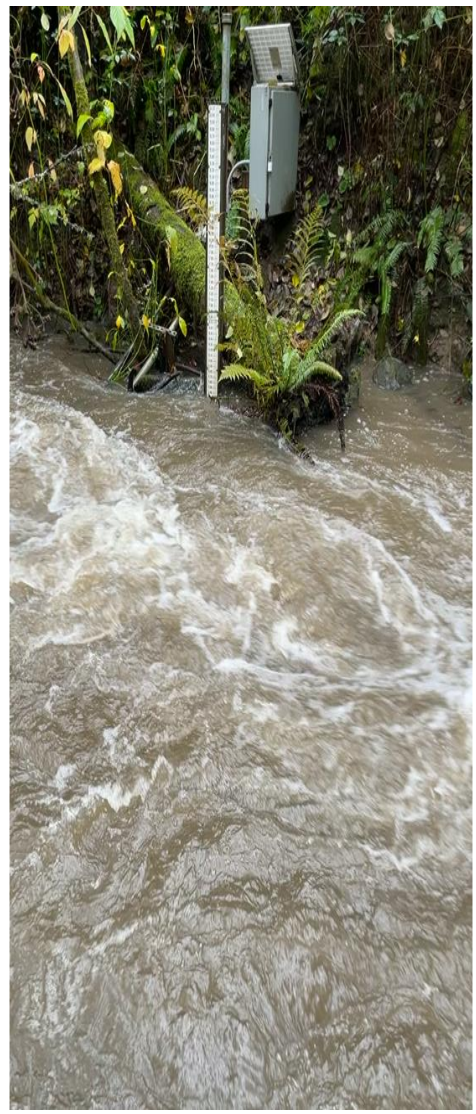
Lower Columbia Urban Streams (LCUS) Monitoring
Annual Status Report (2021-2022)
Clark County Public Works, Clean Water Division

SAM funds Clark County to conduct annual stream health monitoring and track changes over time in the Lower Columbia region. This status and trends monitoring will help evaluate regional progress towards reducing stormwater impacts on environmental health.

Stream health conditions in this study are measured by multiple indicators and LCUS findings are summarized below:

- Land Cover: All subwatersheds exceed TIA values for supporting conditions that are healthy for macroinvertebrates and salmonids (TIA > 15%).
- Flow Metrics (based on stage): TQmean values for most sites fell into “Supporting Salmonid Use”.
- Total Impervious Area (TIA) and Daily Traffic Intensity (ADT): Subwatershed Benthic Index of Biotic Integrity (BIBI) scores generally declines with increasing TIA and ADT traffic values > 20,000 daily trip miles per square mile.
- BIBI: Taxa analysis showed moderate changes in composition due to replacement of some sensitive taxa by more tolerant taxa. LCUS sites with a “Fair” BIBI score showed more taxa diversity than sites with a “Poor to Very Poor” BIBI score.
- Stream Temperature: No sites met state stream temperature criteria beneficial for salmonid use.
- Sediment: Metals (arsenic, cadmium, chromium, copper, lead and zinc) met freshwater sediment cleanup standards.
- Habitat: Substrate embeddedness for all sites fell into the “Suboptimal to Poor” stream condition category. All but two sites had “Poor or Very Poor” BIBI scores with human disturbance index percentages > than 14. All but one site with greater than 54% riparian cover had “Fair” BIBI scores. Sites with less than 54% riparian cover typically had “Poor or Very Poor” BIBI scores.



Cougar Creek (CGR020) during rain event.

Why stream monitoring for stormwater management?

Stormwater management actions, implemented in Lower Columbia region under municipal stormwater permits, are intended to help reduce stormwater impacts to receiving waters. SAM's Lower Columbia Urban Streams (LCUS) monitoring provides a regional status assessment of selected streams in the permit coverage areas. Continued monitoring will eventually allow assessment of stream health trends. These assessments assist in evaluating whether collective stormwater and environmental management efforts are meeting state and regional goals to protect water quality and biota in streams. Current status of stream health in Clark County can be found in the 2022 Stream Health Report.

Stormwater runoff from urban and urbanizing areas is a major contributor to habitat and water quality degradation in small streams. Local jurisdictions throughout the Lower Columbia River region are increasing their stormwater management efforts to reduce flow volumes and pollutants. WY2022 is the second year of a long-term regional evaluation of stream health that focuses on areas covered by municipal stormwater permits in the southwest Washington region, which include Clark and Cowlitz Counties; the Cities of Camas, Longview, Vancouver, Battle Ground, Kelso, and Washougal, and the Washington State Department of Transportation (WSDOT). This ongoing study is funded by the regional permittees. Clark County is performing the study under an Interagency Agreement (IAA) with Ecology. This study will provide a better understanding of influential stressors contributing to impaired waters and overall stream health. Identifying stressors that impact hydrology and biological health may suggest solutions to decrease the impacts of stormwater runoff on streams. Over time, LCUS results may detect changes in stream quality that indicate the effectiveness of stormwater management strategies. LCUS monitoring sites and associated drainage areas can be found in Appendix A.

Monitoring receiving water health indicators in urban/urbanizing areas

The LCUS study follows protocols developed for the on-going statewide stream health monitoring program Status and Trends Monitoring for Watershed Health and Salmon Recovery (WHSR) for physical habitat and biological measurements (https://apps.ecology.wa.gov/publications/documents/0603203.pdf).To better capture the stormwater related hydrologic, water and sediment chemistry changes, this study also monitors water level and temperature continuously for one full water year at each targeted sampling site (Appendix B).

LCUS streams health status in 2021-2022

Impervious surfaces and land use

Total Impervious Area, or TIA, is a measure of the amount of hard surface and serves as an indicator of the potential impacts of urbanization and development on stream health. Impervious cover results in multiple stressors to a subwatershed, such as increased pollutant loads from stormwater runoff, altered stream flow, decreased bank stability, and increased water temperatures. The significance of this metric in reducing salmon recovery potential is based on the multiple impacts to the subwatershed as well as the nearly irreversible nature of imperviousness due to urbanization.

In terms of the subwatershed condition for TIA, all LCUS sites have a medium or high degree of impervious surface (Figure 1). TIA for each LCUS subwatershed ranged from 32 to 99 percent when all developed land cover categories were added together within each monitoring site's drainage area. This means that the subwatersheds of the LCUS study have too much impervious area for supporting watershed conditions that are healthy for macroinvertebrates and salmon. Watersheds with greater than 15% TIA may be at risk for more adverse conditions effecting healthy biota in streams (EPA, 2018).

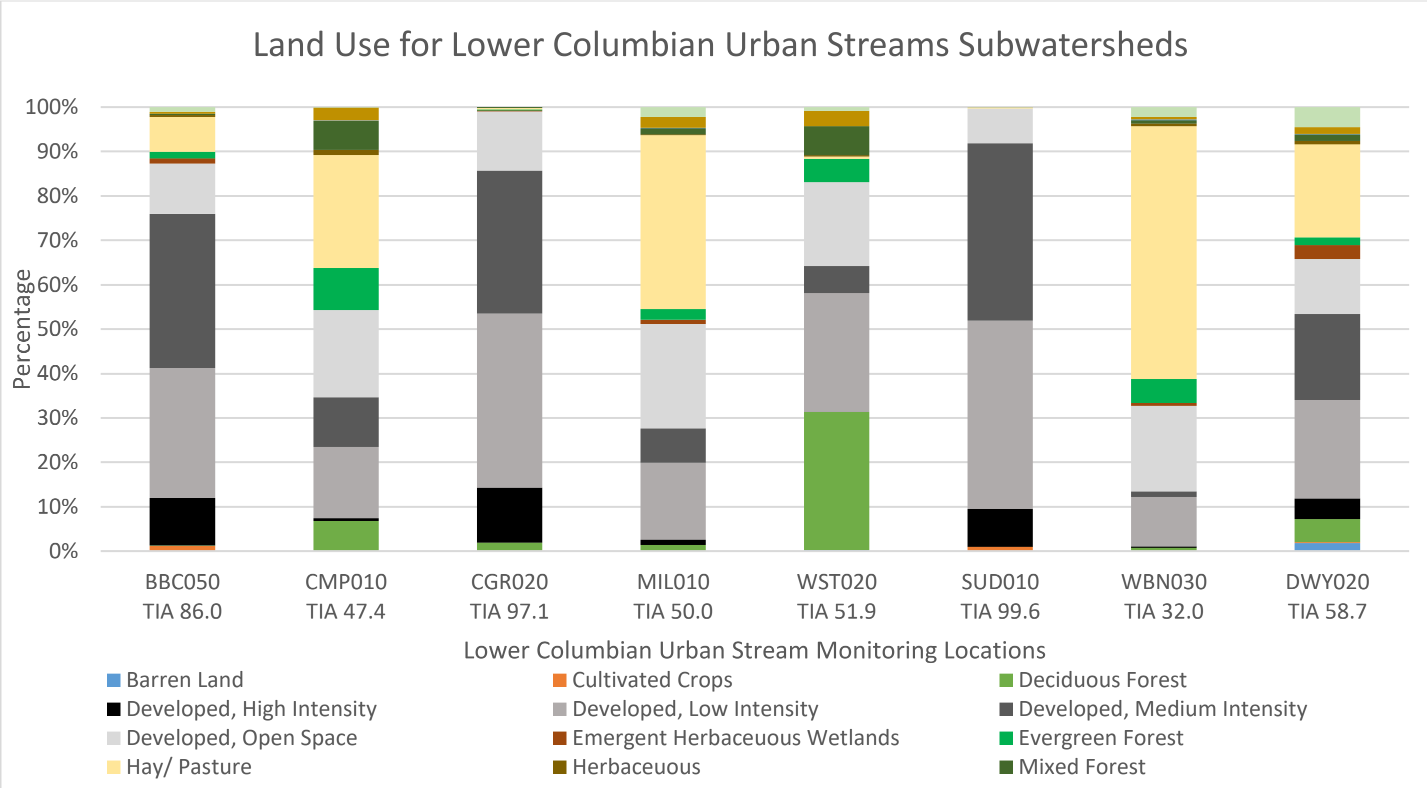


Figure 1. Land use for LCUS subwatersheds monitored for water year 2023, including Total Impervious Area (TIA %). Land cover data are derived from the 2016 National Land Cover Database (NLCD).

