

2.5.5.3 Swan Island Lagoon

Table 2.6.5.3. Swan Island Lagoon Annual Loads (kg/year)

	Zinc	PAHS	TSS	BEHP	Total PCBs
Low	417.28	0.77	38178.90	3.91	0.12
High	1001.46	1.85	91629.35	9.39	0.29
Average	751.10	1.39	68722.01	7.04	0.22

2.6.5.4 River Mile 6-8W

Table 2.6.5.4. River Mile 6-8W Annual Load (kg/year)

	Zinc	PAHS	TSS	BEHP	Total PCBs
Low	189.05	1.06	34300.78	3.92	0.12
High	453.73	2.55	82321.87	9.40	0.30
Average	340.30	1.91	61741.40	7.05	0.22

2.6.5.5 International Slip

Table 2.6.5.5. International Slip Annual Loads (kg/year)

	Zinc	PAHS	TSS	BEHP	Total PCBs
Low	162.12	1.47	49782.00	2.10	0.14
High	389.10	3.54	119476.79	5.05	0.33
Average	291.82	2.65	89607.59	3.79	0.25

2.6.5.6 Remaining areas draining to Portland Harbor outside five focus areas

Table 2.6.5.6. Other or Remaining Portland Harbor Areas Annual Loads (kg/year)

	Open Space	Light Industrial/ Commercial/ Residential
Zinc	4.086	141.012
Total PAHs	0.004	0.698
BEHP	0.006	5.535
Total PCBs	0.0003	0.035

Notes: TSS ratios not available in LWG 2016 RI.
Loads based on average precipitation range.

2.6.5.7 Harbor-wide stormwater contaminant load summary

Using the average annual contaminant loads generated by area above, DEQ created pie charts to visually display the proportional loads of each focus contaminant by land use throughout the Portland Harbor drainage area. As explained in Section 2.5.2, TSS ratios were not available to adjust load proportions by land uses, so Harbor-wide load summaries could not be prepared for TSS. The following figures are organized by: orange slices representing approximately 34 percent of the Portland Harbor drainage categorized as Heavy Industrial areas, with various shades representing land area proportions of the five focus areas; green slices representing approximately 42 percent of the land area as Open Space; and yellow slices representing approximately 24 percent of the land area categorized as Light Industrial, Commercial, Residential and Transportation. All average loads are indicated within each slice and were calculated using data collected between 2012 and 2017 and the average range of annual precipitation of 45 inches per year.

As shown in Figure 2.6.5.7.1, the average annual zinc load in stormwater discharged to Portland Harbor is estimated at approximately 2,396.65 kg/yr. Of that, approximately 94 percent is discharged from the heavy industrial areas, which generate approximately 34 percent of the volume of runoff; about six percent of the zinc load is discharged from the light industrial/commercial/residential/transportation, which generates about 24 percent of the volume of runoff; and well under one percent of the zinc load is discharged from open spaces, which generate approximately 42 percent of the volume of runoff.

