Puget Small Streams Monitoring Program
Annual Status Report, Water Year 2020
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The Stormwater Action Monitoring (SAM) program partners with the U.S. Geological Survey to conduct annual stream health monitoring and to track changes over time in the Puget Sound region. The Puget Small Streams (PSS) status and trends monitoring is a way to track our regional progress toward reducing stormwater impacts on environmental health.

Stream health conditions for this study were sampled from sites categorized by the percentage of total impervious area (TIA%) within each sample basin. Findings from 2020 include:

- Dissolved metals were below water-quality criteria in all samples but increased with increasing TIA%.
- Nutrients increased with increasing TIA% and the most urbanized sites (40–100 TIA%) were often in poor condition.
- Sediment metals and organic pollutants increased with increasing TIA%, but sites were rarely found in poor condition.
- Stream macroinvertebrate bioassessment scores declined as TIA% increased and most sites were considered in poor condition.
- Although not statistically significant, data from 2020 show decreased quality in terms of bioassessments and sediment metals since 2015, with largest declines in the most urban category (40–100 TIA%).

Why Stream Monitoring for Stormwater Management?

In Washington State, stormwater management actions, implemented broadly in the Puget Sound region under municipal stormwater permits, are intended to protect receiving-water health from constituents in stormwater. The SAM PSS monitoring program provides regional status and trends assessment of small streams in the Puget Lowland ecoregion. The PSS monitoring program was designed to answer the question from Song and Sheibley (2020), “Are regional conditions in receiving water quality and biota improving in concert with broad implementation of required stormwater management practices?”

Results from this study document the cumulative impacts of stormwater from urban and urbanizing areas and assess whether collective stormwater management efforts are meeting our goals to protect water quality and biota in streams.

Monitoring Receiving Water Health Indicators in Urban/Urbanizing Areas

The PSS monitoring program aims to sample 33 sites each summer which span a gradient of impervious cover within their basins. These urban gradient sites are chosen using the U.S. Environmental Protection Agency’s Generalized Random Tessellation Stratified (GRTS) survey design to select spatially balanced, random sample locations within the study frame. A sample list was created for the first 20 years of the SAM PSS project, providing the initial list of 33 sites to be sampled each year, plus a list of backup sites, to be used in case a site becomes unsuitable for sampling. Stream sites become unsuitable for sampling if they go dry, are not actively flowing, are too difficult to access, there are safety concerns, or landowner permission is not granted. The GRTS study design was chosen because it allows an unbiased extrapolation of any measured indicator (biological, chemical, and physical) from the sampled sites to estimates of those indicators representing the whole region (Song and Sheibley, 2020).

The 33 urban gradient sites are chosen from four different categories of percentage of total impervious area (TIA%) within their watersheds:

- 0 to 10 percent,
- 10 to 20 percent,
- 20 to 40 percent, and
- 40 to 100 percent.

In addition to the urban gradient sites, two additional reference sites within the Puget Lowland ecoregion are sampled each water year in cooperation with the Washington State Department of Ecology (hereafter, Ecology) Watershed Health Monitoring (WHM) program. The water year is defined as beginning on October 1 and ending on September 30th; for example, water year 2020 starts on October 1, 2019, and ends on September 30, 2020. Reference sites are used to establish a project-specific dataset of “least-disturbed" conditions to generate good, fair, and poor criteria that are then used to classify urban gradient sites. During the initial 5-year period of the PSS study (water years 2020 to 2024), while the database for conditions of least-disturbed sites is developed, annual data will be compared to good, fair, and poor categories previously established by DeGasperi and others (2018) and described further in subsequent sections.

The PSS monitoring program conducts a one-time summer sampling event where a large number of parameters are measured at each urban gradient stream site. The measured parameters include a suite of parameters for water and sediment quality, streamflow, channel and riparian habitat metrics, and biological measures (macroinvertebrates and algae). Many of the parameters monitored represent integrative measures of stream health which replace chasing storms and monitoring stormwater chemistry, which are often expensive and highly variable. In addition to the one-time summer sample, sites are equipped with a temperature and water-level sensor to examine temperature and flow dynamics throughout the water year. A full list of sampled parameters are provided in the PSS monitoring program Quality Assurance Project Plan (Song and Sheibley, 2020).

Annually, the PSS monitoring data will be summarized as a short status assessment in order to share results to date with regional partners. For these annual summaries, a detailed statistical analysis comparing concentrations across TIA% categories will not be performed due to reduced power from small sample sizes within each TIA% category. A more detailed analysis and report, which will address the statistical significance of changes across stream categories, is expected at the end of each permit cycle. These 5-year reports will summarize all the data collected in the previous 5 years with the first 5-year report expected after the 2024 calendar year.

Puget Small Streams Health Status in 2020

During water year 2020, 31 of 33 urban gradient sites and 2 reference sites were sampled (fig. 1; Appendix A). As summer progressed, several stream sites dried up or became stagnant with no flowing water and were replaced by sites from the site back-up list. However, time ran out before all sites that were dropped had a replacement found. Summer of 2020 was also the first year of the global COVID-19 pandemic making fieldwork more logistically challenging.

The number of sites for each category are provided in table 1. All data presented here are available from Ecology's Environmental Information Management database (EIM; Washington State Department of Ecology, 2024) by searching for Study ID "SAM_PSS" for 2020 data, and "SAM_PLES" for 2015 data. All macroinvertebrate data are available from the Puget Sound Stream Benthos database (PSSB; King County, 2023) using the project "Ecology: SAM_PSS" for 2020 data and "Ecology: Stormwater RSMP" for the 2015 data.