Hydrologic metrics

Flashiness, or frequency of high flows, of a stream is an important characteristic of the stream hydrologic regime that indicates likely presence of erosive flows and reflects how quickly and often flow in a waterbody increases and decreases during rainfall events. Urbanization is the primary cause of increased flashiness and hydrologic alterations. Increased stream flashiness in urban areas is typically a result of increased hardscape, soil compaction, and the increased hydraulic efficiency of traditional stormwater and flood management practices that are designed to quickly drain urban areas. Natural conditions may also contribute to stream flashiness. For example, regions with little attenuation of runoff, such as an area with clay soils or rock layers, typically have higher flashiness than areas with more permeable soils. (Schoonover et al., 2006). This LCUS study uses alternative interpretations of TQMean, Richard-Baker Index (RBI) and Flow Reversals based on continuous stage for analyses of flashiness of streams as defined in Figure 2. Booth and Konrad 2017, found that hydrologic metrics based on stage provide useful metrics of status and trends monitoring of urbanizing subwatersheds.

TQMean: The TQmean is the percent of days that stream stage is greater than the mean annual stage. Flashier streams have lower TQmean values.

RBI: Is a dimensionless index of stage oscillations relative to total flow, based on daily average stage measured per water year.

Flow reversals: The number of times that the stage rate changed from an increase to a decrease or vice versa during the year. Stage changes of less than 2% are not considered.

Figure 2. LCUS hydrology metric definitions derived from Booth and Konrad, 2017.

TQmean tends to decrease with increased urbanization and a value of less than about 0.27 is associated with non-supporting streams for salmon, while a TQmean of greater than 0.37 is associated with fully supporting streams (Clark County, 2022). All LCUS sites had a TQmean of 0.37 or greater. RBI and flow reversal values tend to increase with urbanization. RBI values greater than 0.25 and flow reversal values greater than 65 are typically associated with subwatershed that have a TIA greater than 20% (Booth and Konrad, 2017). Cougar Creek and Suds Creek had a TIA greater than 97% and were the only sites to have an RBI value greater than 0.25.

It appears that despite having all LCUS sites having too much TIA to support healthy biota in streams, much of the site hydrology may not be in the poor health category. Further analysis will be conducted in future monitoring years to identify regulating factors supporting site hydrology.

Location Type	Location Name	Location ID	Flow Metric Results (using stage as a surrogate for flow)		
			TQ mean	RBI	Reversals
Trend	Burnt Bridge Creek	BBC050	0.48	0.15	40
Trend	Cougar Creek	CGR020	0.39	0.36	46
Trend	Campen Creek	CMP010	0.44	0.23	45
Trend	Mill Creek	MIL010	0.47	0.18	34
Trend	Westover Creek	WST020	0.52	0.19	47
Status	Dwyer Creek	DWY020	0.49	0.22	48
Status	Suds Creek	SUD010	0.37	0.38	41
Status	Woodburn Creek	WDB030	0.51	0.18	37

Table 1. Hydrology metrics of flashiness calculated by analyzing 15-minute continuous stage data.

BIBI

Benthic macroinvertebrate communities provide a strong indicator of stream habitat quality and can be significantly influenced by changes to habitat associated with urban stream hydrology, water quality, embeddedness and stream temperature.

BIBI scores can also be a strong indicator of water quality problems that harm salmon. Two common problems are excessive temperature due to the lack of shade and toxic effects of urban stormwater runoff. Low BIBI scores can indicate factors other than hydrology that prevent a stream from supporting salmon and other sensitive aquatic life.

Clark County has used the BIBI score as a tool to quantify stream health for many years. Clark County stores all BIBI data in the Puget Sound Database (https://pugetsoundstreambenthos.org/) and has the original taxonomic counts converted to the 100-point system (Table 2). Streams having "Poor" BIBI scores (40 or less) are considered non-supporting for salmon habitat (Ecology, 1999). Five LCUS sites had a BIBI score of less than 40 (Table 3).

Table 2. BIBI Biological Condition Categories

Biological Condition	0 to 100 BIBI
Excellent	80 to 100
Good	60 to 80
Fair	40 to 60
Poor	20 to 40
Very Poor	0 to 20

Table 3. LCUS BIBI Scores.

	BBC050	CMP010	CGR020	MIL010	WST020	WBN030	SUD010	DWY020
BIBI Score	12	28	20	56	35	60	25	52
BIBI Category	Very Poor	Poor	Very Poor	Fair	Poor	Fair	Poor	Fair

Taxa composition at all 2022 LCUS sites ranged from four to six on the EPA's Biological Condition Gradient (BCG). The BCG framework represents ecological conditions in terms of measurable ecological characteristics, or attributes, of an aquatic community in response to anthropogenic stressors (EPA, 2021).

A BCG range from four to six indicates that chemistry, habitat, and / or flow regime was altered from natural conditions. At the four to six BCG level, there are moderate to extreme changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa (EPA, 2021). BIBI samples showed many more tolerant taxa, many taxa that are both lotic and lentic, and loss of sensitive taxa. This could be due in part macroinvertebrate populations showing stress from drought conditions (B. Wisseman, email message to Chad Hoxeng, May 5th, 2022).

Traffic Intensity and BIBI

Traffic intensity, as measured by vehicle trips per square mile (ADT), typically increases with urbanization and provides a robust urbanization metric. Traffic intensity is associated with both the level of urbanization and the presence of high traffic freeways and highways in rural areas. Low density urban residential areas tend to have much lower traffic and associated pollution than commercial, industrial and multifamily areas along arterial roadways.

Considering that much of the stormwater pollution in the MS4 comes from roads, traffic intensity is strongly associated with stormwater influence on streams in both urban and rural areas.

There is detailed estimated traffic count data for every road in Clark County, including cities, based on computer modeling by a regional transportation planning agency. The transportation model provides a detailed and uniform surrogate for potential stormwater impacts across Clark County. Figure 2 shows a general decreasing BIBI with increasing traffic intensity. It appears that BIBI scores in basins with an ADT value of 20,000 or greater typically fall into the "Poor" category. Considering that BIBI scores depend on a number of factors, including substrate and water quality, BIBI scores can be low in areas of low urbanization (e.g. land under intensive agricultural use). However, BIBI scores are rarely better than poor in areas of intense urbanization.

All LCUS sites with an ADT greater than 20,000 had a "Poor" or "Very Poor" BIBI score (excludes Westover Creek with no ADT data). Sites with ADT less than 20,000 had "Fair" BIBI scores with the exception of Campen Creek which had "Poor" BIBI score.

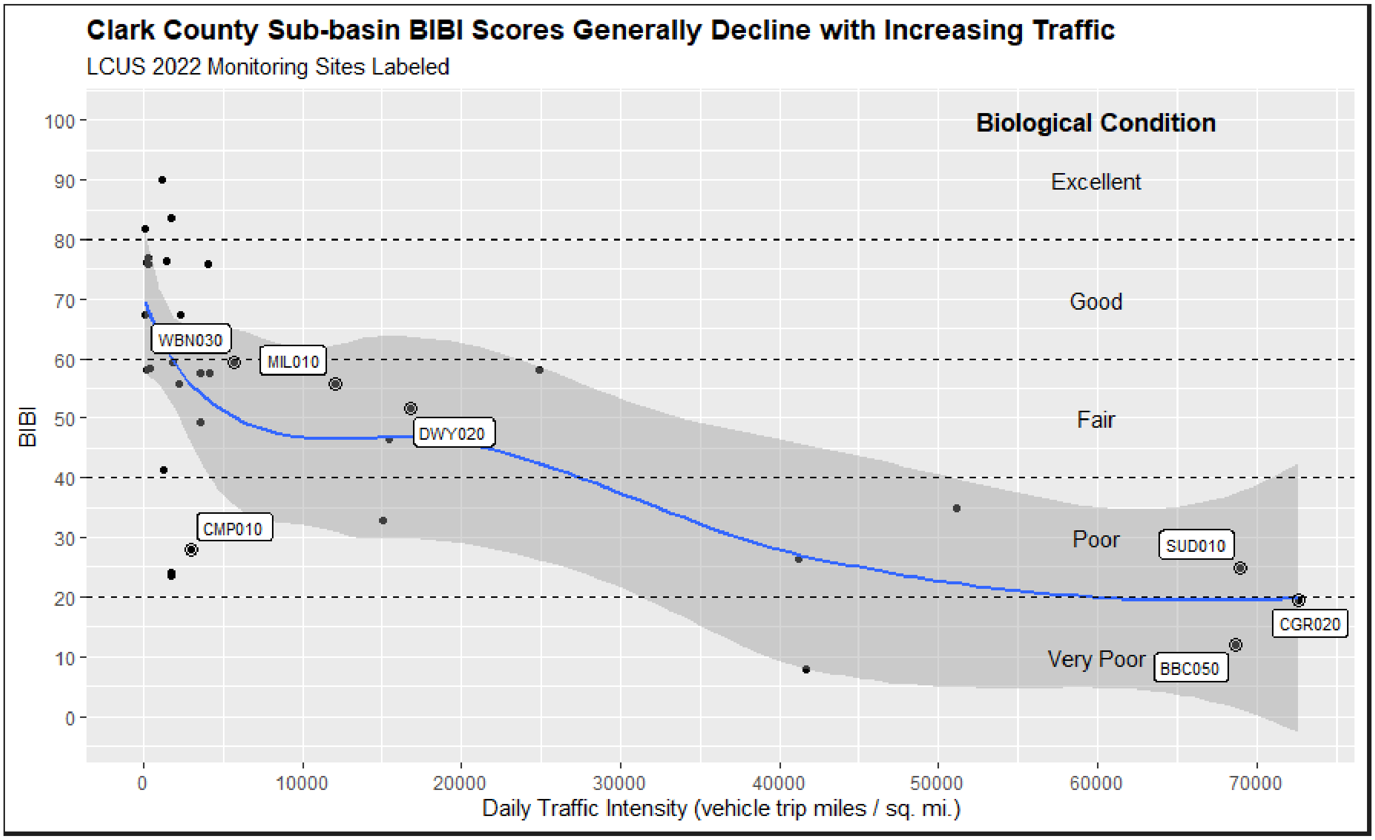


Figure 2. Comparison of available Clark County BIBI scores to sub-basin traffic intensity (Clark County, 2022).

Stream Temperature

Water temperatures have a large impact on the productivity and diversity of freshwater ecosystems. Anadromous species like salmon and steelhead require cool fresh waters throughout their life cycles (Figure 3).