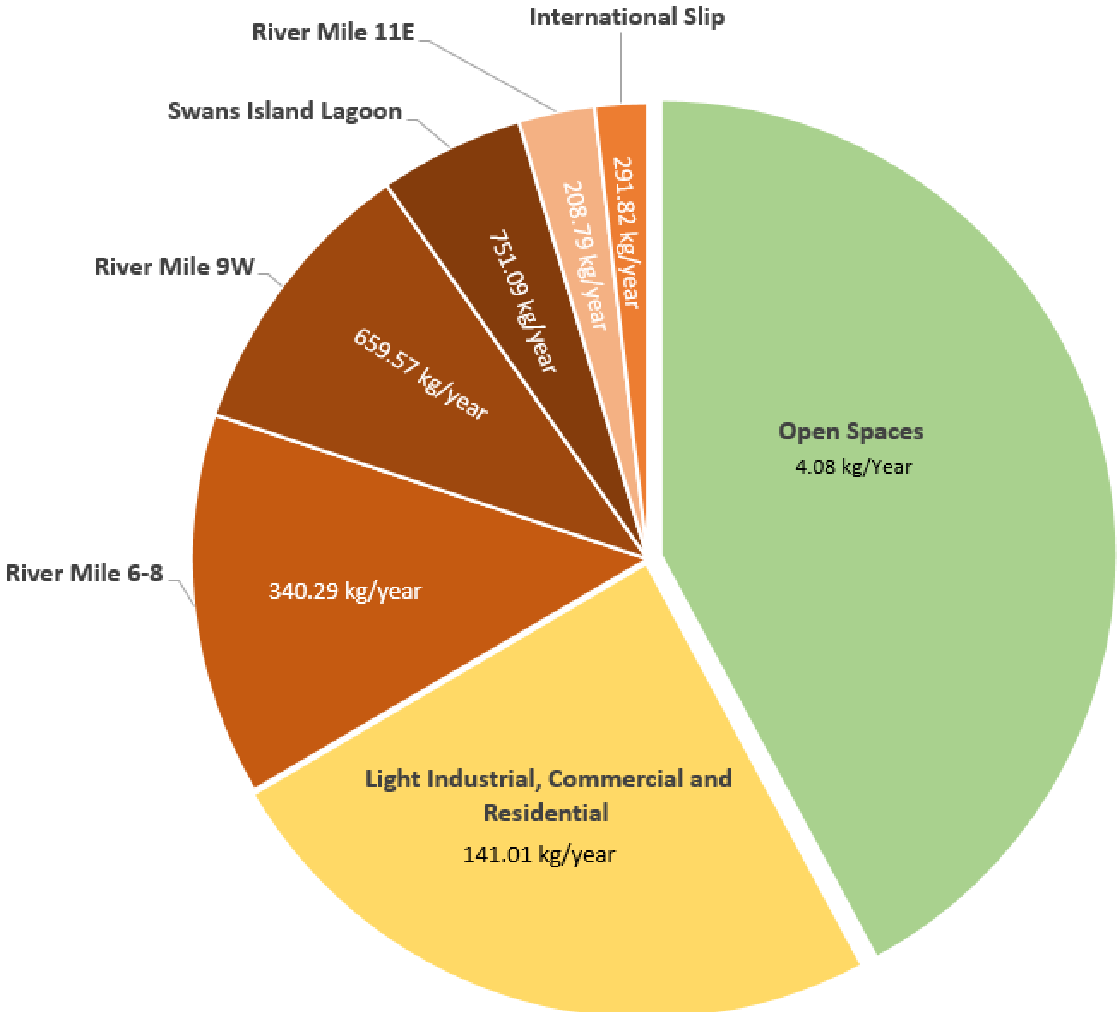

Figure 2.6.5.7.1. Harbor-wide average zinc loads in stormwater 2012-2017 of 2,396.65 kg/yr based on average annual precipitation of 45 inches per year.

As shown in Figure 2.6.5.7.2, the average annual total PAHs load in stormwater discharged to Portland Harbor is estimated at approximately 9.41 kg/yr. Of that, approximately 93 percent is discharged from the heavy industrial areas, which generate approximately 34 percent of the volume of runoff; about seven percent of the PAHs load is discharged from the light industrial/commercial/residential/transportation, which generates about 24 percent of the volume of runoff; and zero percent of the PAHs load is discharged from open spaces, which generate approximately 42 percent of the volume of runoff.

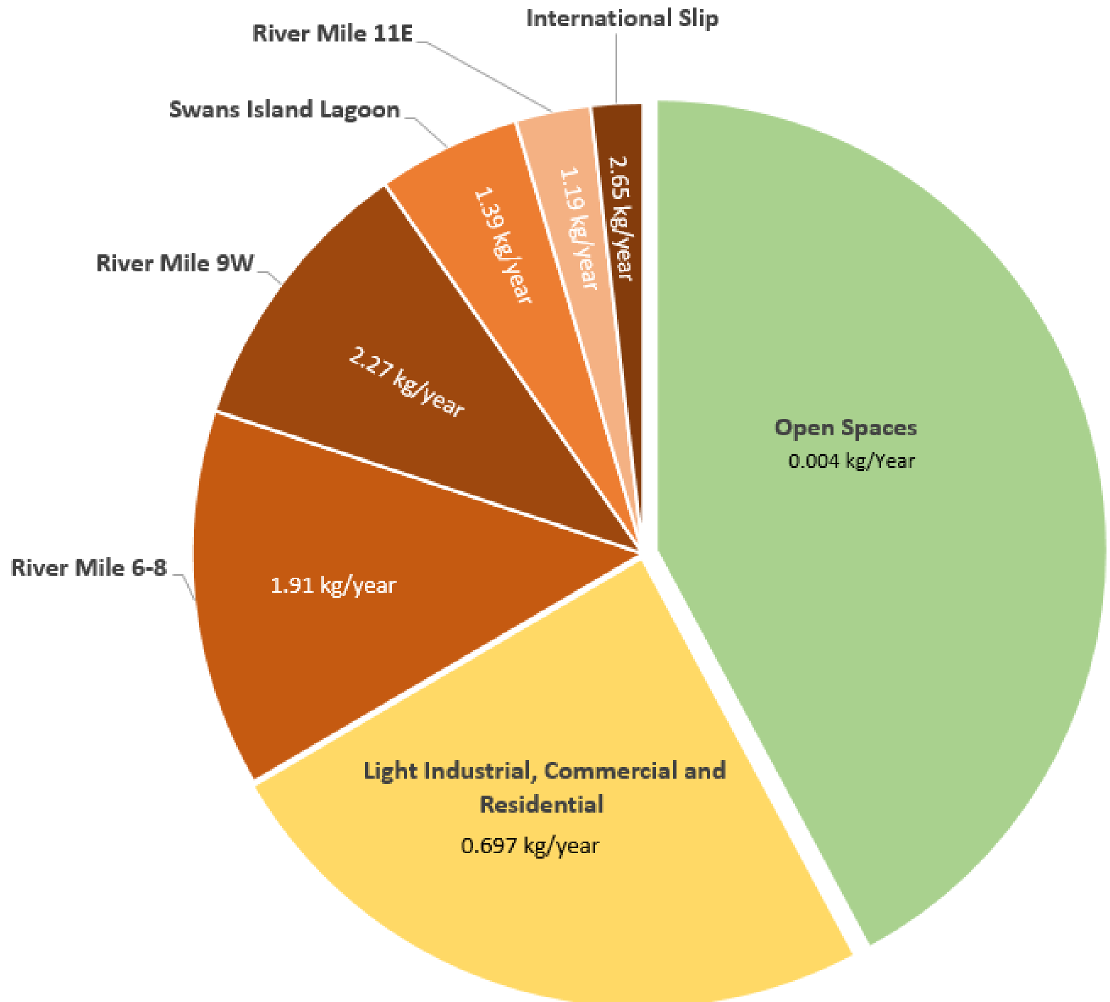

Figure 2.6.5.7.2. Harbor-wide average total PAHs loads in stormwater of 9.41 kg/yr based on average annual precipitation of 45 inches per year.

As shown in Figure 2.6.5.7.3, the average annual BEHP load in stormwater discharged to Portland Harbor is estimated at approximately 38.69 kg/yr. Of that, approximately 86 percent is discharged from the heavy industrial areas, which generate approximately 34 percent of the volume of runoff; about 14 percent of the BEHP load is discharged from the light industrial/commercial/residential/transportation, which generates about 24 percent of the volume of runoff; and zero percent of the BEHP load is discharged from open spaces, which generate approximately 42 percent of the volume of runoff.