Sampled Streams in Water Year 2020

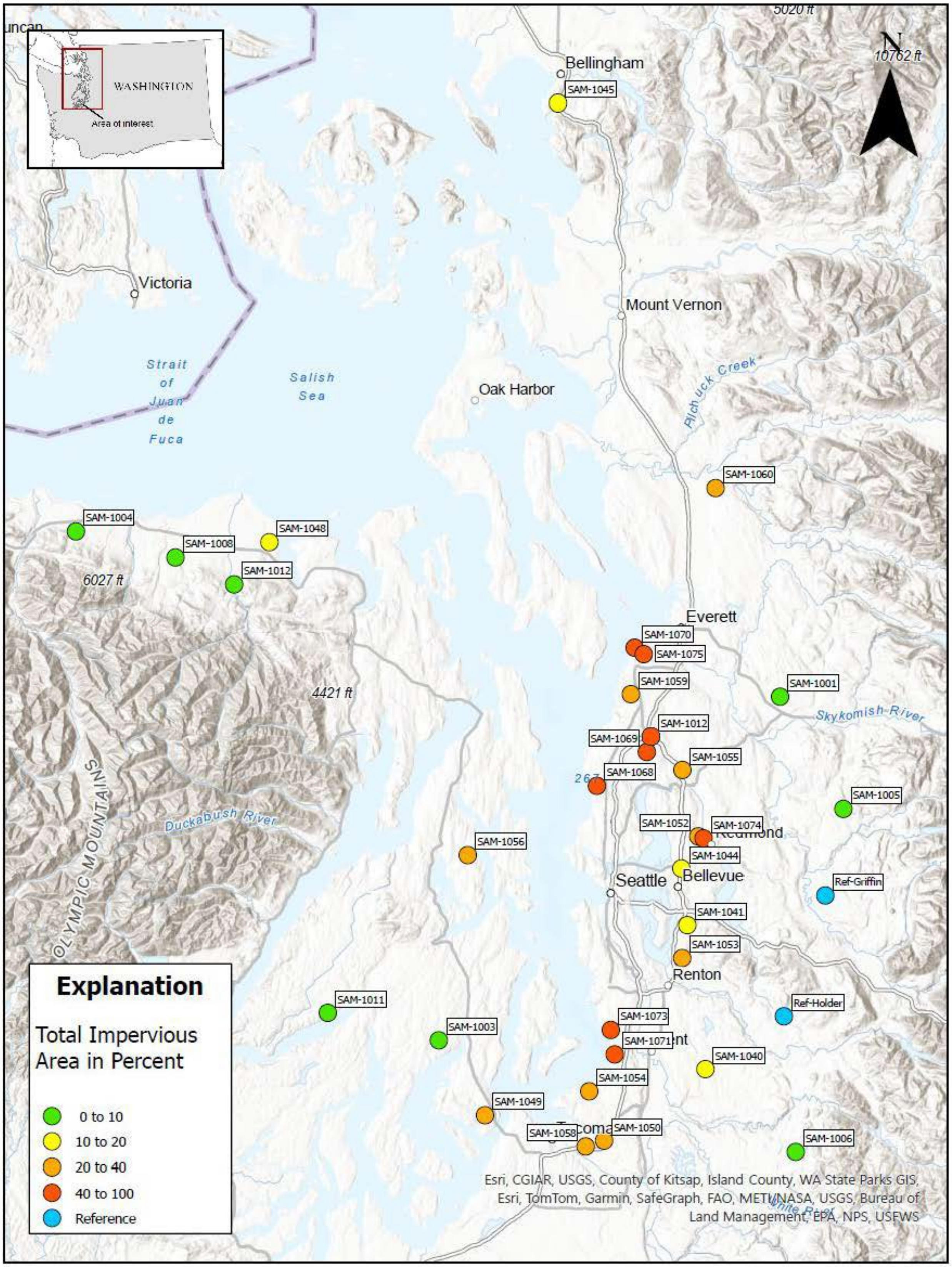

Figure 1. Puget Small Stream sites sampled in summer 2020, Washington.

Table 1. Total number of sites sampled in water year 2020 for each stream category, Puget Sound, Washington.

[TIA%, total impervious area in percent]

Stream category	Target sample size	Actual number sampled
Reference	2	2
0 – 10 TIA%	9	8
10 – 20 TIA%	9	5
20 – 40 TIA%	9	10*
40 – 100 TIA%	6	8*
Totals	33	31

*In 2020, streams in these categories unintentionally had extra sites sampled.

Water Quality

Surface water at each location was analyzed for field parameters (temperature, specific conductance, pH, dissolved oxygen [DO]) using a multiparameter water-quality meter. Additional water samples were collected for laboratory analysis of chloride, turbidity, total suspended solids, hardness, dissolved organic carbon, nutrients (total and dissolved nitrogen and phosphorus), metals (total and dissolved), and bacteria (fecal coliform, *Escherichia coli* [*E.coli*]).

Detection frequency of all measured water-quality parameters were categorized into three groups (DeGasperi and others, 2018). Group A indicated the parameter was detected in over 50 percent of samples; group B for parameters detected between 20 and 50 percent of the time; and group C for those parameters with less than a 20 percent detection rate. Almost all water-quality parameters fell into group A and were commonly detected (Appendix B). The exceptions were for ammonia (group B), total and dissolved cadmium (group C), and total zinc (group C). Total zinc was determined to be infrequently detected even though dissolved zinc was frequently detected. This discrepancy is due to a higher reporting limit for total zinc (5 micrograms per liter [µg/L]) compared to dissolved zinc (1 µg/L).

Bacteria, water temperature, dissolved oxygen, and pH were compared to Washington State water-quality standards WAC 173-201A-200 (Washington Department of Ecology, 2020). These water-quality standards differ depending on the designated use of the particular stream reach. Here, we follow the convention used in DeGasperi and others (2018) and compare the results to water-quality criteria for primary contact recreation for bacteria, *E. coli* and fecal coliform (100 colonies per 100 milliliters), and core summer salmonid habitat for temperature (highest 7-day average daily maximum; 16°C), DO (1-day minimum of 10.0 milligrams per liter [mg/L]), and pH (within the range of 6.5 to 8.5). Criteria for DO and pH are best assessed using continuous data; however, only discrete values are recorded during the one-time summer sampling event and used here. Continuous temperature data are collected at the urban gradient sites, but at the time of this report, final approval of the time-series data was not completed. Therefore, temperature from discrete values during the one-time summer sampling event are used here. For fecal coliform, 16 of 33 (49 percent) sites exceeded the criteria for primary contact recreation and 27 percent of sites exceeded the criteria for *E.Coli*. Core summer salmonid habitat criteria were exceeded for DO at 24 percent of sites, at 0 percent of sites exceeded the criteria for pH, and 9 percent of sites exceeded the criteria for temperature. Exceedances of the bacteria criteria occurred across most categories of total impervious cover, with more sites in the higher groups (20–40 percent, and 40–100 percent) showing higher bacterial counts (fig. 2). An explanation of the boxplot characteristics is provided in Appendix C.

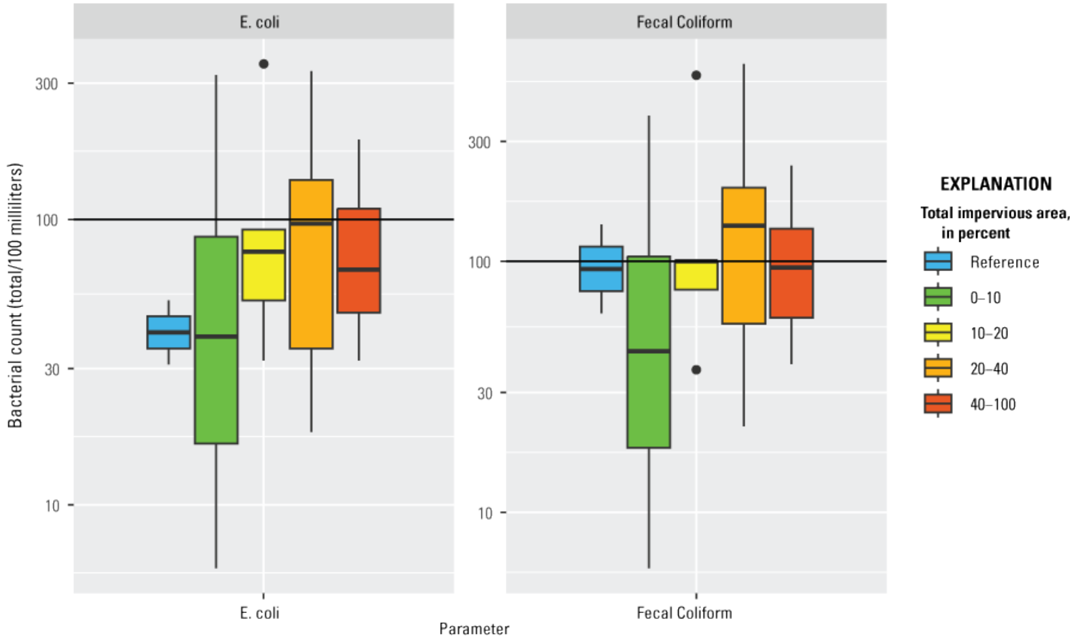

Figure 2. E. coli and fecal coliform bacteria concentrations across total impervious area categories. The solid line represents the 100 colonies per 100 mL water-quality standard for primary contact recreation. A description of boxplot characteristics is shown in Appendix C.