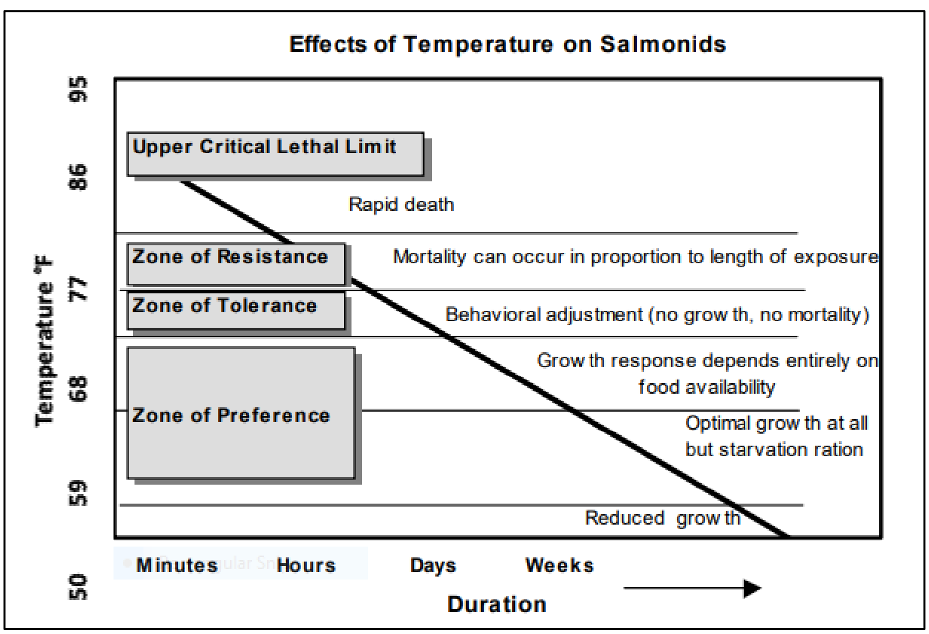


Figure 3. General biological effects of temperature on salmonids of the Pacific Northwest in relation to duration and magnitude of temperature (Sullivan et al. 2000).

Washington state aquatic life temperature criteria in freshwater to protect salmonids is based on the 7-day average of the daily maximum temperature (7-DADmax) measured from June 15 - September 15, equaling a 93 day total monitoring period (Table 4).

No LCUS site met Washington State aquatic life temperature criteria for fresh water (Table 5). Six out of the eight LCUS sites exceeded their Washington State aquatic life temperature criteria over 60 percent of the designated 93-day criteria period, suggesting that these streams are not supportive of salmonids.

Table 4. Washington State aquatic life temperature criteria in fresh water.

Category	Highest 7-DADMax
Char Spawning and Rearing	53.6°F
Core Summer Salmonid Habitat	60.8°F
Salmonid Rearing, and Migration Only	63.5°F
Salmonid Spawning, Rearing, and Migration	63.5°F
Nonanadromous Interior Redband Trout	64.4°F
Indigenous Warm Water Species	68.0°F

Table 5. Stream temperature (7-DADMax) of LCUS WY2022 sites.

Location Type	Stream Name	Location ID	Max 7-DADMax	MaxDate	Max 7-DADDaily Difference	Max Date	Days >60.8	Days >63.5	Days >71.6	Days >73.4	Highest 7-DADMax Aquatic Life
Trend	Burnt Bridge Creek	BBC050	75.7	29-Jul-2022	8.3	12-Jul-2022	89	87	24	10	63.5
	Cougar Creek	CGR020	65.3	28-Jul-2022	6.1	24-Jun-2022	67	18	0	0	60.8
	Campen Creek	CMP010	70.6	30-Jul-2022	8.6	24-Jun-2022	87	74	0	0	63.5
	Mill Creek	MIL010	66.7	29-Jul-2022	4.0	24-Jun-2022	70	29	0	0	60.8
	Westover Creek	WST020	65.5	30-Jul-2022	4.0	24-Jun-2022	68	25	0	0	63.5
Status	Woodburn Creek	WBN030	68.9	29-Jul-2022	7.2	24-Jun-2022	81	60	0	0	63.5
	Suds Creek	SUD010	66.1	29-Jul-2022	5.1	24-Jun-2022	75	35	0	0	63.5
	Dwyer Creek	DWY020	73.5	29-Jul-2022	6.7	11-Jul-2022	87	79	7	3	63.5

Stream sediment and Habitat Conditions

Streambed sediment samples were collected once during the summer of 2022 from the stream substrate at all LCUS sites. Sieved sediment samples were analyzed for metals and organic contaminants, including PAHs and total organic carbon. Metals were detected at every site and were below freshwater sediment cleanup objectives. PAHs were detected at five of the eight LCUS monitoring locations. Fluoranthene, phenanthrene and pyrene were the most common PAHs detected and were found at five sites. BBC050 had the majority of highest PAHs values. LCUS sediment data can be found in Ecology's Environmental Information Management (EIM) database at https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database.

Excessive fine-grained sediment in streams, as measured by embeddedness or the amount of fine sediment in gravel beds, has adverse effects on the biota that inhabit streams (Figure 4). Embeddedness for LCUS sites ranged from 44 to over 80 percent falling into the suboptimal to poor stream condition category (Table 6).

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
2.a Embeddedness (high gradient)	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

2a. Embeddedness--High Gradient

Figure 4. Embeddedness stream habitat embeddedness condition category (Environmental Protection Agency, 1998).

Table 6. Percent embeddedness for WY2022 LCUS sites based on 121 in stream substrate measurements per stream.

Habitat Parameter	BBC050	CGR020	CMP010	MIL010	WST020	WBN030	SUD010	DWY010
Embeddedness	75	79	78	45	80	49	61	44
Habitat Condition	Marginal	Poor	Poor	Suboptimal	Poor	Suboptimal	Marginal	Suboptimal

Human disturbance activities, such as vegetation removal, road building, construction near streambanks, litter and more are physical habitat stressors to streams and can negatively affect fish, macroinvertebrates, as well as human uses of the waterbody. Measuring the extent and intensity of human disturbance of streams using Watershed Health Monitoring Protocols gives an indication of the impact of human activities on the natural environment. All but two LCUS sites (MIL010 and DWY010), had either a "Poor" or "Very Poor" BIBI score with having a human disturbance percentage greater than 14.

Riparian vegetation and cover are extremely important for healthy streams because of the many functions it serves including bank stabilization, fish habitat, food chain support, thermal cover and flood control. LCUS sites with greater than 54 percent riparian cover had "Fair" BIBI scores and sites with less than 54 percent had "Poor" or "Very Poor" BIBI scores. The exception being Westover Creek which had a "Poor" BIBI score with a riparian vegetation cover of 63 percent, likely due to its riparian vegetation cover being dominated by blackberry.

Stream health changes over time: Are they improving?

Over time, the Southwest Washington Permittees and Ecology will use this study to track stream conditions as they may relate to stormwater management impacts on streams and evaluate overall and long-term effectiveness of municipal stormwater permits, land use changes and environmental regulations.

What in this year's findings are important for stormwater management?

As we continue to track regional conditions and identify key stressors impairing stream health, local officials and stormwater managers will be able to compare stream conditions and help prioritize and focus stormwater management practices. State and local agencies can use this information to develop regional protection, restoration strategies and evaluate the effectiveness of those programs.

Stormwater managers should review Table 7, determine what combinations of the key stressors are present in their jurisdictions, and then consider adjusting their management programs to address these stressors. Continued monitoring of trend and status site conditions will help establish reasonable expectations for good and poor biological conditions and help identify important stressors.

Table 7. List of important stressors identified in the LCUS study that effect overall stream health.

LCUS Summary Findings for WY2022
Imperviousness in all LCUS subwatersheds are greater than 15%, indicating subwatershed conditions are not healthy for supporting macroinvertebrates and salmon (TIA > 15%).
Most flow metrics are supportive of salmonid use.
Benthic invertebrate taxa analysis showed moderate changes in composition due to replacement of some sensitive taxa by more tolerant taxa.
BIBI scores generally declines with increasing TIA and ADT traffic values > 20,000 daily trip miles per square mile.
LCUS sites failed to meet state stream temperature criteria beneficial for salmonid use.
Sediment metals met freshwater sediment cleanup standards.
Substrate embeddedness for all sites fell into the “Suboptimal to Poor” stream condition category.
Streams with human disturbance percentages greater than 14 tend to have "Poor to Very Poor" BIBI scores.
Riparian cover less than 54 percent tend to have "Poor to Very Poor" BIBI scores.

Next step

The LCUS study design includes trend sites that will be monitored yearly and status sites that will be sampled at five-year intervals.

Reporting will include annual assessment of stressors that effect overall stream health. Over time, this study will provide enough data to categorize LCUS streams in good, fair, or poor condition. Trend analyses and risk assessments will be conducted every five years to identify the key stressors causing poor stream conditions in the region.

The long-term goals of the study are: to evaluate the status and trends of water quality and hydrology in surface waters draining subwatersheds primarily within urban and urbanizing areas under the jurisdiction of NPDES municipal stormwater permittees; and to evaluate the status and trends of in-stream biological health, sediment quality and in-stream/riparian habitat conditions that are primarily within urban and urbanizing areas under the jurisdiction of NPDES municipal stormwater permittees.

Data are available on EIM database with Study ID SAM_LCU.

Additional results are published in the Appendix.