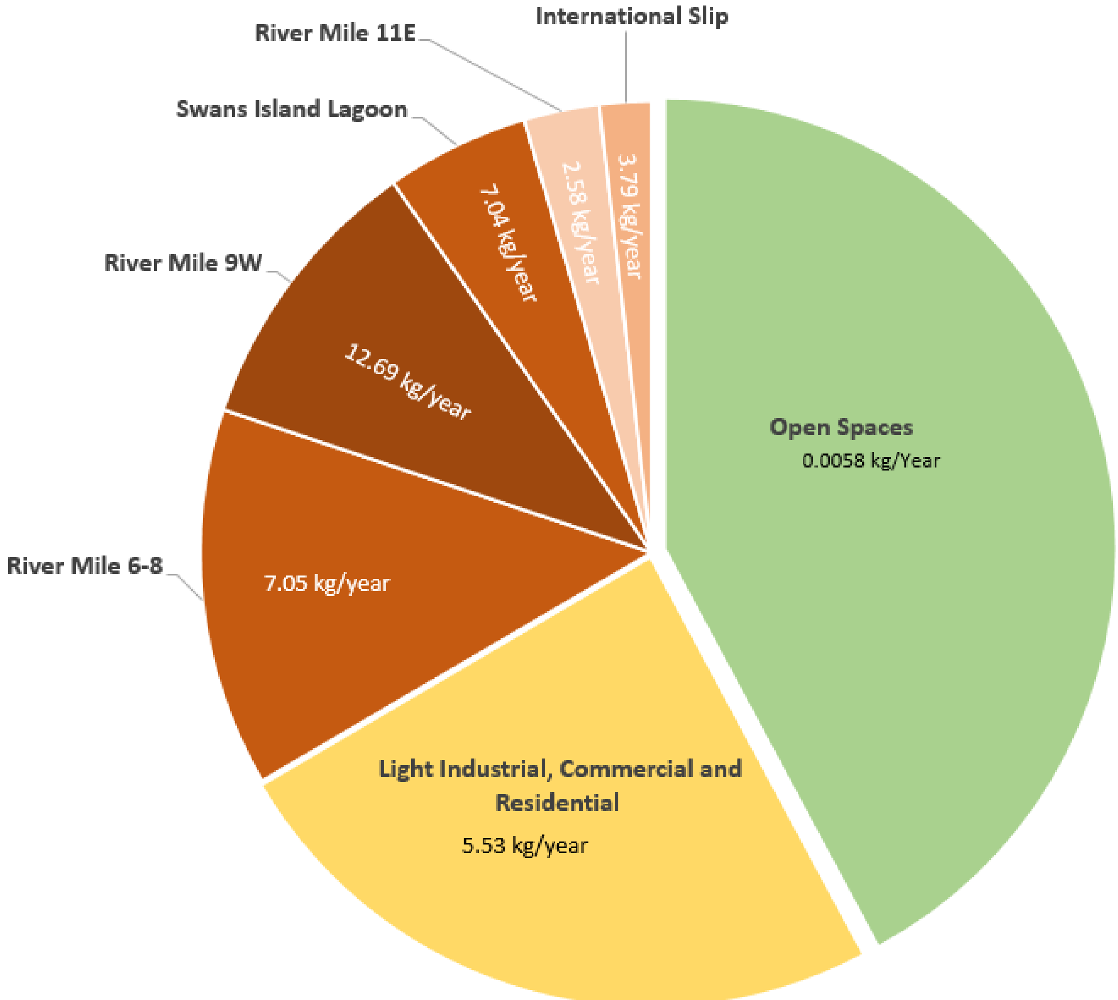

Figure 2.6.5.7.3. Harbor-wide average BEHP loads in stormwater of 38.69 kg/yr based on average annual precipitation of 45 inches per year.

As shown in Figure 2.6.5.7.4, the average annual total PCBs load in stormwater discharged to Portland Harbor is estimated at approximately 0.93 kg/yr. Of that, approximately 96 percent is discharged from the heavy industrial areas, which generate approximately 34 percent of the volume of runoff; about 3.6 percent of the PCBs load is discharged from the light industrial/commercial/residential/transportation, which generates about 24 percent of the volume of runoff; and zero percent of the PCBs load is discharged from open spaces, which generate approximately 42 percent of the volume of runoff.