Total and dissolved nutrients were frequently detected in PSS samples in 2020. There are currently no numeric water-quality criteria for nutrients within Washington State; however, DeGasperi and others (2018) provided data from a set of Puget Sound reference sites to classify urban gradient sites into good, fair, and poor condition (table 2). For total nitrogen, seven sites were classified in poor condition and were mostly within the 20–40 percent impervious cover category (fig. 3). For total phosphorus, 17 sites were in poor condition and included most sites in the higher impervious cover categories (fig. 3).

Table 2. Nutrient thresholds to categorize SAM PSS streams, from DeGasperi and others (2018).

[Numbers in parentheses represent the number of sites within each category; mg/L, milligrams per liter; >, greater than; <, less than]

Metric	Poor	Fair	Good
Total phosphorus (mg/L)	>0.050 (17)	0.050 to 0.041 (4)	<0.041 (10)
Total nitrogen (mg/L)	>0.862 (7)	0.862 to 0.459 (11)	<0.459 (13)

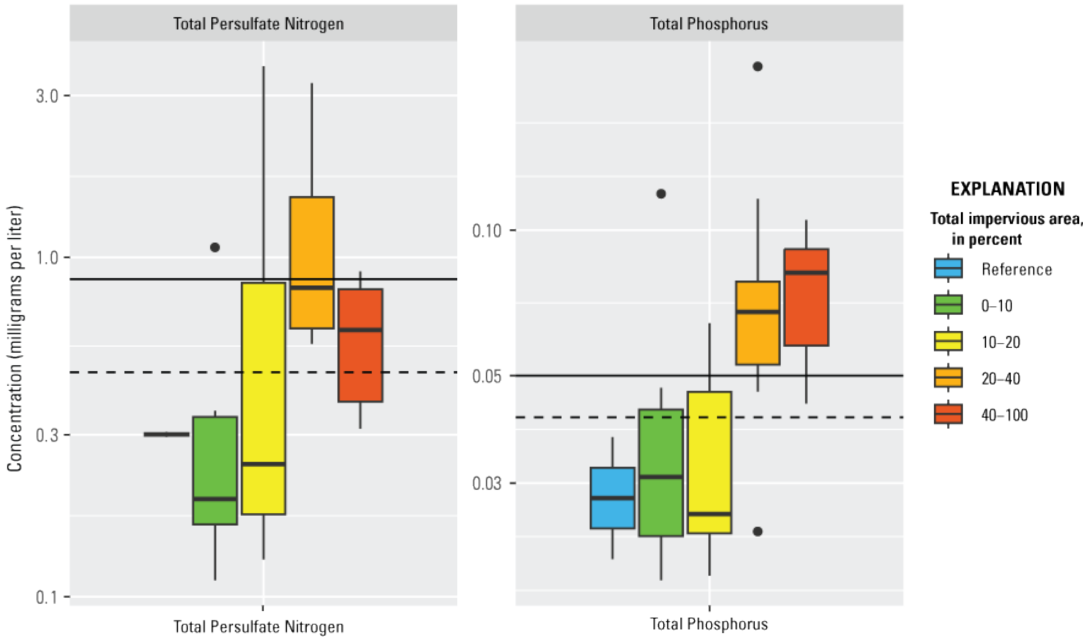

Figure 3. Total nitrogen and phosphorus concentrations across total impervious area categories. Data below the dashed line represent good condition, and data above the solid line represent poor condition. A description of boxplot characteristics is shown in Appendix C.

Metals criteria for freshwater are defined in WAC 173-201A-240 (Washington Department of Ecology, 2020), and for the metals selected for the PSS study, all but arsenic have criteria that are dependent on the hardness measured in the same sample. For dissolved arsenic, the acute and chronic aquatic life criteria are 360 and 190 µg/L, respectively, and all results for dissolved arsenic were well below these criteria. Comparisons to acute and chronic metals standards for cadmium, chromium, copper, lead, silver, and zinc used simultaneously measured hardness values to calculate the sample-specific standard against which to compare each result. None of the samples for these metals exceeded their hardness-derived criteria for both acute and chronic aquatic life criteria. Dissolved copper, lead, and zinc tended to increase with increasing impervious cover within each basin (fig. 4) but also showed other interesting patterns. For example, dissolved copper and zinc were higher in reference sites compared to the 0–10, 10–20, and 20–40 TIA% categories (fig. 4). Overall, dissolved metals concentrations were low throughout the 2020 sites with highest values in the 40–100 TIA% category.

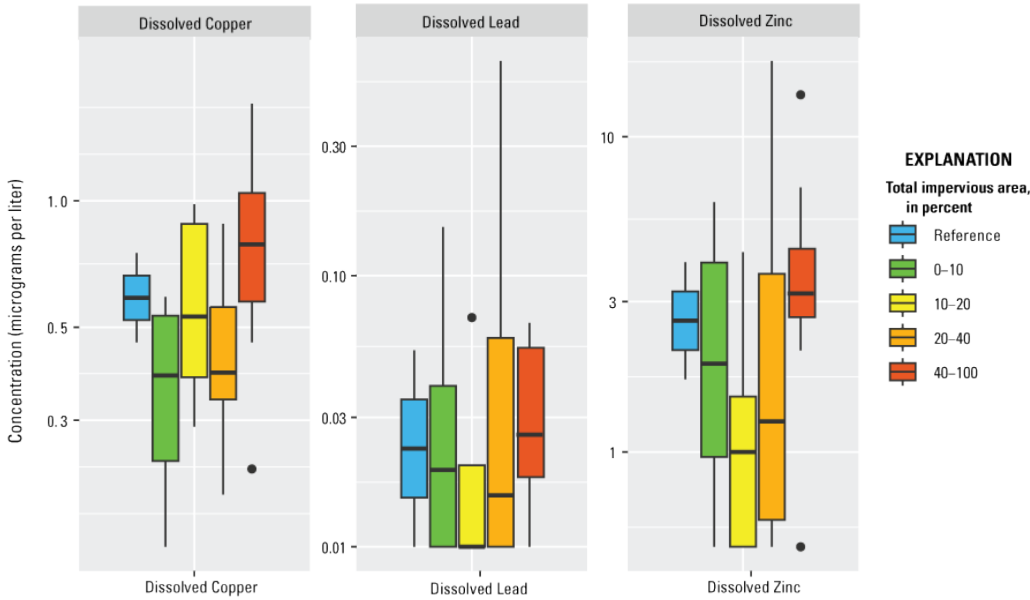

Figure 4. Dissolved metals concentrations across total impervious area categories. A description of boxplot characteristics is shown in Appendix C.

Sediment Quality

Fine sediment samples (sieved through 63-micron filter) were analyzed for metals (arsenic, cadmium, chromium, copper, lead, and zinc) and organics (sieved sediment through a 2millimeter filter), including polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs), and phthalates.

Detection frequency of sediment parameters varied across chemical groups and were categorized into the same A, B, and C groups as the water-quality parameters. Sediment metals were detected in 100 percent of samples (Appendix B). Across the 13 different PBDEs, 7 were never detected and none were categorized as a group A parameter (commonly detected; Appendix B). Detection frequency of PAHs and phthalates was variable, with some parameters detected in almost all samples, to some never detected. The parameters in group C, and detected the least across all samples, were: 2-Chloronaphthalene, 5-Methylchrysene, Di-N-Butylphthalate, Di-N-Octyl Phthalate, Diethyl phthalate, Dimethyl phthalate, and Phenanthrene, 3,6-dimethyl-.