For more information: SAM status & trends webpage

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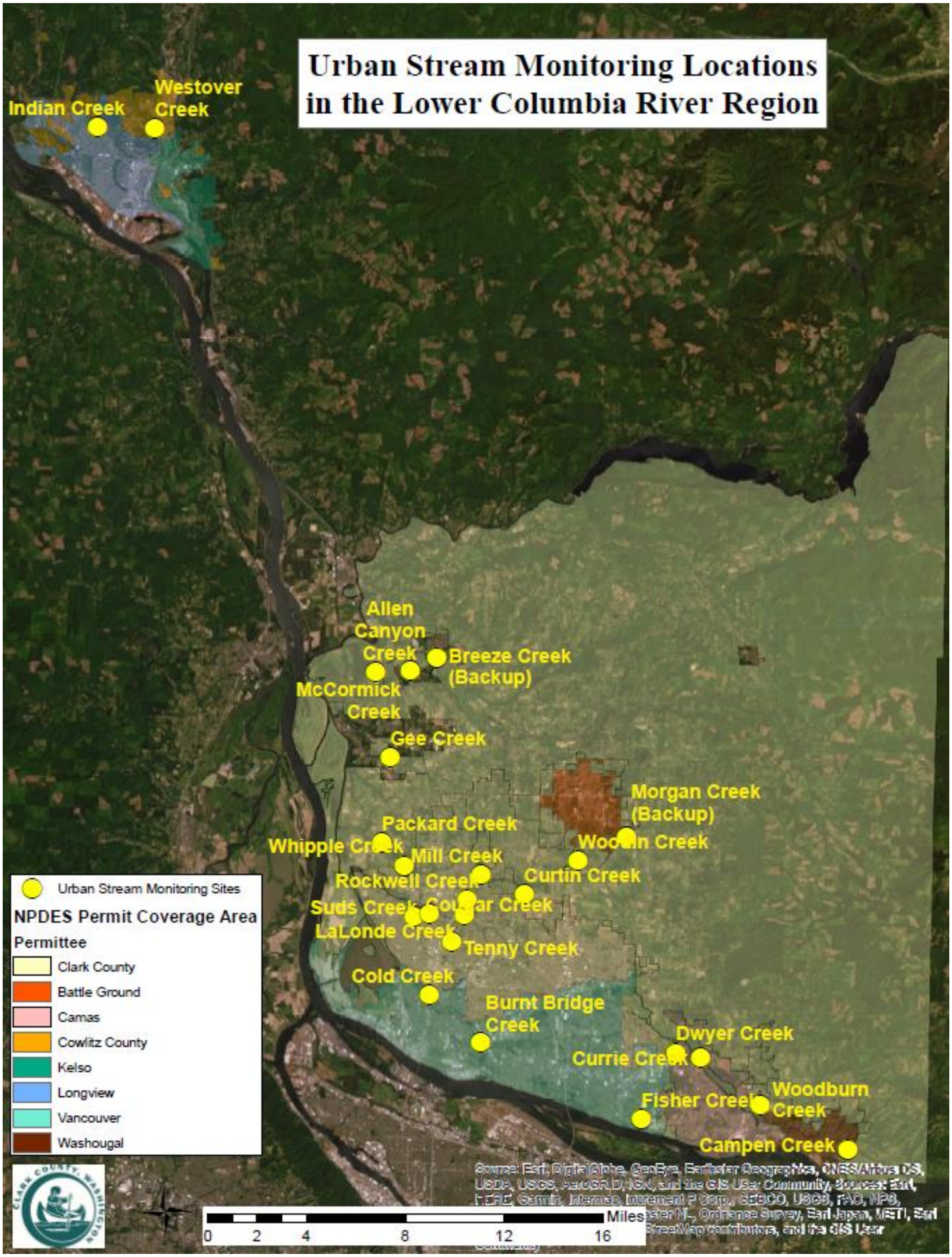
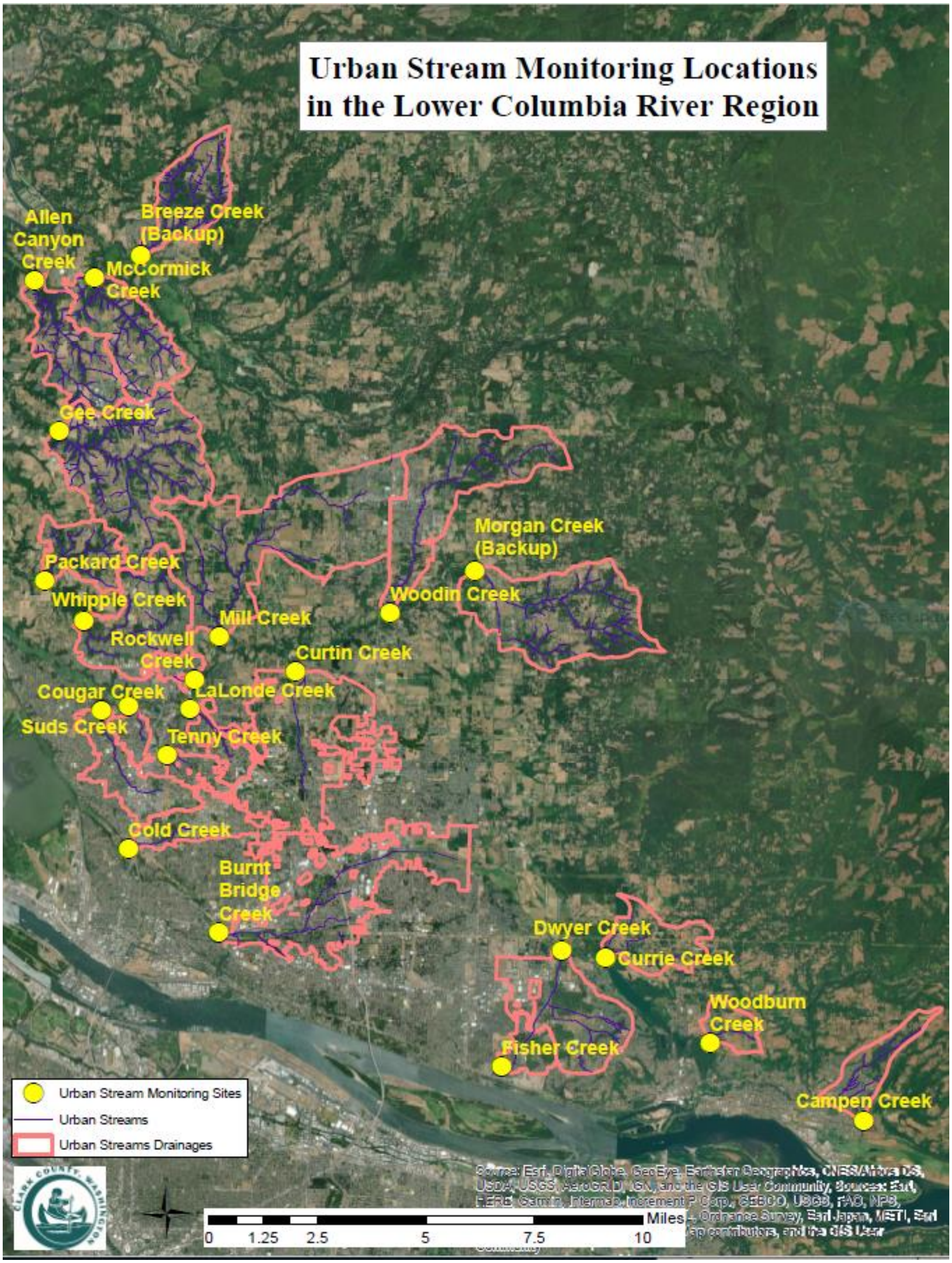
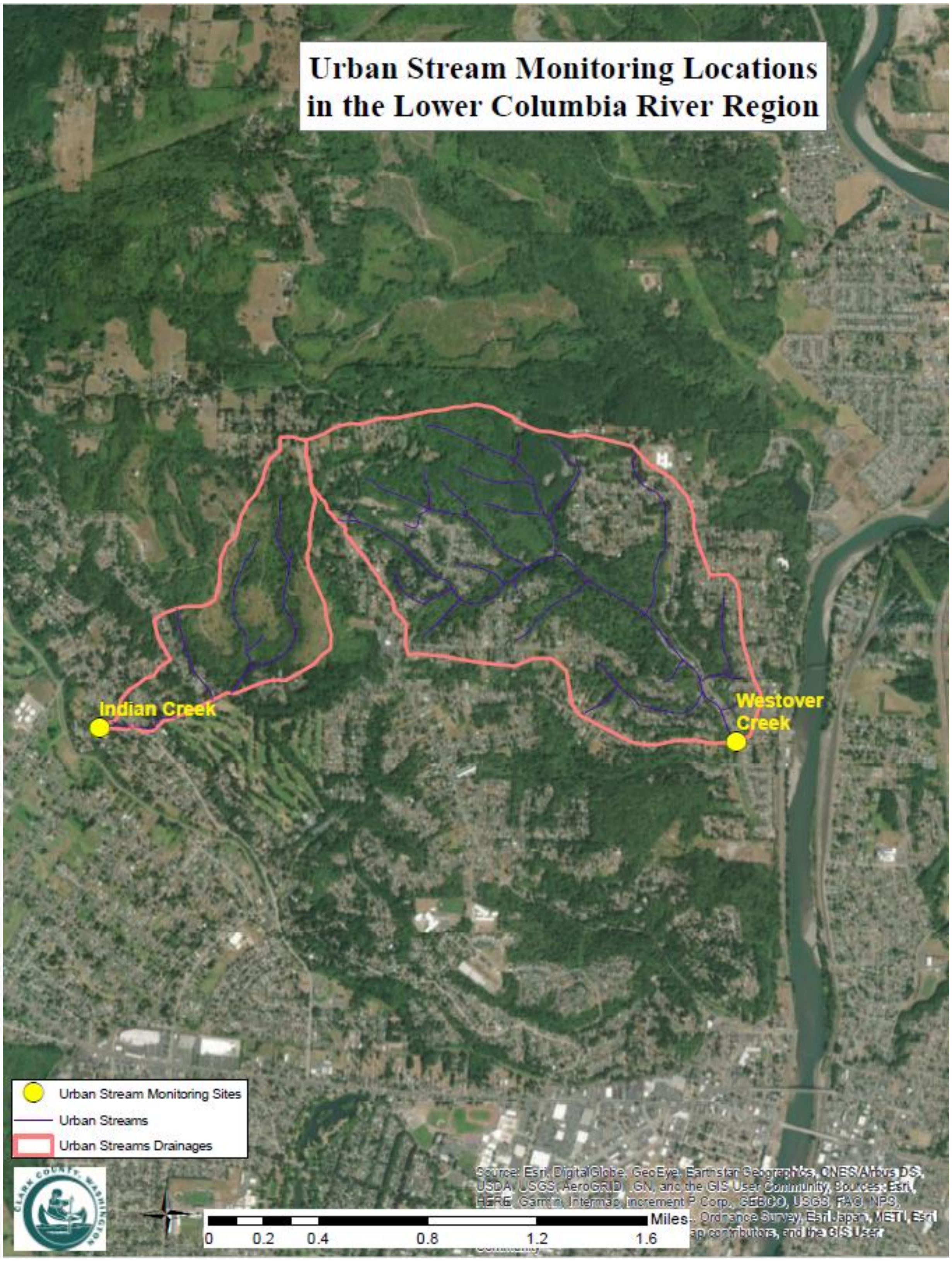
Appendix A. LCUS permittee areas, monitoring sites and associated drainage areas.



Map of urban stream monitoring locations and study boundaries in the Lower Columbia River Basin.



Map of urban stream monitoring locations and associated drainage catchments in Clark County.



Map of urban stream monitoring locations and associated drainage catchments in Cowlitz County.

Appendix B. Continuous time series data (stage and temperature) for LCUS sites for water year 2022.