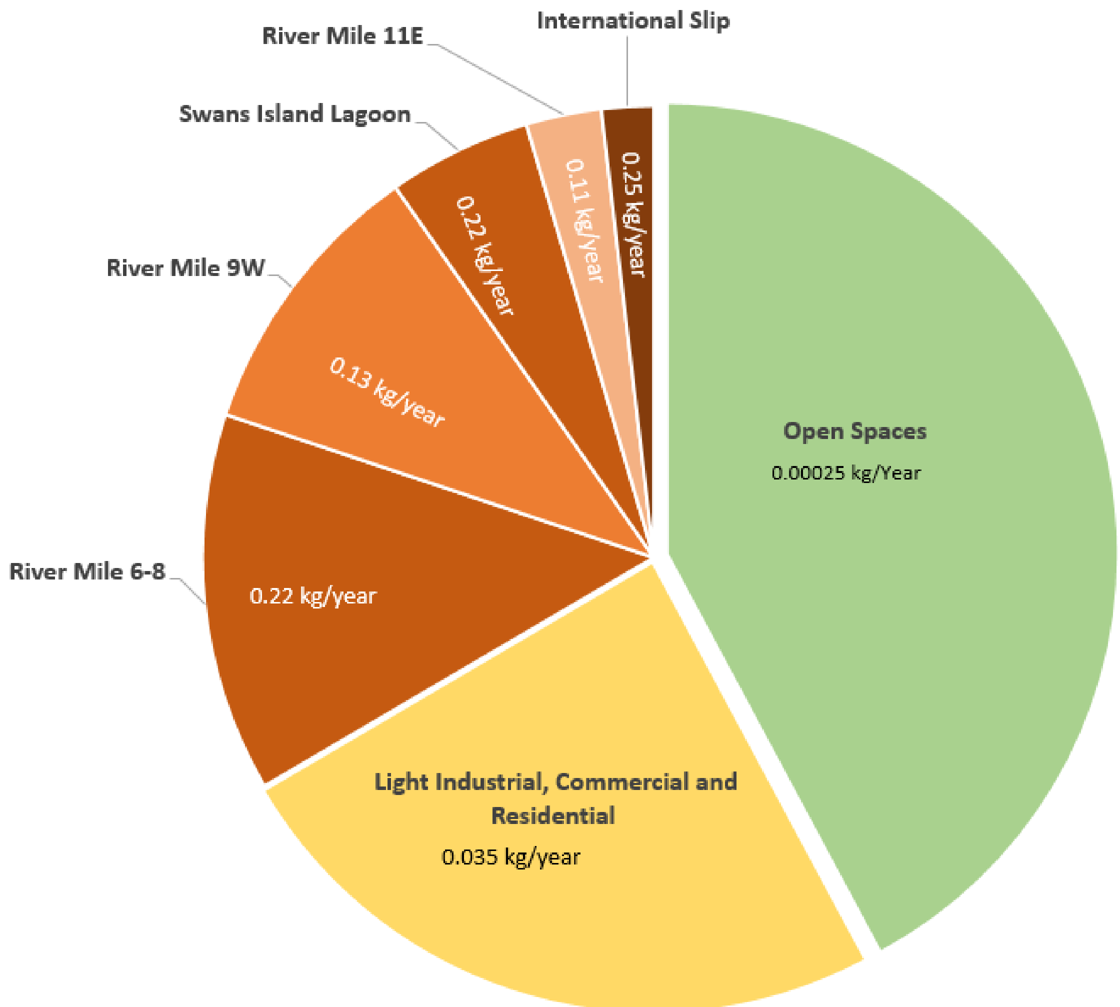

Figure 2.6.5.7.4. Harbor-wide average total PCBs loads in stormwater of 0.93 kg/yr based on average annual precipitation of 45 inches per year.

These proportions are similar to estimated PCBs loads percentages calculated by the City of Portland. The City found the percentages of Portland Harbor land areas and PCBs loads to be approximately 57 percent open space with 0.02 percent of the PCBs load, 18 percent residential/commercial/light industrial with three percent of the PCBs load and 25 percent heavy industrial with 97 percent of the PCBs load (Sanders 2012).

To get an idea of load reductions over time, DEQ compared average heavy industrial (five focus areas) loads of PCBs, PAHs, BEHP and zinc, from two time periods. Using the average annual precipitation range of 45 inches per year, DEQ calculated average contaminant loads for the available data from 2003 through 2010 and compared this to the averages from 2017. When 2017 datasets were inadequate, 2016 data was used. DEQ chose these time periods because DEQ's Guidance for Evaluating the Stormwater pathway at Upland Sites began to be implemented in 2010 and the NPDES 1200Z Industrial Stormwater general permit was renewed in 2012 with more stringent requirements, including monitoring of most Portland Harbor contaminants of concern. Because the focus on establishing stormwater controls at Portland Harbor sites began in earnest in 2010, comparison of these time periods offered the best look at conditions prior to and after implementation of controls where load reductions might be reflected. Figure 2.6.5.7.5 indicates significant contaminant load reductions attributable to implementation of stormwater investigation and control at sites within the Portland Harbor drainage areas, both through the source control process for legacy contamination, as well as through NPDES 1200Z permit implementation at sites with on-going operations.