Sediment chemistry status assessments were determined for three metals (copper, lead, and zinc) and two organic chemical compound groups (total PAHs and total PBDEs) following the methods in DeGasperi and others (2018). In that report, thresholds values for these sediment parameters were based on a study by MacDonald and others (2000), where threshold effects concentrations (TECs) and probable effects concentrations (PECs) were determined from paired sediment chemistry and toxicity samples (table 3). For copper, total PAHs, and total PBDEs no sites were in poor condition (table 3). A single site for lead, and 2 sites for Zinc, were considered in poor condition (table 3). Similar to water-quality data, sediment concentrations varied with TIA% in the sample basins. For dissolved metals, median values for copper, lead, and zinc appeared to increase with TIA% and were highest in the 40–100 TIA% category (fig. 5). The data for sediment organics were more variable (fig. 6). For total PAHs, the highest concentrations were found in the 10–20 TIA% group. For total PBDEs the data were similar across the TIA% groups. The total phthalates were the most variable and data from the 10–20 and 40–100 TIA% groups showed the highest concentrations.

Table 3. Freshwater sediment quality thresholds from MacDonald and others (2000).

[Numbers in parentheses indicate the number of sites from 2020 within that category; PEC, probable effects concentration; TEC, threshold effects concentration; >, greater than; <, less than; mg/kg, milligrams per kilogram; µg/kg, micrograms per kilogram; PAHs, polycyclic aromatic hydrocarbons; PBDEs, polybrominated diphenyl ethers; total number of sites is 31 representing the urban gradient sites]

Parameter	PEC (>PEC = Poor)	Fair	TEC (<TEC = Good)
Copper (mg/kg)	149 (0)	31.6 to 149 (18)	31.6 (13)
Lead (mg/kg)	128 (1)	35.8 to 128 (12)	35.8 (18)
Zinc (mg/kg)	459 (2)	121 to 459 (18)	121 (11)
Total PAHs (mg/kg)	22,800 (0)	1,610 to 22,800 (2)	1,610 (29)
Total PBDEs (µg/kg)	3,100 (0)	31 to 3,100 (1)	31 (30)

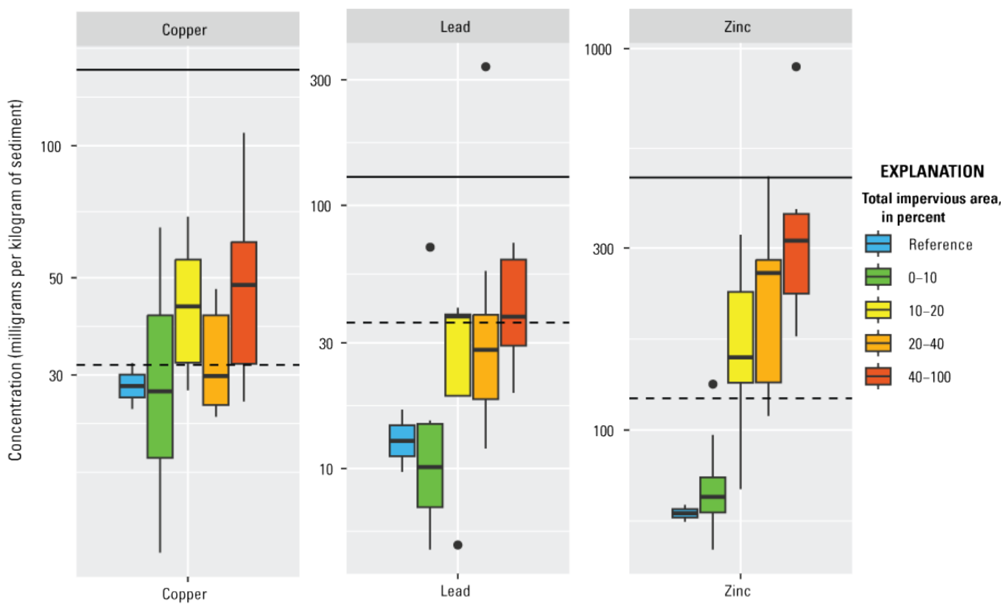

Figure 5. Sediment metals across total impervious area categories. Data below the dashed line represent good condition, and data above the solid line represent poor condition. A description of boxplot characteristics is shown in Appendix C.

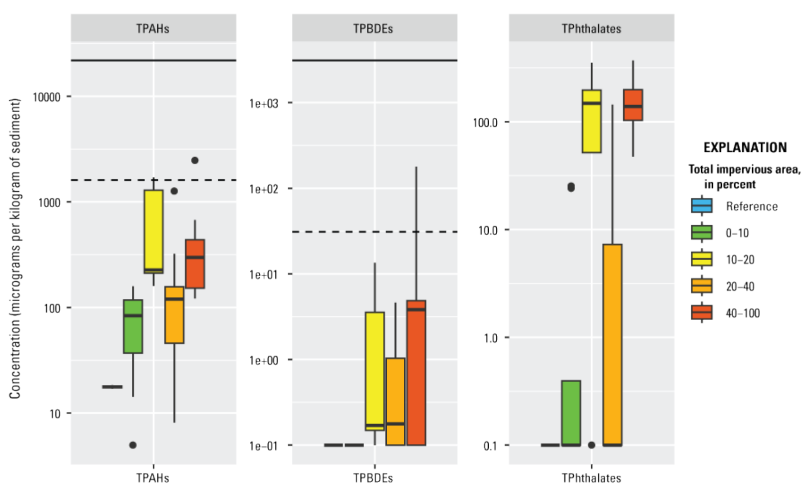

Figure 6. Organic concentrations in sediment across total impervious area categories. Data below the dashed line represent good condition, and data above the solid line represent poor condition. A least-disturbed criteria for total phthalates has not been developed yet.

Biological Measures

Five biological metrics were calculated from the macroinvertebrate and algal community data. The Benthic Index of Biological Integrity (BIBI) is an overall macroinvertebrate score that responds predictably to human disturbances, and ranges from 0 to 100 (Morley, 2000). The Hilsenhoff Biotic Tolerance Index (HBTI) is based on macroinvertebrate data and an indicator of easily degraded organic matter pollution (Hilsenhoff, 1988). The Fine Sediment Sensitivity Index (FSSI) is a macroinvertebrate metric and indicator of issues due to fine sediment (Relyea and others, 2012). The Metal Tolerance Index (MTI) is a measure of metal pollution impact on macroinvertebrate communities (McGuire, 2009). The final metric, based on algal data, is the Trophic Diatom Index (TDI) and is an indicator of nutrient pollution (Kelly and Whitton, 1995; Kelly and others, 2001). Similar to water and sediment chemistry parameters, we used biological threshold data from DeGasperi and others (2018) to classify sites into good, fair, and poor conditions (table 4).

Overall, the biological condition as estimated by the five biological metrics was poor for most PSS sites in 2020. The one exception was the MTI where 25 of the 31 urban gradient sites were considered in 'good' condition (table 4). The BIBI and FSSI metrics were classified as poor in a majority of sites sampled, whereas the HBTI had similar numbers of sites in both good and poor condition. The biological metrics followed similar patterns as water and sediment chemistry when the data were grouped by the TIA% category. For BIBI and FSSI, higher values of these metrics indicate more suitable conditions for aquatic life, and streams in the 0–10 TIA% group had higher values compared to the other stream TIA% groups (fig. 7). For HBTI and MTI, lower values indicate better conditions and the HBTI seems to increase with increasing TIA% within the basin (fig. 8). The MTI was classified as 'good' across most sites and did not vary with TIA% category (fig. 8). Finally, low TDI values indicate 'good' conditions, and most sites in the 0–10 TIA% group are classified as such (fig. 8). The TDI increased with increasing TIA% with the basin, and almost all streams in the 20–40 and 40–100 TIA% categories were considered poor (fig. 8). There are no reference site data included in figs. 7 through 11 because those data are collected by Ecology's Watershed Health Monitoring program, not the SAM PSS program. These data will be used in the 5-year summary report to establish least-disturbed conditions.