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Time Series Data Report
15-minute Stage (ft.) at Burnt Bridge Creek (BBC050) Water Year 2022

Sep 18, 2023 | 1 of 1

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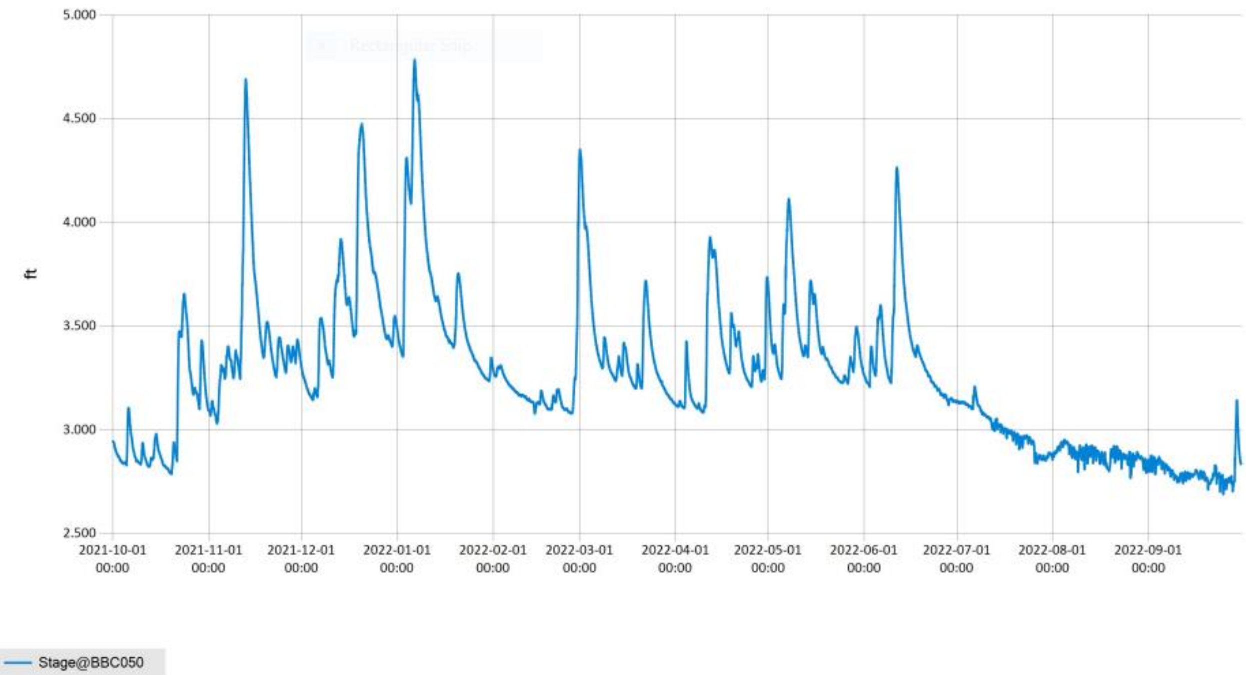

Time Series Data Report
15-minute Stage (ft.) at Campen Creek (CMP010) Water Year 2022

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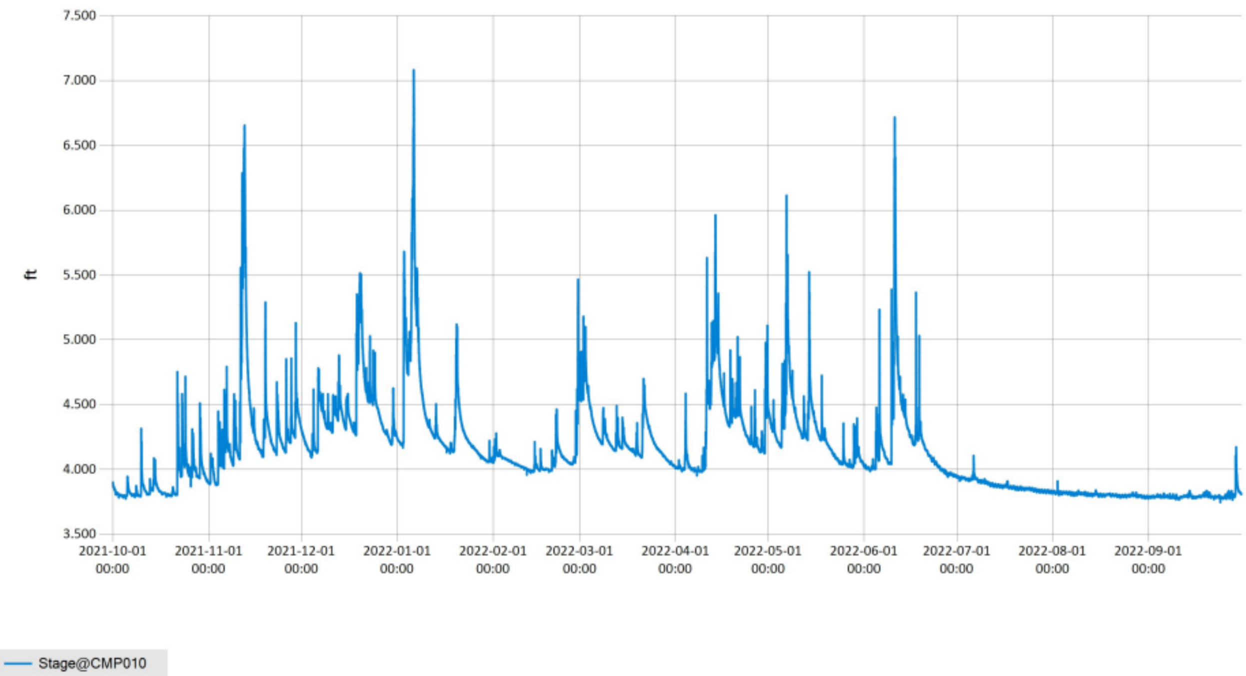

CLARK COUNTY WASHINGTON
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CLEAN WATER

Time Series Data Report
15-minute Stage (ft.) at Cougar Creek (CGR020) Water Year 2022

Sep 25, 2023 | 1 of 1

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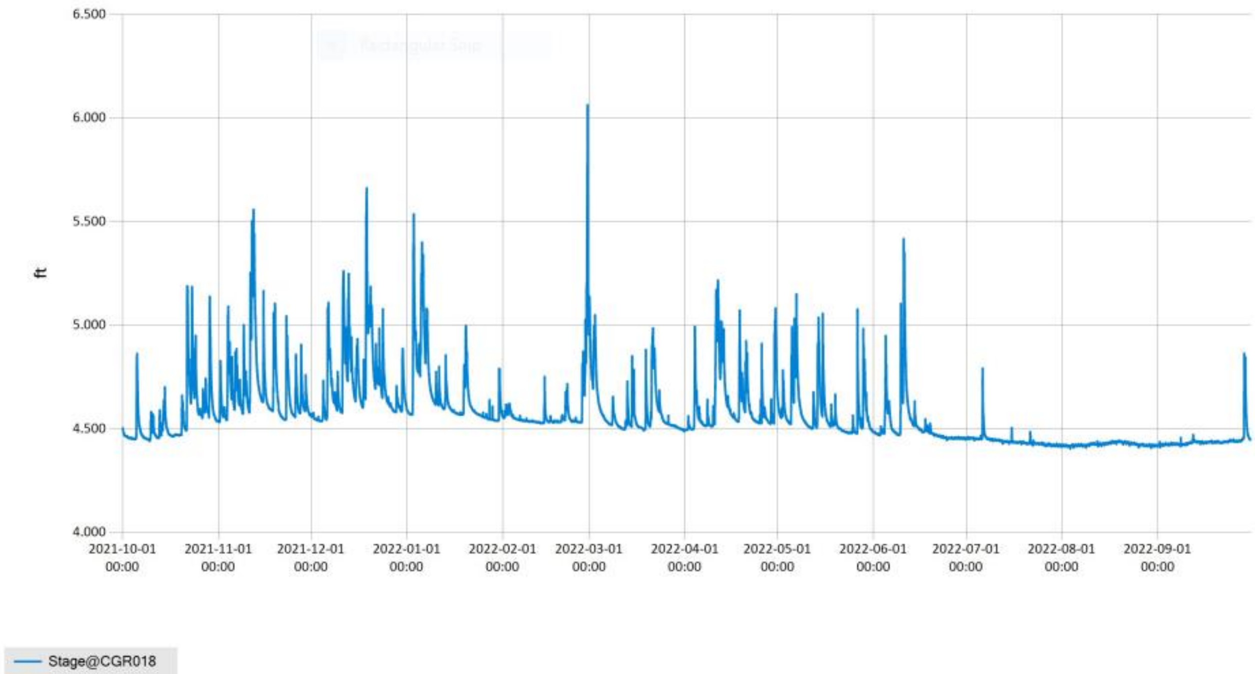

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Time Series Data Report
15-minute Stage (ft.) at Mill Creek (MIL010) Water Year 2022

Sep 25, 2023 | 1 of 1

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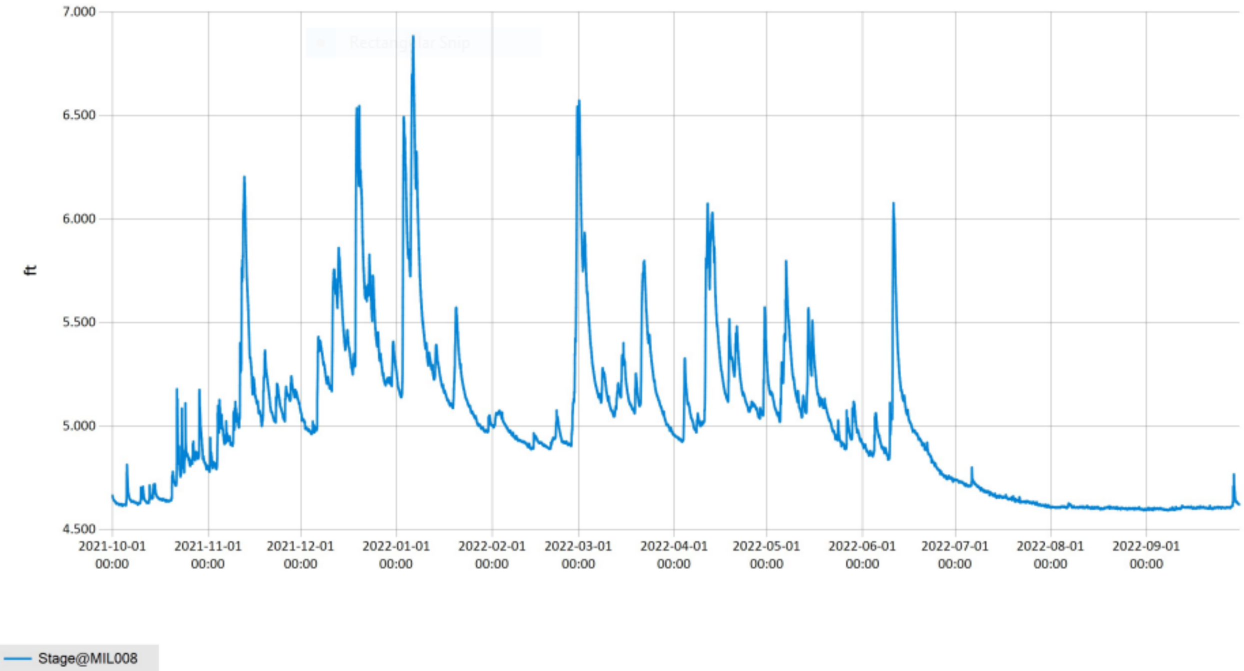