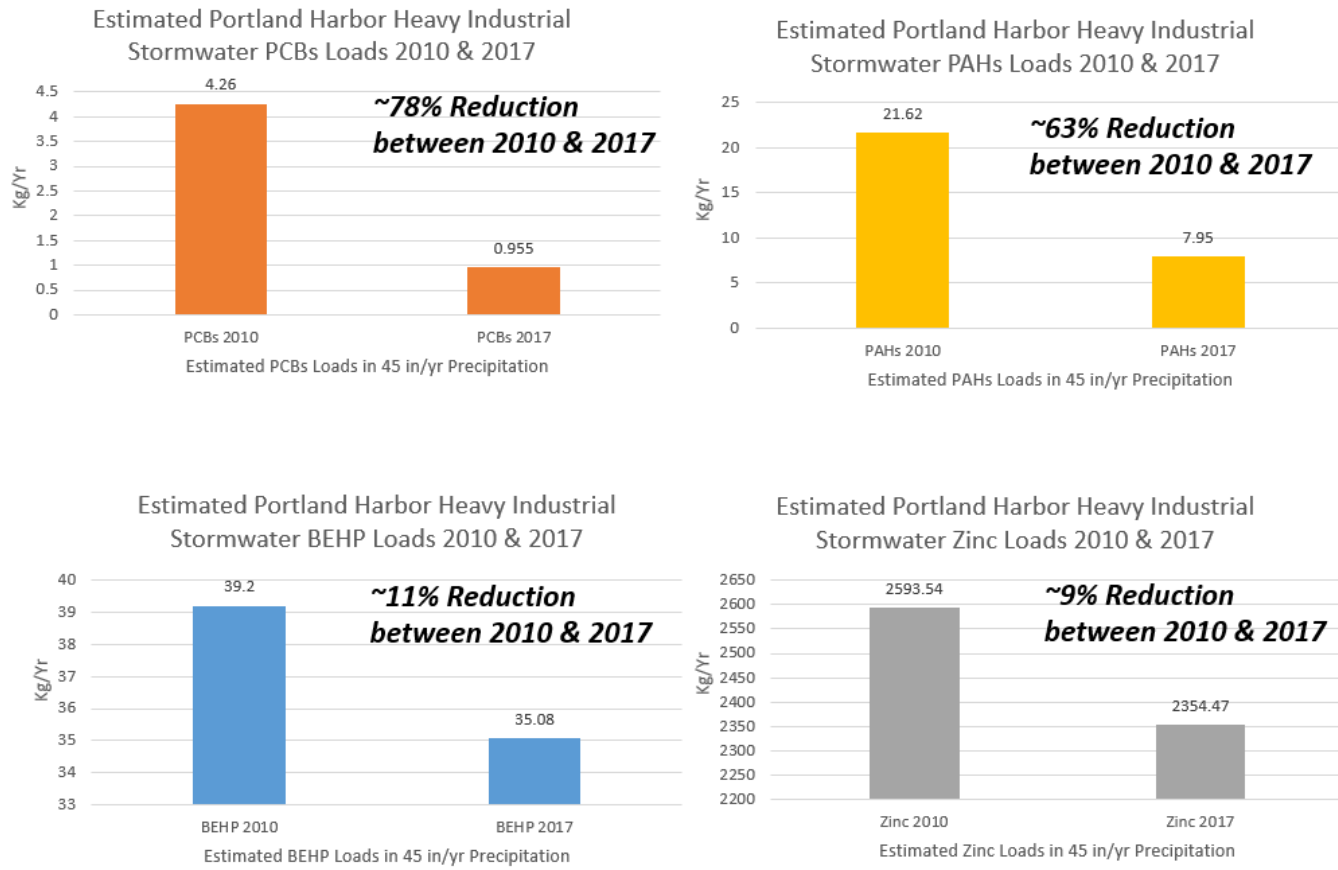

Figure 2.6.5.7.5. Estimated contaminant load reductions from heavy industrial areas in Portland Harbor.

Although information was not available to estimate TSS loads by land use, evaluation of trends in TSS concentrations can be valuable in assessing contaminant load reductions. Because many of the contaminants of concern within Portland Harbor strongly associate with particulate fractions, some amount of correlation with TSS concentration reductions and contaminant load reductions is supported. Reductions in concentrations of multiple hydrophobic contaminants have been demonstrated in association with TSS reductions by a number of studies. For example, a study conducted for Washington Department of Ecology's industrial stormwater permit, as well as by data analyses from discharges into Portland Harbor and the Columbia Slough, found reductions in PCBs and metals that correlated with TSS reductions (DEQ 2018). In addition, lowered TSS concentration discharge allowances (at 30 mg/L) to prevent sediment recontamination is required by EPA, Washington Department of Ecology and DEQ in stormwater permits for sites that discharge into sediment remediation areas (DEQ 2018). As part of the Willamette Basin Mercury Total Maximum Daily Load evaluations in 2019, DEQ conducted an analysis for using TSS as a surrogate for instream total mercury and found strong correlation between these parameters (DEQ 2019).

In addition, analyses conducted in 2006 by the City of Portland found that conservatively estimated TSS loads from all Portland Harbor stormwater discharges were 0.1 percent to 1 percent, depending on the season, of TSS loads estimated in the river flows through Portland Harbor. As this analysis occurred prior to completion of combined sewer overflow controls in 2011, DEQ anticipates even lower TSS loads (and associated contaminants loads) in stormwater discharges since 2011.

As Figure 2.6.5.7.5 demonstrates contaminant load reductions over time, DEQ anticipates TSS is also being reduced in discharges of stormwater into Portland Harbor. Because the 2017 renewal of the 1200Z permit requires reductions of TSS discharged to Portland Harbor (from 100 mg/L to 30 mg/L) and the Columbia Slough (from 50 mg/L to 30 mg/L), so DEQ anticipates implementation of the permit to result in further reductions in TSS and associated contaminants in stormwater discharges from the hundreds of facilities regulated by this permit in Portland Harbor and Columbia Slough.

2.6.6 Lower Willamette River discharge volume

The average annual Willamette River discharge through Portland was estimated using USGS data from 1973-2015 and was determined to be ~1.04E+12 cubic feet per year (USGS 2019). Based on the average annual precipitation and impervious areas in the Portland Harbor, stormwater from the Portland Harbor contributes approximately 0.07 percent of the total annual average Willamette River discharge, as shown in Figure 2.6.6.1. Most of the stormwater discharge occurs during winter months. A similar calculation done by the City of Portland estimated the average annual runoff volume into the Harbor to be 0.06 percent of the Willamette River discharge for 1997 wet year conditions and 0.08 percent for 2001 dry year conditions (CoP 2006). The same City analysis showed that, even with variation in seasonal flows, the percent contribution from stormwater didn’t exceed 0.1 percent. To be highly conservative another stormwater volume was calculated assuming the entire Portland Harbor area was impervious and a 60-inch annual rainfall was used. This scenario is conservative and is not likely to happen in this area. Even using the extremely conservative approach the total contribution of stormwater was calculated to be less than 0.25 percent of the average annual Willamette River discharge. The calculations preformed in this DEQ study and the City report indicate the contribution of stormwater to the Lower Willamette River is minimal in terms of volume.