Table 4. Biological thresholds to categorize SAM PSS streams, from DeGasperi and others (2018).

[Numbers in parentheses represent the number of sites from 2020 in those categories; >, greater than; <, less than}]

Metric	Metric type	Poor	Fair	Good
Benthic Index of Biological Integrity (BIBI)	Macroinvertebrate	<60.8 (23)	60.8 to 77.4 (6)	>77.4 (2)
Hilsenhoff Biotic Tolerance Index (HBTI)	Macroinvertebrate	>4.98 (11)	4.55 to 4.98 (6)	<4.55 (14)
Fine Sediment Sensitivity Index (FSSI)	Macroinvertebrate	<77 (27)	77 to 110 (1)	>110 (3)
Metals Tolerance Index (MTI)	Macroinvertebrate	>3.57 (1)	2.27 to 3.57 (5)	<2.27 (25)
Trophic Diatom Index (TDI)	Periphyton (algae)	>61.1 (17)	58.3 to 61.1 (4)	<58.3 (10)

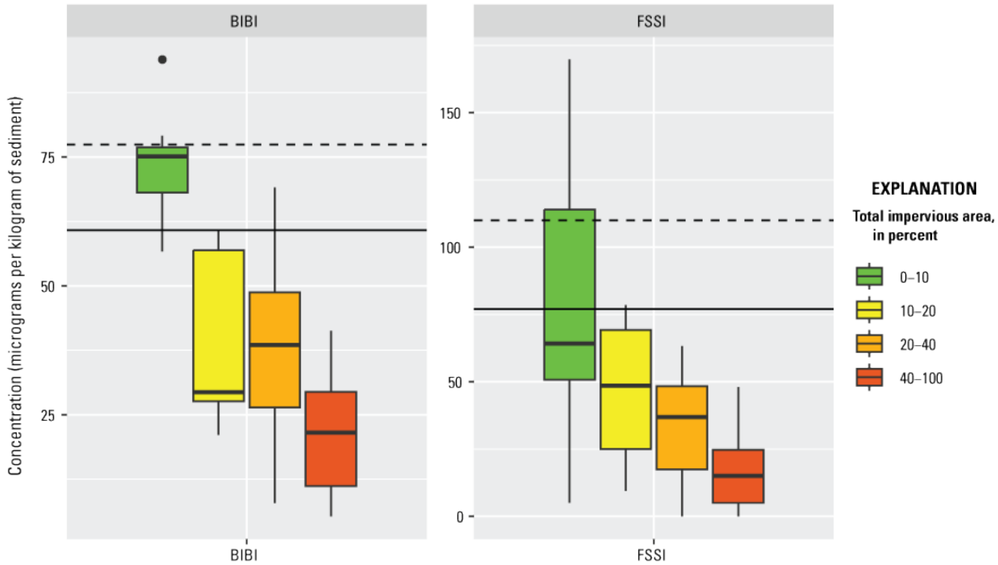

Figure 7. Benthic Index of Biotic Integrity (BIBI) and Fine Sediment Sensitivity Index (FSSI) values for the 2020 PSS streams. Data below the solid line indicate poor conditions and data above dashed line indicate good conditions. A description of boxplot characteristics is shown in Appendix C. There are no reference site data because the biological data are collected by Ecology's Watershed Health Monitoring program, not the SAM PSS program.

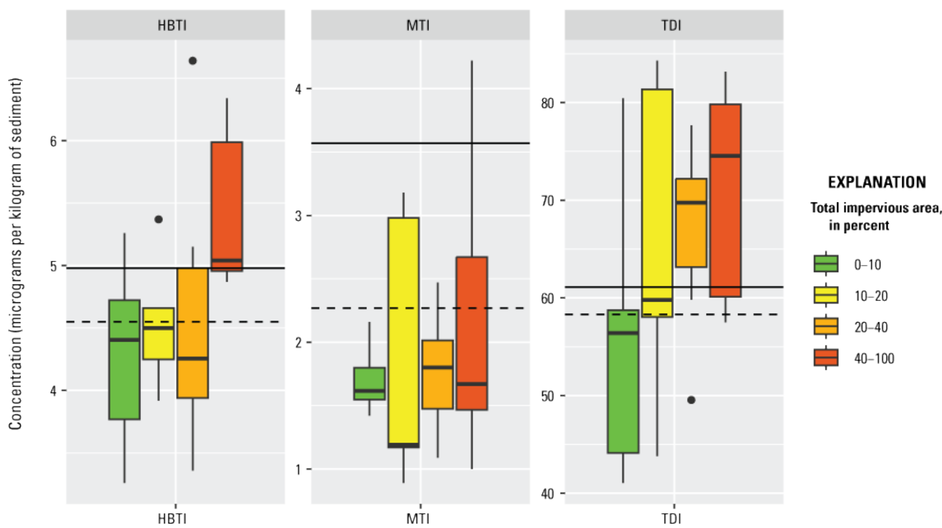

Figure 8. The Hilsenhoff Biotic Tolerance Index (HBTI), Metals Tolerance Index (MTI), and Trophic Diatom Index (TDI) for the 2020 PSS streams. Data above the solid line indicate poor conditions and data below dashed line indicate good conditions. A description of boxplot characteristics is shown in Appendix C. There are no reference site data because the biological data are collected by Ecology's Watershed Health Monitoring program, not the SAM PSS program.

Habitat and Riparian Metrics

During the one-time summer sampling event, a detailed assessment of instream and riparian conditions were determined. The data collected from these events were used to calculate a set of habitat and riparian metrics (Janisch, 2020). These metrics are available from the Ecology Watershed Health Monitoring database by searching for Study ID "SAM_PSS." DeGasperi and others (2018) identified a subset of these metrics that represent traditional reporting categories of habitat data and included:

- Riparian Canopy Cover—Stream densitometer measurement,
- Wood—Wood volume normalized to a 100-meter (m) reach length,
- Pools—Residual pool area,

- Substrate—Median particle diameter,
- Bed stability—Logarithm of relative bed stability.

Thresholds from DeGasperi and others (2018) were used here while the SAM PSS study develops its own set of project least-disturbed thresholds (table 5). In general, for these five-habitat metrics, the 2020 PSS sites showed a low frequency of being in a poor condition.

Table 5. Stream habitat thresholds to categorize SAM PSS streams, from DeGasperi and others (2018).