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CLEAN WATER

Time Series Data Report

15-minute Stage (ft.) at Westover Creek (WST020) Water Year 2022

Sep 25, 2023 | 1 of 1

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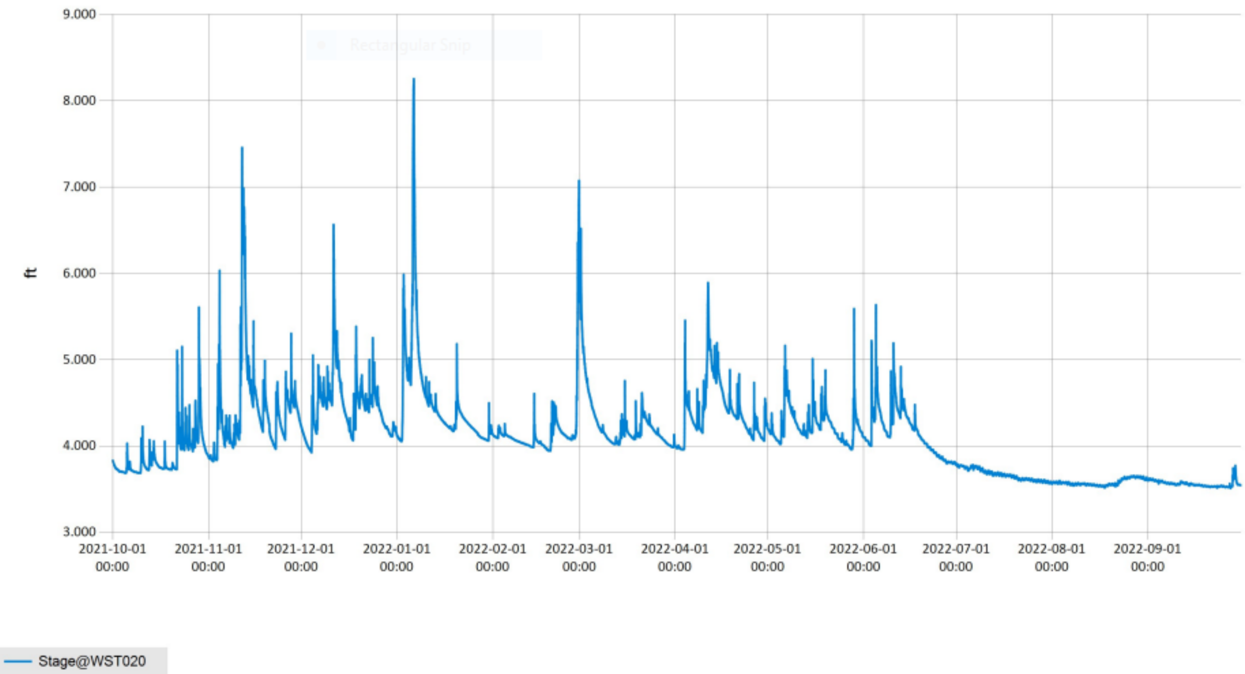

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Time Series Data Report
15-minute Stage (ft.) at Dwyer Creek (DWY020) Water Year 2022

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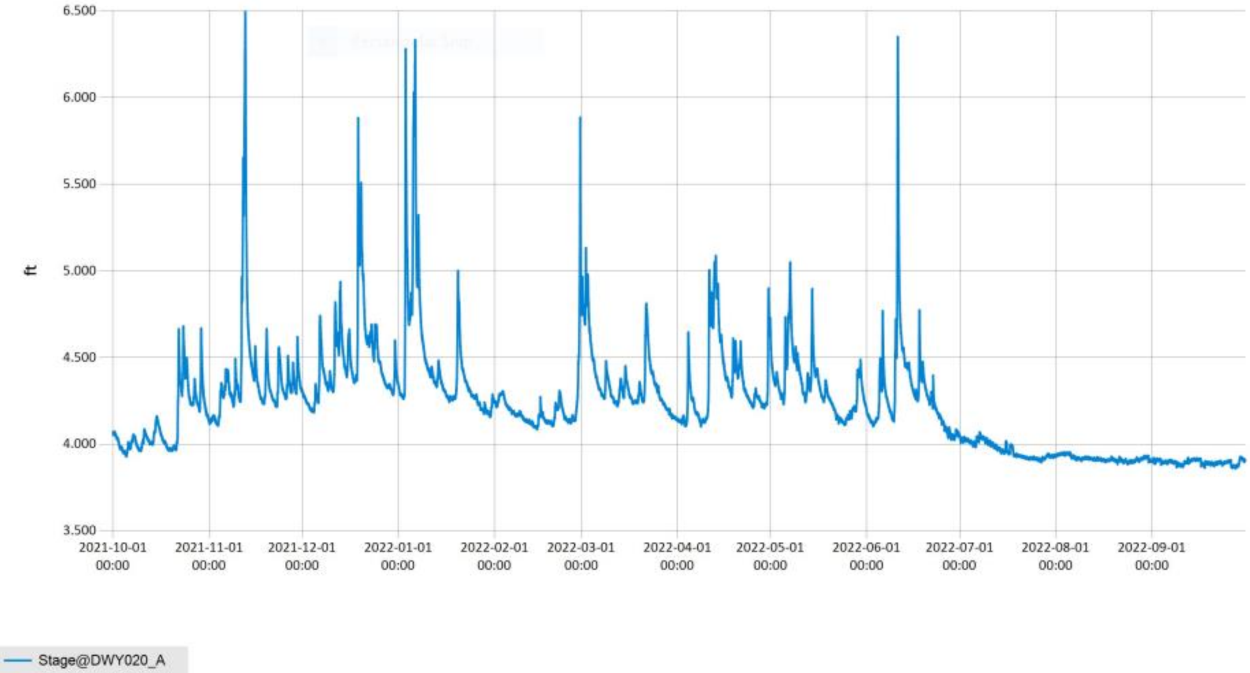

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Time Series Data Report

15-minute Stage (ft.) at Suds Creek (SUD010) Water Year 2022

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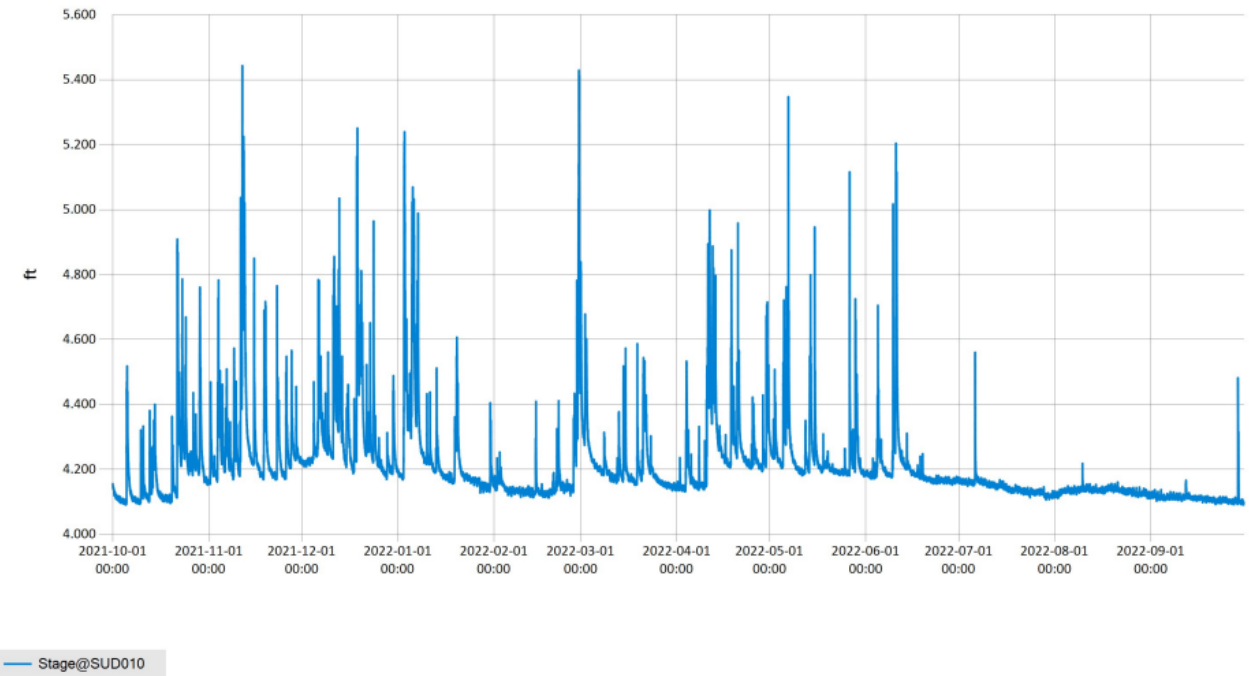

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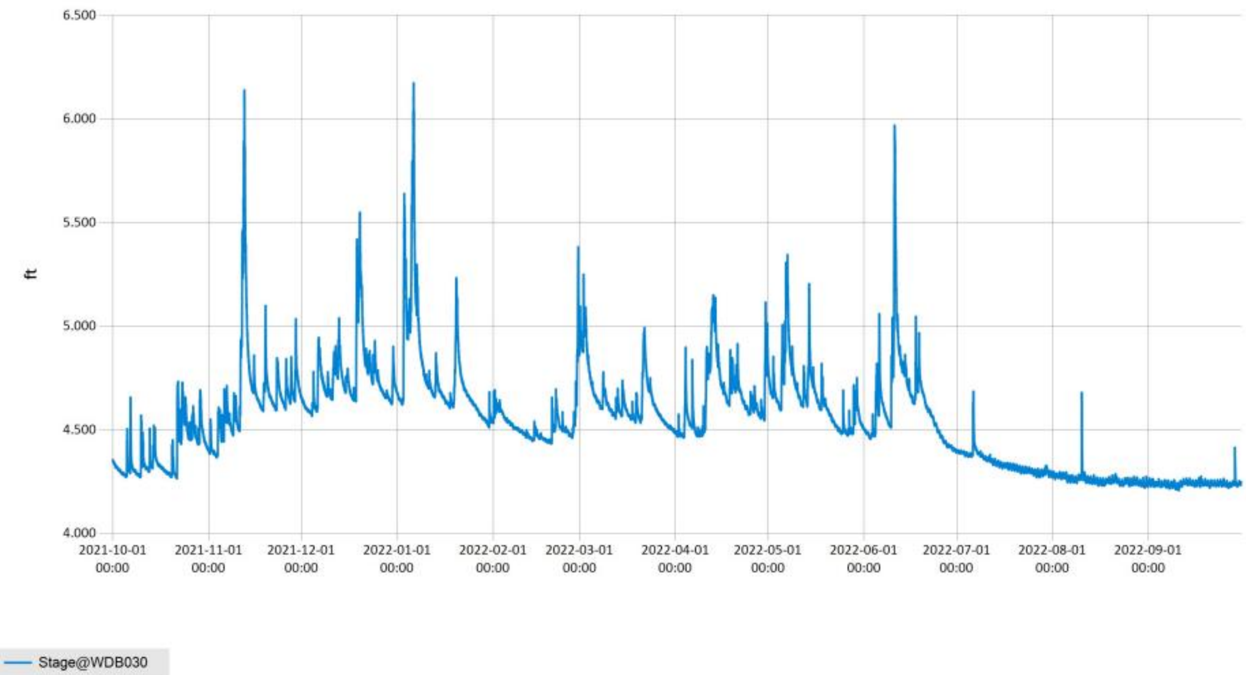
Time Series Data Report
15-minute Stage (ft.) at Woodburn Creek (WDB030) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00