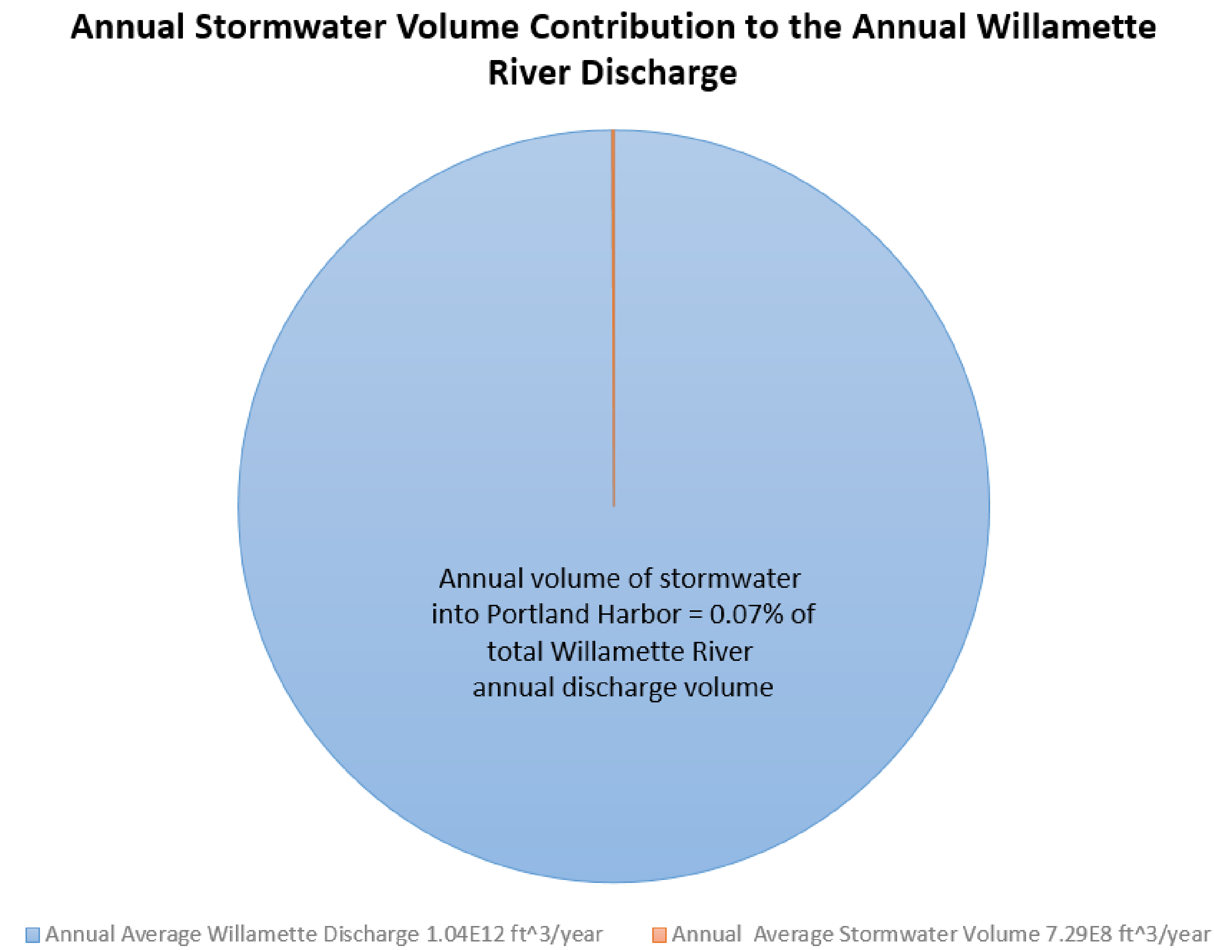

Figure 2.6.6.1. Average annual Portland Harbor stormwater runoff volume compared to average annual Willamette River discharge.

3. Evaluation of potential stormwater impacts

3.1 Potential for sediment recontamination via stormwater

Evaluating the potential for sediment recontamination via stormwater requires evaluation of the potential effects of contaminant loads delivered to remediated sediment. A comprehensive evaluation must consider the volumes of stormwater and solids discharged, the volumes of receiving water and sediment moving into and through the project area, and the concentrations of solids discharged and river bottom sediment within the system. Also needed, is an understanding of the association of contaminants with solids, the fraction of solids discharged likely to settle onto a defined area of river bottom sediment and the effects of mixing and chemical interactions in both the water column and the river sediment. DEQ's stormwater contaminant load study did not undertake this level of comprehensive evaluation and, therefore, cannot be used to draw comprehensive conclusions regarding sediment recontamination. However, strong semi-quantitative conclusions can be drawn from information in DEQ's study on stormwater contaminant load estimates and reductions, river sediment and water flow volumes and TSS loads. These findings, along with lessons learned from evaluation of recontamination modeling conducted in Portland Harbor and at other sediment remediation sites, can inform both conclusions about stormwater recontamination potential and preparations for quantifiable actions in response to any detected recontamination, post-remedy.

In the context of common sediment recontamination causes, presented in Section 1.1 of this report, incomplete in-stream contaminant removal and unidentified upstream of adjacent sediment contamination are the most frequent sources of recontamination (ASTSWMO 2013 & 2016). In contrast, stormwater is implicated when legacy contamination has not been investigated and controlled or when combined sewage overflows have not been controlled. Neither of these stormwater conditions exists in the study area. Portland Harbor is the only Superfund sediment site in the nation where combined sewer overflows have been controlled. In addition, industrial sources were separated from storm sewers in the 1950s and public and private stormwater conveyances have been comprehensively investigated for control of legacy contaminants. DEQ's 2016 Portland Harbor Upland Source Control Summary Report details the extensive evaluation of public and private stormwater conveyances and discharges into Portland Harbor. The report describes stormwater source controls and regulatory controls being in place at sites that cover approximately 70 percent of the developed land draining to Portland Harbor, with the remaining 30 percent of developed land being mostly commercial and residential land use (DEQ 2016). The results and discussion in this report confirm that much lower loads of contaminants are contributed in stormwater from these land uses. DEQ's comprehensive implementation of stormwater source controls and 1200Z permit coverage across 70 percent of the developed drainage area show clear downward trends in contaminant concentrations and load reductions of nine to 78 percent at all estimated annual precipitation ranges. The City of Portland evaluated the results of post source control sampling conducted in 2016 and 2017 at a selection of outfalls representative of the 35 active City stormwater outfalls, which deliver discharges of stormwater to Portland Harbor comingled from multiple facilities and from Forest Park. The evaluation demonstrates significant downward trends in most contaminant concentrations and, in most every case, concentrations are at levels that are typical of urban stormwater discharges (CoP 2018).