[Numbers in parentheses represent the number of sites in that category; variable name from Janisch, (2020); the total number of sites is 31 representing the urban gradient sites; >; greater than; <, less than; m, meter]

Metric	Metric variable	Poor	Fair	Good
Riparian Cover (densiometer)	X_DensioCenter	<66.1 (1)	66.1 to 81.6 (3)	>81.6 (27)
Wood volume per 100 m	LWDSiteVolume100m	<8.3 (8)	8.3 to 16.5 (6)	>16.5 (17)
Residual pool area	ResPoolArea100	<3.2 (6)	3.2 to 6.4 (10	>6.4 (15)
Substrate median particle diameter	Dgm	<0.65 (5)	0.65 to 10.7 (20)	>10.7 (6)
Logarithm of relative bed stability	LRBS	< –3.15 (0)	–3.15 to –2.747 (0)	> –2.747 (31)

Continuous Temperature and Water-Level Data

The PSS monitoring program aims to collect continuous temperature and water-level data at each stream site. The U.S. Geological Survey has a rigorous data quality and data review process to ensure that all continuous data are analyzed, approved, and audited prior to release to the public. For traditional measures, like streamflow, these processes are well defined and documented. For the PSS project, we are using measures of sensor depth as a surrogate for water level, and not stream stage, which is common at stream gage locations. This is because stage needs to be tied into a local datum, often including detailed surveying to define sensor locations at the site, and periodic checking of the surveyed levels during the deployment to determine if datum shifts are needed. It was beyond the scope of the PSS project to maintain that level of effort across all 33 locations. In addition, since data collection would only be for 1 year, an alternative approach was developed the PSS project. As a result of this non-standard process, a modified process for analyzing, approving, and auditing the continuous records for the PSS project was developed.

At the time of this report (March 2024), the 2020 water year temperature and water-level data have not been fully approved and are not ready for public release. The continuous data collected from water year 2020 will be reserved for the 5-year summary report; however, these data will be published as soon as they are finalized in a companion data release and stakeholders will be notified of this release.

Are Streams Improving in the Puget Sound Region?

A detailed trend analysis is planned for after the initial 5-year data collection period is completed (after water year 2024). However, all of the urban gradient sites sampled in 2020 were also sampled during the first iteration of the SAM small streams project in 2015. Therefore, some basic comparisons of the data can be made. Here, we focus on changes between 2015 and 2020 for a few key parameters: sediment metals and biological measures. Because these sites were revisited, a nonparametric paired t-test, the Wilcoxon signed rank test, was performed to test the significance of changes in these parameters within each TIA% category. With this comparison we will begin to address the question of stream condition improvements.

Sediment Metals

The change in sediment metal concentrations from 2015 to 2020 showed mixed results (fig. 9). For copper, median values decreased for the 0–10 and 20–40 TIA% groups but increased for the 10–20 and 40–100 TIA% groups. For lead, only the 20–40 TIA% group showed a decrease in median value. Finally, for zinc, the two lowest TIA% groups (0–10 and

10–20 percent) showed a decrease in median value, whereas the higher TIA% groups (20–40 and 40–100 percent) showed an increase in median values. One consistent feature for these metals was a general increase in median values at the highest TIA% category. However, results of the nonparametric paired t-test for sediment metals showed that none of the changes in median values were statistically significant.

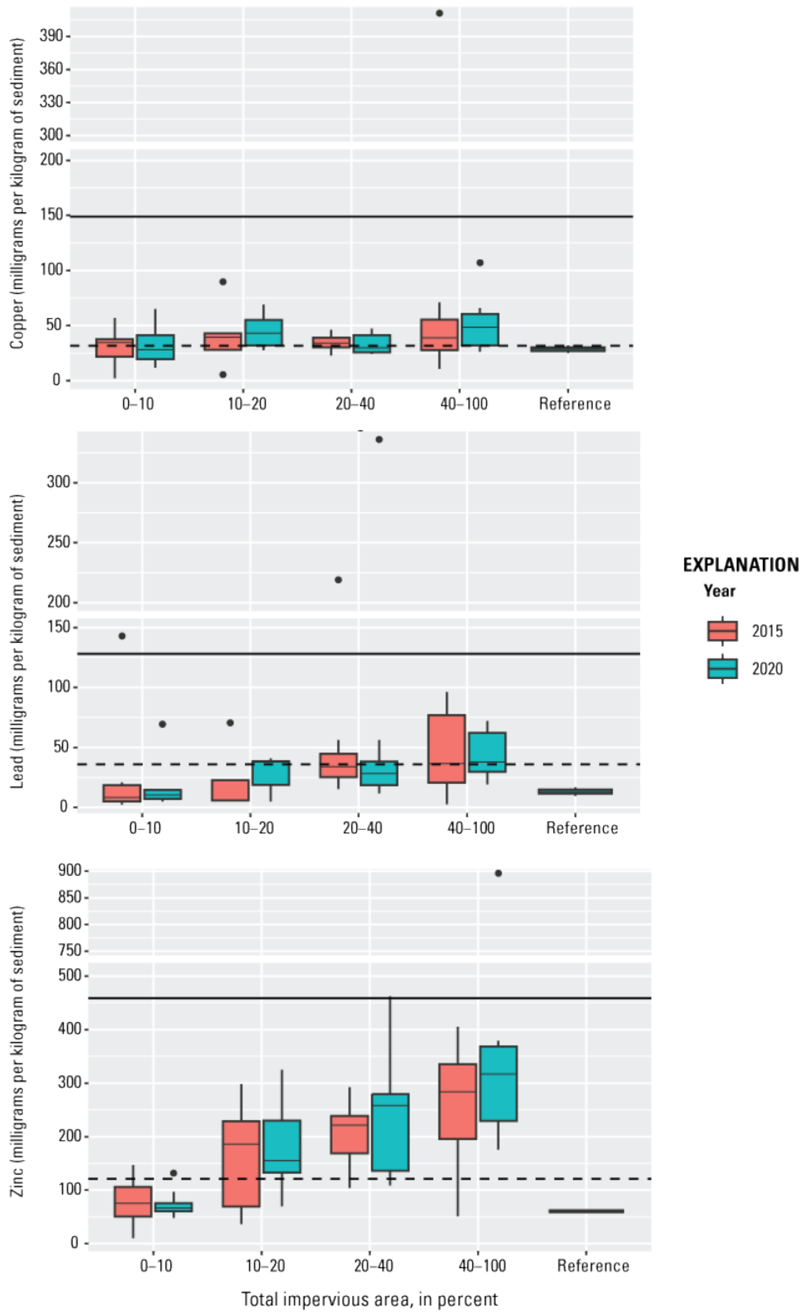

Figure 9. Sediment metals concentrations from 2015 and 2020 across TIA% category. Values above solid line represent poor conditions, values below dashed line represent good conditions. A description of boxplot characteristics is shown in Appendix C. There were no reference sites sampled in 2015.

Biological Measures

We compared two biological measures over time: BIBI and TDI. The BIBI score was chosen because it is a good overall index of the macroinvertebrate community and the TDI score was chosen for its indication of nutrient pollution. The BIBI scores from 2015 to 2020 were similar, but in general, median values across all TIA% categories went down in 2020 (fig.

10). This is most noticeable in the highest TIA% group (40–100 percent). For the TDI, where smaller values indicate better conditions, median values increased in 2020, across most TIA% groups (fig. 11). This increase was most notable in the 0–10 TIA% group. However, the median TDI score was much less in 2020 compared to 2015 for the 10–20 TIA% group. Similar to sediment metals, none of the changes in median values were statistically significant.