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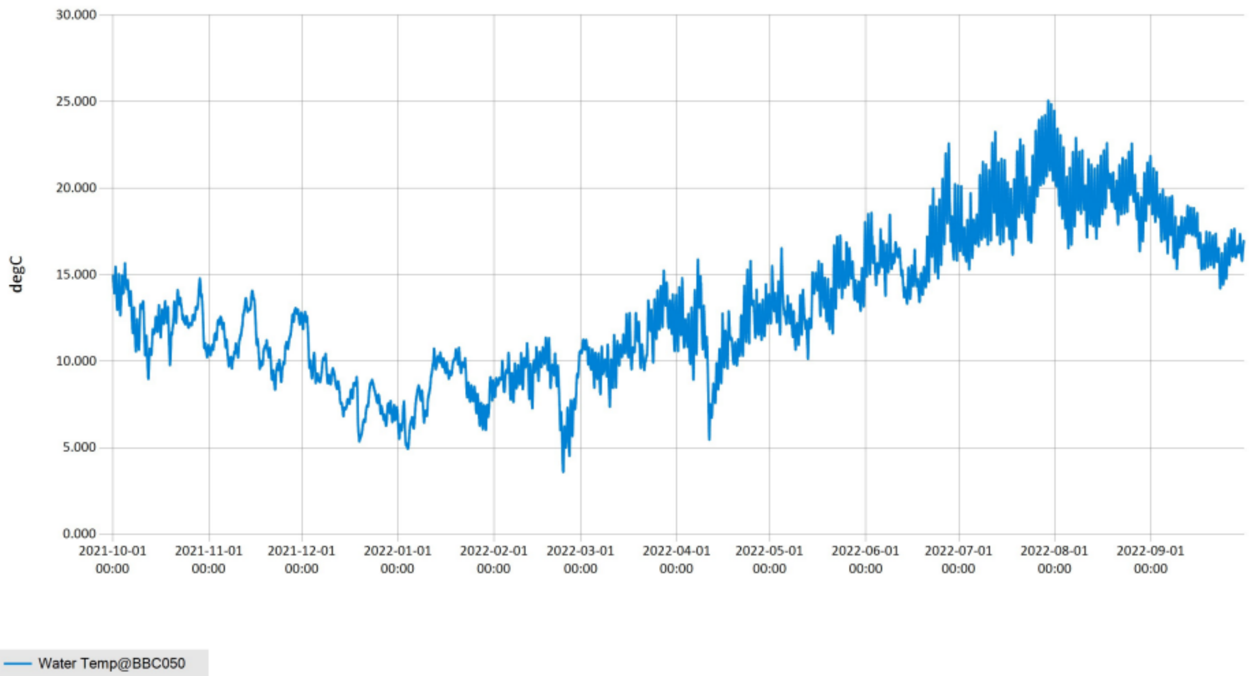
Time Series Data Report
15-minute Water Temp (deg C) at Burnt Bridge Creek (BBC050) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00



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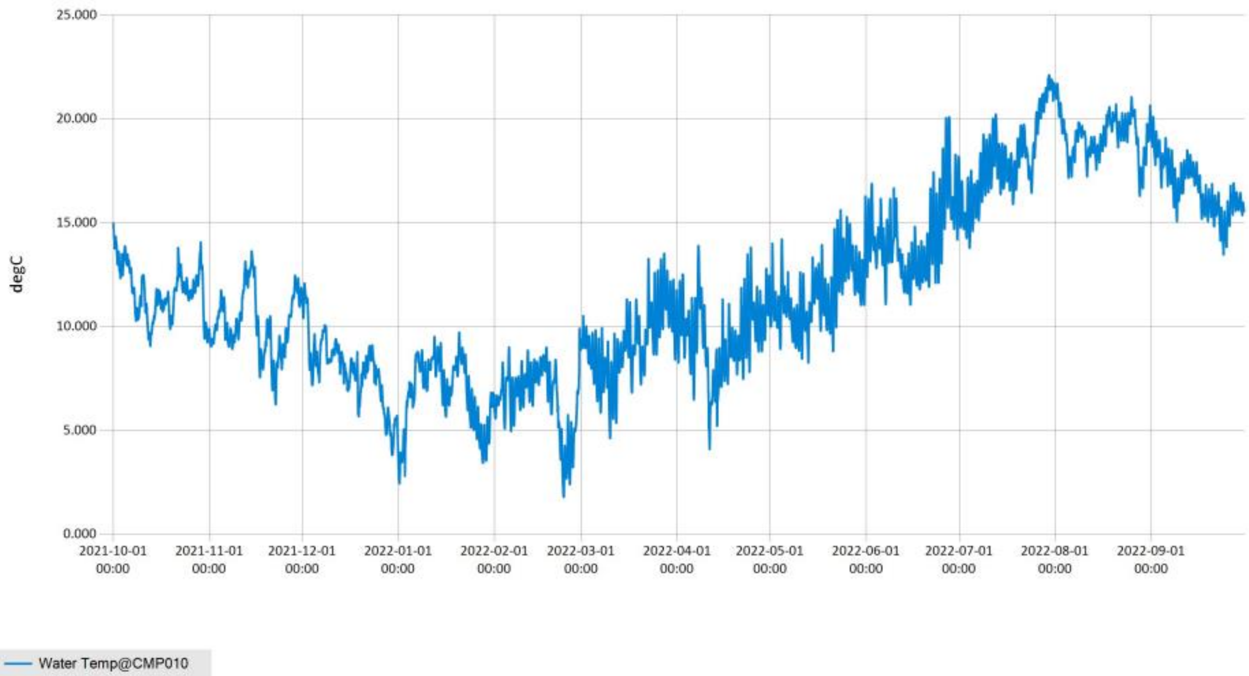
Time Series Data Report

15-minute Water Temp (deg C) at Campen Creek (CMP010) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00



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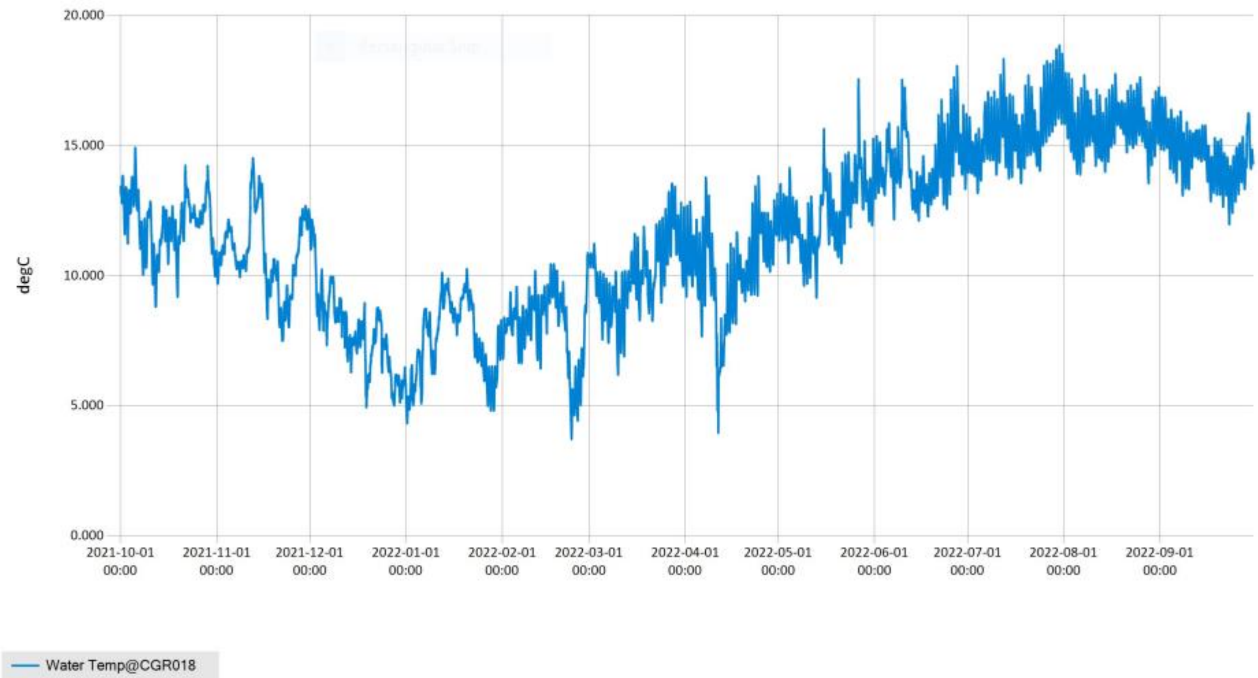
Time Series Data Report
15-minute Water Temp (deg C) at Cougar Creek (CGR020) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00