Other characteristics that make stormwater discharging into Portland Harbor unique include the very small volume of stormwater contribution relative to river volumes and the fact that half the stormwater drainage area is undeveloped, forested areas. As confirmed by the evaluations in this report, stormwater runoff filtered through vegetated lands and conveyed in streams into stormwater pipes contributes nearly negligible contaminant loads. These relatively uncontaminated inputs make up about half of the annual stormwater discharges to Portland Harbor, which total only 0.07 percent of the average annual Lower Willamette flow volumes. Further, annual TSS load from Portland Harbor stormwater discharges averages about 0.23 percent of the TSS load in Willamette flows measured over 15 years at River Mile 12.7 (CoP 2006), and are trending down in stormwater discharges. All of this amounts to very different starting potential for recontamination of sediment via stormwater into Portland Harbor, than the more densely developed and industrialized basins that discharge larger volumes of sewage/stormwater into smaller receiving streams that have been recontaminated due to uninvestigated conveyance lines and uncontrolled combined sewage overflows (ASTSWMO 2013 and 2017).

An additional line of evidence that recontamination potential of Portland Harbor sediment through stormwater discharges is limited, is the fact that recontamination evaluation modeling conducted to date indicates that Willamette bedload volumes and concentrations mask stormwater discharge recontamination potential. Prior to development of EPA's 2012 Draft Technical Memorandum on Site Level Recontamination Evaluation Framework, prepared by CDM, DEQ conducted multiple runs of SEDCAM models specific to outfalls discharging into the lower Willamette River. DEQ set up scenarios using individual contaminant and TSS concentrations measured at outfalls in 2007-08, estimated stormwater volumes due to average annual precipitation, assigned discharge deposition areas at multiple ranges from the outfalls and evaluated a range of deposition rates based on river deposition information collected during Lower Willamette Group investigations. For zinc, copper, PCBs and BEHP, initial concentrations at an outfall in the middle of the study area were set to the sediment concentration upstream of the outfall, assuming remediation would achieve at least background levels. Then, over 20 years, at all ranges of deposition rate and area, the concentrations at an outfall approached, but did not reach the concentration due to deposited sediment coming down from further upstream. In addition, the total concentrations after 20 years were generally below the JSCS screening level values. This is because, even when stormwater contaminant and TSS concentrations are several orders of magnitude higher than bedded sediment concentrations, the volumes of bedload far exceed the volumes of solids discharged in stormwater, either from individual outfalls or collectively from all outfalls. These results are similar to findings from the Lower Willamette Group modeling, presented in the 2016 Remedial Investigation, that collective stormwater discharges were unlikely to deposit contaminants at concentrations above the remediated surface levels (and would be even lower with natural recovery deposition), except in discrete areas like the International Slip and Swan Island Lagoon, which are off channel and not subject to mainstem depositional rates. These results do not take into consideration the reduced contaminant concentrations and loads measured in stormwater discharges over more than a decade since 2008, which would be anticipated to have even less impact than the modeled loads.

The conclusion which summarizes all of these lines of evidence is that, even if contaminant loads delivered in stormwater were not reduced further and entirely settled onto sediment, recontamination of actively remediated areas or impediment of natural recovery are unlikely to occur due to stormwater discharges, at either the project scale (entire Superfund reach) or on a georegion scale (five focus areas). However, localized stormwater discharges (e.g., a high concentration or high volume contribution through a single outfall), especially into quiescent, off-channel areas, may result in localized recontamination of sediment above cleanup or remedial action levels, if needed stormwater source control measures are not completed or if a new, high concentration source becomes active. Therefore, it is critically important that source control measure implementation continues for all sites discharging to Portland Harbor. And, for on-going stormwater discharges, a site-level recontamination evaluation may be necessary during the area specific source control sufficiency determination process to confirm Harbor-wide scale assumptions on the local scale.

While this report focuses only on prevention of recontamination from the stormwater pathway, it is important to note that recontamination due to in-water and adjacent sources may have greater potential to recontaminate sediment than stormwater. However, actions have also been taken to address the in-water and adjacent upland pathways. DEQ investigated and is requiring control of contaminant transport pathways at all adjacent upland sites through the comprehensive JSCS approach described in great detail in DEQ's 2016 Portland Harbor Upland Source Control Summary Report. In addition, DEQ evaluated upriver sediment (from River Mile 12 through 26) and completed in-river remediation at five sites between River Miles 12 and 15, as described in Willamette River Sediment Study reports available on DEQ's website at: https://www.oregon.gov/deq/Hazards-and-Cleanup/CleanupSites/Pages/Willamette-River.aspx. And riverbank sources will continue to be addressed through implementation of EPA's 2019 Guidance for River Bank Characterization and Evaluations. In consideration of these upland and upriver controls, along with the stormwater controls and load conclusions presented in this report, the potential for sediment recontamination to occur via any of these pathways is significantly reduced.