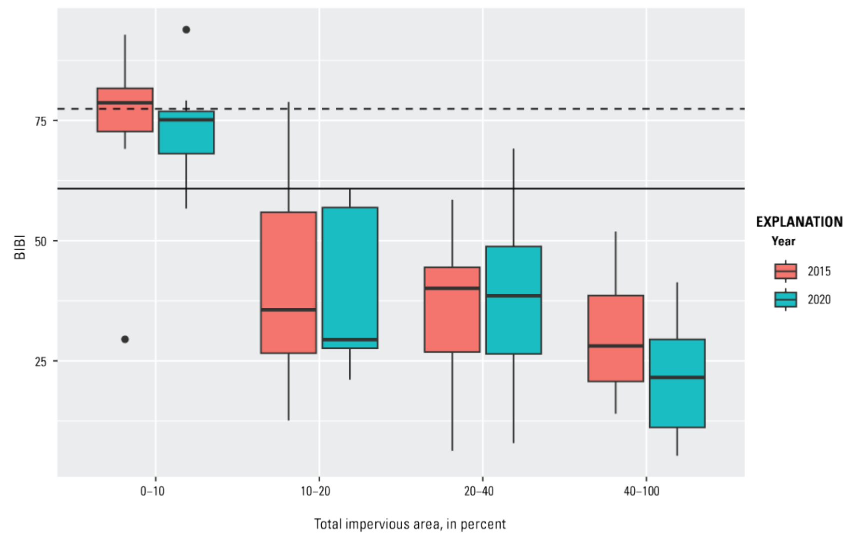

Figure 10. BIBI scores from 2015 and 2020 across TIA% category. Values below solid line represent poor conditions, values above dashed line represent good conditions. A description of boxplot characteristics is shown in Appendix C. There are no reference site data presented here because reference sites were not sampled in 2015.

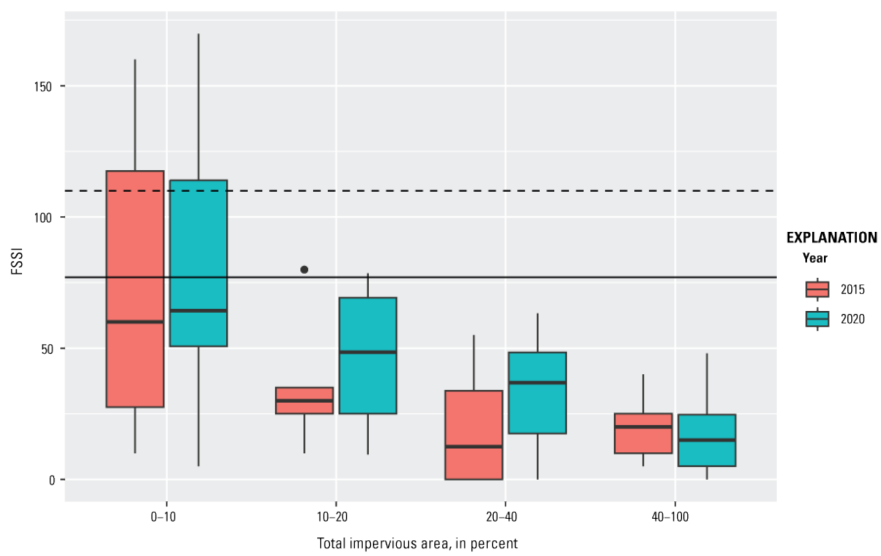

Figure 11. TDI scores from 2015 and 2020 across TIA% category. Values above solid line represent poor conditions, values below dashed line represent good conditions. A description of boxplot characteristics is shown in Appendix C. There are no reference site data presented here because reference sites were not sampled in 2015.

What in this Year's Findings are Important for Stormwater Management?

These data represent the first year of monitoring under the new PSS sampling design. Continued monitoring of both reference and urban gradient sites throughout the initial 5-year monitoring period (2020 to 2024) will allow project specific development of "least-disturbed" conditions. This will enable categorizing all urban gradient sites into groups of good, fair, and poor for all parameters monitored in this project. This annual summary of data collected in summer 2020 has provided several themes worth noting:

- All water-quality parameters were commonly detected with the exception of ammonia and total and dissolved cadmium and total zinc which were infrequently detected.
- Dissolved metals concentrations were below water-quality criteria, but, in general, concentrations increased with increasing TIA% within each sample basin.
- Nutrients increased with increasing TIA% and those in the highest category (40–100 percent) were often in poor condition.
- Sediment metals also increased with increasing TIA%, but sites were rarely found in poor condition.
- Sediment organics, measured as total PAHs, PBDEs, and phthalates, showed increases with increasing TIA%; however, the sites were rarely found to be in poor condition.
- Of the five biological metrics shown, all of them showed worse conditions as TIA% increased, with sites in the 20–40 and 40–100 TIA% categories frequently in poor condition.
- Habitat measures of large wood, bed stability, shading, substrate, and fish habitat were rarely considered poor.
- Compared to 2015, data from 2020 show decreased quality in terms of BIBI, TDI and sediment metals, with the largest declines in the most urban sites (40–100 TIA% category). However, these changes are not statistically significant.

Next steps

The SAM PSS study includes annual sampling of 31 urban gradient sites, with a new set selected each year from 2020 to 2024. This will result in approximately 150 unique small stream sites sampled during this 5-year period. Data collected each year will be provided in these short annual summary reports. A larger status and trends report will be completed every 5 years that analyzes the PSS data across time. For water year 2021, the PSS project will continue with the current monitoring plan and sample 31 urban gradient and 2 reference sites.

Raw data will be available on EIM database with Study ID SAM_PSS and the Puget Sound Stream Benthos site with Project ID Ecology:SAM_PSS.
For more information: SAM status & trends webpage

References

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Appendix A. List of sampled sites in Water Year 2020

[Category, total impervious area in percent; ID, identifier; latitude and longitude in North American Datum of 1983]

Field ID	WHM Site ID	Stream Name	County	Latitude	Longitude	Category
SAM-1041	PSS05515-000391	Coal Creek	King	47.56029	–122.17056	10 to 20
SAM-1071	PSS05515-000451	McSorley Creek	King	47.375533	–122.315704	40 to 100
SAM-1055	PSS05515-000859	North Creek	Snohomish	47.77913	–122.18783	20 to 40
SAM-1050	PSS05515-001454	West Hylebos Creek	Pierce	47.253482	–122.333499	20 to 40
SAM-1006	PSS05515-000814	Unnamed tributary	King	47.24308	–121.93832	0 to 10
SAM-1012	PSS05515-003691	Swamp Creek	Snohomish	47.82499	–122.25544	0 to 10
SAM-1004	PSS05515-001556	Tumwater Creek	Clallam	48.09051	–123.47257	0 to 10
SAM-1056	PSS05515-009831	Unnamed tributary	Kitsap	47.65162	–122.63206	20 to 40
SAM-1040	PSS05515-010563	Little Soos Creek	King	47.35755	–122.126732	10 to 20
SAM-1054	PSS05515-013054	Unnamed tributary	King	47.32259	–122.36677	20 to 40
SAM-1069	PSS05515-015067	Unnamed tributary	Snohomish	47.8035	–122.26311	40 to 100
SAM-1044	PSS05515-016983	Yarrow Creek	King	47.64008	–122.18555	10 to 20
SAM-1070	PSS05515-027199	Unnamed tributary	Snohomish	47.95027	–122.29354	40 to 100
SAM-1068	PSS05515-023787	Boeing Creek	King	47.75397	–122.36585	40 to 100
SAM-1001	PSS05515-020891	Unnamed tributary	Snohomish	47.885264	–121.988577	0 to 10
SAM-1048	PSS05515-027812	Bell Creek	Clallam	48.08485	–123.06708	10 to 20
SAM-1008	PSS05515-005892	Pederson Creek	Clallam	48.05888	–123.26124	0 to 10
SAM-1053	PSS05515-029907	Honey Dew Creek	King	47.5137	–122.17984	20 to 40
SAM-1073	PSS05515-030323	Des Moines Creek	King	47.4099	–122.3249	40 to 100
SAM-1005	PSS05515-005879	Stossel Creek	King	47.7285	–121.85184	0 to 10
SAM-1045	PSS05515-032304	Padden Creek	Whatcom	48.71521	–122.48325	10 to 20
SAM-1003	PSS25515-006227	Little Minter Creek	Pierce	47.389153	–122.681672	0 to 10
SAM-1049	PSS25515-024158	Sullivan Gulch Creek	Pierce	47.285092	–122.581634	20 to 40
SAM-1052	PSS15515-256359	Unnamed tributary	King	47.685919	–122.151759	20 to 40
SAM-1011	PSS05515-003875	Stimson Creek	Mason	47.42334	–122.91392	0 to 10
SAM-1012	PSS05515-000831	Canyon Creek	Clallam	48.02367	–123.13834	0 to 10
SAM-1058	PSS05515-007726	Wapato Creek	Pierce	47.24463	–122.37148	20 to 40
SAM-1059	PSS05515-026139	Picnic Point Creek	Snohomish	47.88446	–122.29921	20 to 40
SAM-1074	PSS15515-050295	Peters Creek	King	47.683219	–122.14057	40 to 100
SAM-1075	PSS05515-015391	Powdermill Gulch	Snohomish	47.94141	–122.27415	40 to 100
SAM-1060	PSS05515-013860	Prairie creek	Snohomish	48.17791	–122.1306	20 to 40
Holder	BIO06600-HOLD02	Holder Creek	King	47.43431	–121.96807	Reference
Griffin	SEN06600-GRIF09	Griffin Creek	King	47.60588	–121.8864	Reference