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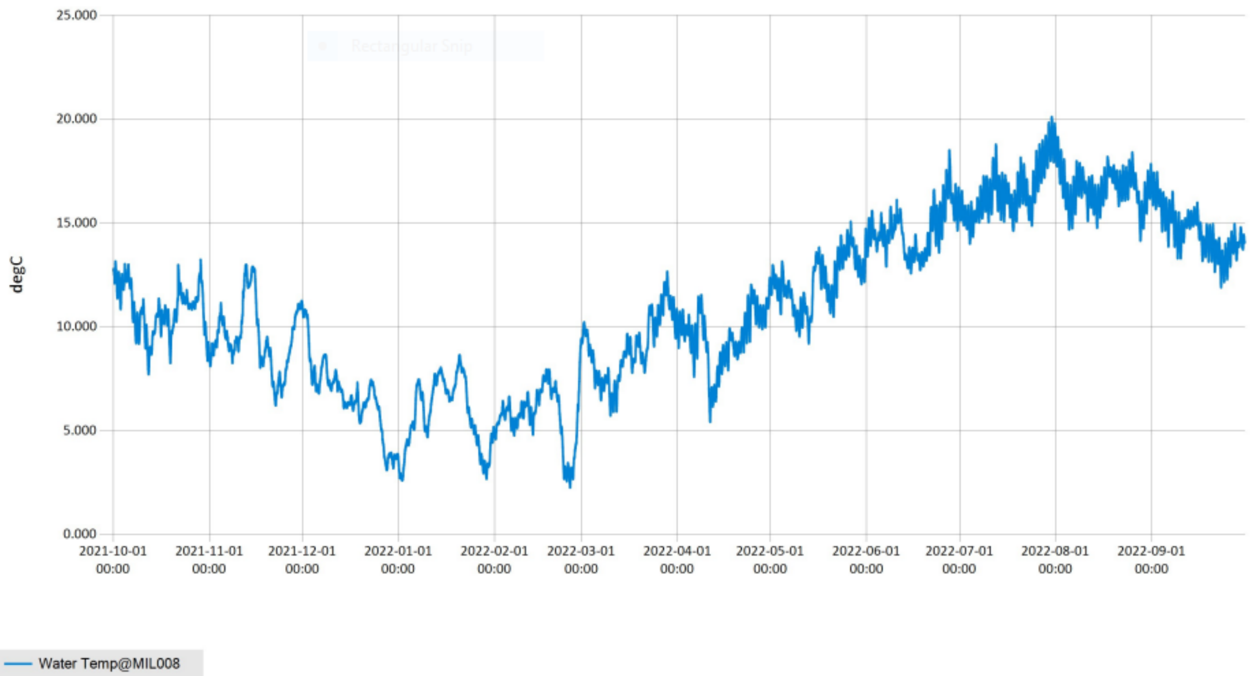
Time Series Data Report
15-minute Water Temp (deg C) at Mill Creek (MIL010) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00



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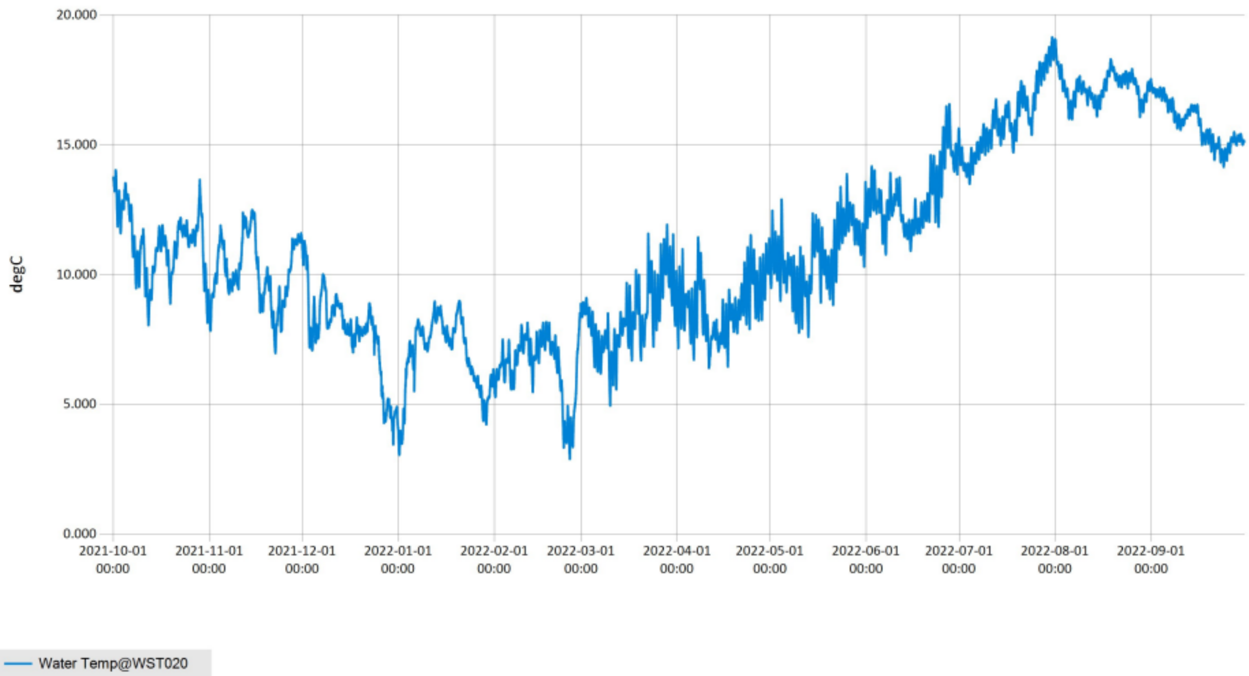
Time Series Data Report

15-minute Water Temp (deg C) at Westover Creek (WST020) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00



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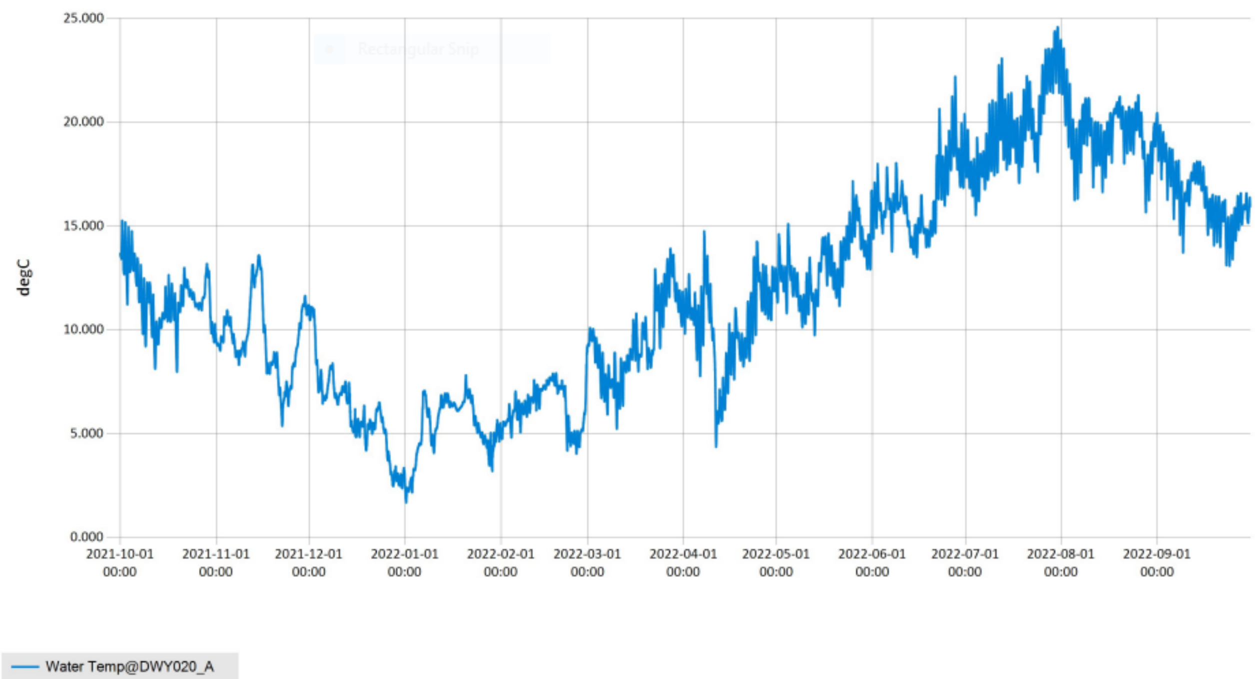
Time Series Data Report

15-minute Water Temp (deg C) at Dwyer Creek (DWY020) Water Year 2022

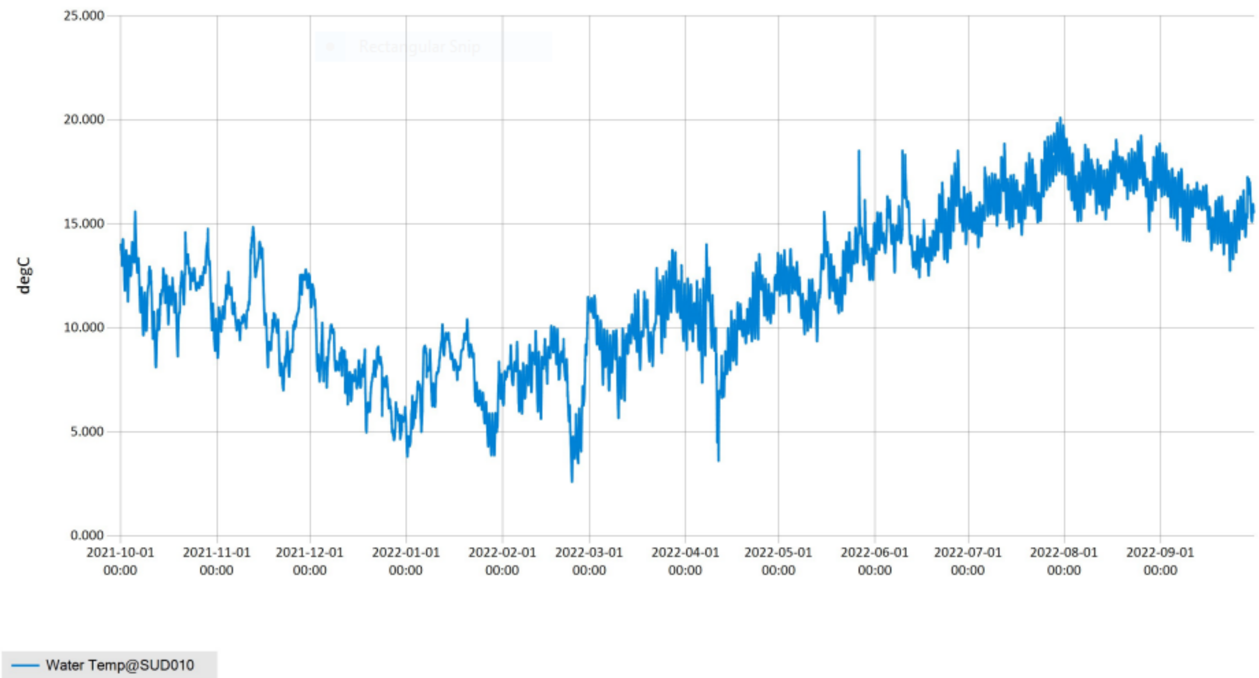
Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59   UTC Offset: -08:00



Time Series Data Report

15-minute Water Temp (deg C) at Suds Creek (SUD010) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59   UTC Offset: -08:00



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Time Series Data Report
15-minute Water Temp (deg C) at Woodburn Creek (WDB030) Water Year 2022

Period Selected: 2021-10-01 00:00 - 2022-09-30 23:59 UTC Offset: -08:00