3.2. Potential for unacceptable risk to in-water receptors via stormwater

DEQ's understanding of the evaluation and prevention of unacceptable risk to in-water receptors is outlined in Section 4.0 of DEQ's 2016 Source Control Summary Report. DEQ since collaborated with EPA on the source control sufficiency process to ensure area by area sources are adequately controlled prior to remedy implementation and adaptive management. Surface water cleanup levels are generally risk-based and assessed during these processes to guide attainment of remedial action objectives, including prevention of unacceptable in-water risk. DEQ anticipates evaluation of stormwater discharges to be a very minor component of the overall process.

Although people and in-water receptors do not have direct contact with stormwater within conveyances, there is a possibility for some risk once stormwater discharges into Portland Harbor. While a full risk assessment is not an element of source control determinations, a risk evaluation following the applicable elements of the CERCLA process may be undertaken. Applicable elements are limited, however, because stormwater is not a direct and separate medium (stormwater is discharged into and mixed with surface water that is also receiving contaminant leaching from sediment); there are limited durations of intermittent stormwater discharges; and an inability of single point sampling to capture adequate areas of exposure for multiple receptors or represent chronic (long term) exposure. As such, considerable uncertainty is involved in making determinations about risk to in-water receptors from stormwater. However, this also indicates that any potential risk from low concentrations of contaminants, in variable volumes of stormwater, discharged intermittently, into a waterway with annual discharge flows of ~1.04E+12 cubic feet per year (USGS 2019), is likely low. The total volume of all stormwater discharged to Portland Harbor annually is approximately 0.07 percent of the annual river discharge. Representative contaminant concentrations and loads discharged in stormwater continue to trend down. For these reasons, as well as limited exposure potential, DEQ concludes that risk to in-water receptors from on-going stormwater discharges into Portland Harbor is low and surface water risk will be addressed by EPA's sediment remedy (dredging, capping and monitored natural recovery) and DEQ's on-going water quality programs.

4. Conclusions

This report helps confirm the conclusions of DEQ's 2016 Portland Harbor Upland Source Control Summary Report that source control efforts in the uplands surrounding the study area are effective, such that sediment recontamination or unacceptable in-water risk are unlikely to occur and will not delay EPA's in-water cleanup.

EPA and DEQ collaborated to develop a source control sufficiency process to confirm that, prior to final design and implementation of each active in-water sediment remedy area, all upland sources of contamination will be controlled so as to prevent recontamination of the remediated sediment above the remedial action cleanup levels. These evaluations are referred to as Sufficiency Assessments and will be conducted on all potential contaminant transport pathways within each area adjacent and draining to active sediment remediation areas of the river.

The following facts elaborated in the above sections of this report indicate that, in general, stormwater loads estimated from concentrations and volumes will not deliver contaminants to Harbor-wide or georegion-specific sediments above remedial action or cleanup levels:

- A unique and comprehensive stormwater source control program has been applied throughout areas draining to Portland Harbor for nearly two decades and monitoring shows significant downward trends in contaminant concentrations and loads discharged.
- Combined sewage overflows into Portland Harbor have been reduced since 2000 and controlled since 2011. Industrial discharges have been separated since the 1950s and large portions of stormwater drainage have been diverted to the Columbia River following treatment at a municipal sewage treatment plant.
- Half of the stormwater draining to Portland Harbor is from very low contaminant load forested open space, rather than developed areas with higher potential loads.
- All stormwater discharged into Portland Harbor annually comprises approximately 0.07 percent of the annual river discharge. Within these limited discharges over the past two decades, contaminant concentrations trend downward over time and contaminant loads have been reduced by up to 78 percent.
- Annual TSS loads average 0.1 percent to 1 percent of Willamette flows, depending on the season, and are trending down in stormwater discharges. As such, the potential for contaminants to associate with suspended particulates and then settle onto sediment is low and further decreasing.
- General stormwater recontamination evaluation modeling to date indicates that incoming bedloads of contaminants far exceed any impacts from stormwater discharges to sediment over a 20 year time horizon and, in aggregate, remain below remedial action levels.
- The potential for Harbor-wide or georegion-wide stormwater sediment recontamination is minimal, though localized stormwater sediment recontamination could occur if planned stormwater source controls are not completed or new high concentration direct discharges occur.

Completion of site-related stormwater source controls and on-going stormwater discharge regulation is anticipated to continue these trends of contaminant load reductions in the downward direction. This stormwater strategy implementation, along with geographically specific source control sufficiency assessments, implementation of the sediment remedies and post-remedy monitoring and adaptive management, substantially reduces the minimal potential for sediment recontamination or in-water risk in Portland Harbor via stormwater.

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Appendix A – Concentration data richness by focus area

Please follow the link below to DEQ's website for a pdf of Excel spreadsheets on concentration data richness for each of five focus areas. The spreadsheets provide the number of data points by year utilized in the analysis, along with information about where the data were collected and what percentage of the total data each location represents.

https://www.oregon.gov/deq/Hazards-and-Cleanup/Documents/phreport-AppendixA.pdf

Appendix B – Tables 6.1-3a and 6.1-3b from Lower Willamette Group 2016 Final Portland Harbor Remedial Investigation Report

Please follow the link below to DEQ's website for a pdf of Tables 6.1-3a and 6.1-3b from the Lower Willamette Group's 2016 Portland Harbor Remedial Investigation report. The tables present LWG estimated stormwater and stormwater solids contaminant loads by land use category, which were used to proportionally apply DEQ's estimated heavy industrial stormwater contaminants loads to estimate loads from other land uses.

https://www.oregon.gov/deq/Hazards-and-Cleanup/Documents/phreport-AppendixB.pdf

Appendix C – Contaminant load analysis spreadsheets by focus area

Please follow the link to DEQ's website to access a zip file of the spreadsheets used to calculate stormwater contaminant load estimates for each focus area, following the process steps explained in Section 2 of this report.

https://www.oregon.gov/deq/Hazards-and-Cleanup/Documents/phreport-AppendixC.zip