Appendix B. Detection frequency of water and sediment parameters

[Group, designates range of detection frequency: A greater than 50 percent, B between 20 and 50 percent, and C less than 20 percent; µg/l, micrograms per liter; mg/l, milligrams per liter; #, total number; mL, milliliter; NTU, Nephelometric Turbidity Units; mg/kg, milligrams per liter; µg/kg, micrograms per kilogram; PAHs, polycyclic aromatic hydrocarbons; PBDEs, polybrominated diphenyl ethers]

Detection frequency of measured parameters in water

Parameter name	Number of samples	Detection frequency, percent	Group
Ammonia, Total (mg/L)	33	27	B
Arsenic, Dissolved (µg/L)	33	100	A
Arsenic, Total (µg/L)	33	100	A
Cadmium, Dissolved (µg/L)	33	0	C
Cadmium, Total (µg/L)	33	0	C
Chloride, Total (mg/L)	33	100	A
Chromium, Dissolved (µg/L)	33	100	A
Chromium, Total (µg/L)	33	100	A
Copper, Dissolved (µg/L)	33	100	A
Copper, Total (µg/L)	33	94	A
Dissolved Organic Carbon, Dissolved (mg/L)	33	100	A
E. coli, Total (#/100mL)	33	100	A
Fecal Coliform, Total (#/100mL)	33	100	A
Hardness as CaCO3, Total (mg/L)	33	97	A
Lead, Dissolved (µg/L)	33	55	A
Lead, Total (µg/L)	33	64	A
Nitrate-Nitrite as N, Total (mg/L)	33	97	A
Ortho-Phosphate, Dissolved (mg/L)	33	100	A
Total Persulfate Nitrogen, Total (mg/L)	33	100	A
Total Phosphorus, Total (mg/L)	33	100	A
Total Suspended Solids, Total (mg/L)	32	88	A
Turbidity, Total (NTU)	33	97	A
Zinc, Dissolved (µg/L)	33	76	A
Zinc, Total (µg/L)	33	12	C

Detection Frequency of metals in sediment

Parameter Name	Number of Samples	Detection Frequency, percent	Group
Arsenic (mg/kg)	33	100	A
Cadmium (mg/kg)	33	100	A
Chromium (mg/kg)	33	100	A
Copper (mg/kg)	33	100	A
Lead (mg/kg)	33	100	A

Zinc (mg/kg)	33	100	A

Detection Frequency of PBDEs in sediment

Parameter Name	Number of Samples	Detection Frequency, percent	Group
PBDE-047 (µg/kg)	33	39	B
PBDE-049 (µg/kg)	33	0	C
PBDE-066 (µg/kg)	33	0	C
PBDE-071 (µg/kg)	33	0	C
PBDE-099 (µg/kg)	33	33	B
PBDE-100 (µg/kg)	33	18	C
PBDE-138 (µg/kg)	33	0	C
PBDE-153 (µg/kg)	33	3	C
PBDE-154 (µg/kg)	33	0	C
PBDE-183 (µg/kg)	33	3	C
PBDE-184 (µg/kg)	33	0	C
PBDE-191 (µg/kg)	33	0	C
PBDE-209 (µg/kg)	33	27	B

Detection Frequency of phthalates in sediment

Parameter Name	Number of Samples	Detection Frequency, percent	Group
Bis(2-Ethylhexyl) Phthalate (µg/kg)	33	33	B
Butyl benzyl phthalate (µg/kg)	33	21	B
Di-N-Butylphthalate (µg/kg)	33	3	C
Di-N-Octyl Phthalate (µg/kg)	33	0	C
Diethyl phthalate (µg/kg)	33	9	C
Dimethyl phthalate (µg/kg)	33	6	C

Detection Frequency of sediment PAHs

Parameters	Number of Samples	Detection Frequency, percent	Group
1-Methylnaphthalene (µg/kg)	33	94	A
1-Methylphenanthrene (µg/kg)	33	67	A
1,1'-Biphenyl (µg/kg)	33	100	A
1,6,7-Trimethylnaphthalene (µg/kg)	33	36	B
2-Chloronaphthalene (µg/kg)	33	0	C
2-Methylfluoranthene (µg/kg)	33	64	A
2-Methylnaphthalene µ (g/kg)	33	91	A
2-Methylphenanthrene (µg/kg)	33	67	A
2,6-Dimethylnaphthalene (µg/kg)	33	61	A
4-Methyldibenzothiophene (µg/kg)	33	36	B
5-Methylchrysene (µg/kg)	33	0	C
9H-Fluorene, 1-methyl- (µg/kg)	33	55	A
Acenaphthene (µg/kg)	33	24	B
Acenaphthylene (µg/kg)	33	39	B
Anthracene (µg/kg)	33	64	A
Benz[a]anthracene (µg/kg)	33	85	A
Benzo(a)pyrene (µg/kg)	33	88	A
Benzo(b)fluoranthene (µg/kg)	33	97	A
Benzo(ghi)perylene (µg/kg)	33	97	A
Benzo(k)fluoranthene (µg/kg)	33	88	A
Benzo[e]pyrene (µg/kg)	33	94	A
Carbazole (µg/kg)	33	73	A
Chrysene (µg/kg)	33	94	A
Dibenzo(a,h)anthracene (µg/kg)	33	61	A
Dibenzofuran (µg/kg)	33	64	A
Dibenzothiophene (µg/kg)	33	39	B
Fluoranthene (µg/kg)	33	94	A
Fluorene (µg/kg)	33	58	A
Indeno(1,2,3-cd)pyrene (µg/kg)	33	91	A
Naphthalene (µg/kg)	33	76	A
Phenanthrene, 3,6-dimethyl- (µg/kg)	33	0	C
Phenanthrene (µg/kg)	33	100	A
Pyrene (µg/kg)	33	91	A
Retene (µg/kg)	33	100	A

Appendix C. Boxplot legend description