



Learning By Doing 2022 Aquatic Resource Monitoring Plan



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Aquatic Resource Monitoring Plan Overview

The cooperative partners of Learning By Doing (LBD) are required through two intergovernmental agreements (IGA) to design and implement an Aquatic Resource Monitoring Plan (Plan). The purpose of the Plan as defined in the IGAs is to *“implement a monitoring plan to identify undesirable changes in, and agree upon desired modifications to, the aquatic environment, and to measure the effectiveness of actions taken to protect or improve the aquatic environment.”* Further, the Plan sets agreed-upon goals that *“rely on existing data and new data gathering under existing programs to provide the primary source of information for designing the management goals and for prioritizing those goals and reaches where the goals will be applied.”* (IGA, 2012)

The Plan is developed on an annual basis by the LBD Monitoring Subcommittee following the approved process outlined in the LBD guidance document, Aquatic Resource Monitoring Planning Process (Learning By Doing Monitoring Subcommittee, May 1, 2019). The Plan is applicable to the Cooperative Effort Area (CEA), which includes the Colorado, Fraser and Williams Fork River Basins, upstream of the Colorado River confluence with the Blue River.

The Plan achieves the following goals:

- Fosters an understanding of aquatic resources;
- Aids in effective decision making;
- Identifies changes in the aquatic environment;
- Identifies critical stream reaches;
- Highlights desired improvements, operations and management decisions;
- Prioritizes action steps;
- Evaluates effectiveness of restoration or other actions taken, including application of flow enhancements.

Plan Objectives

Monitoring priorities and objectives are evaluated on an annual basis. Objectives can be broad, such as monitoring aquatic health over the entire CEA, or they can be focused on monitoring changes that result from restoration projects. Therefore, the Plan objectives are dynamic and change from year to year in order to meet the established goals. The objectives of the 2022 Plan are to:

- Compile and summarize existing monitoring activities;
- Maintain a comprehensive stream temperature monitoring network to identify critical areas for stream temperature and to inform environmental water releases and evaluate their effectiveness;



- Assess sediment and characterize bed particle size distribution to evaluate flushing flows, accumulation of fines, and macroinvertebrate and fish spawning habitat;
- Assess the health of macroinvertebrate communities and monitor trends and changes;
- Ensure adequate monitoring in stream segments that are currently listed on Colorado's 303(d) List of Impaired Waters and identify segments in need of more monitoring;
- Assess the population and distribution of fish;
- Document riparian vegetation monitoring in the CEA;
- Document restorations projects within the CEA.

A detailed sampling plan for each objective follows. Unforeseen circumstances can result in changes to the sampling plans.

Summary of Existing Monitoring Efforts

A summary of all monitoring efforts conducted within the CEA is compiled every few years. Appendix B – Monitoring Summary was last updated in 2018 and another update is slated for 2023. The monitoring summary is based on actual sampling that occurred during that year. LBD's monitoring is intended to complement existing monitoring efforts in the CEA; the summary is used to inform LBD's annual Plan.

Monitoring Summary Overview

Monitoring information is requested from and provided by several entities who collect data within the CEA. Information obtained includes site location, type of monitoring and frequency of sample collection. Several entities collect data within the CEA including:

- Bureau of Land Management (BLM)
- Colorado Department of Public Health and Environment/Water Quality Control Division (CDPHE/WQCD)
- Colorado Parks and Wildlife (CPW)
- Colorado River Water Conservancy District (River District)
- Denver Water
- East Grand Water Quality Board (EGWQB)
- Grand County (GC)
- Grand County Water Information Network (GCWIN)
- Learning By Doing (LBD)
- Northern Water
- Northern Water Municipal Subdistrict (Subdistrict)
- Trout Unlimited (TU)
- US Geological Survey (USGS)

While most of the entities listed collect data in the CEA every year, some do not. For example, the CDPHE only collects data in the CEA in certain years for review of water quality standards.

Given the number of different entities that collect data, there is a large amount of monitoring that takes place each year. In effort to normalize and streamline sampling efforts, each sampling station is assigned a river mile ID. The river mile ID is generated by mapping the geographic coordinates provided by the sampling entities and measuring how many miles away the site is from a reference point.

The river mile ID is composed of abbreviated text representing its water body (Table 1) followed by a numeric value representing the distance in miles. River mile zero is located at the most downstream portion of a waterbody, generally the confluence with a larger river. For the Colorado River, river mile zero is at the CEA boundary line,

which is the confluence with the Blue River. The river miles increase at upstream sites. For example, the river mile ID for the Colorado River 10 miles upstream of the boundary of the CEA is CR-10.

Assigning a river mile ID not only standardizes the naming convention of the sites but also allows for sites located in the same place but sampled by different entities to be grouped together as a single site. Table 1 lists the abbreviations used for the various waterbodies when assigning the River Mile IDs.

Table 1 - River Mile Abbreviations

River Name	Site Abbreviation	Group
Arapaho Creek	AC	Upper Co
Blue River	BL	Lower Co
Bobtail Creek	BC	Williams Fork
Cabin Creek	CB	Fraser
<i>Cabin Creek North Channel</i>	CBN	Fraser
<i>Cabin Creek South Channel</i>	CBS	Fraser
<i>Little Cabin Creek</i>	LCB	Fraser
Church Creek	CH	Upper Co
Colorado River	CR	Colorado
<i>North Fork of Colorado</i>	NF	Upper Co
Crooked Creek	CC	Fraser
East Inlet	EI	Upper Co
Elk Creek	EC	Fraser
Fraser River	FR	Fraser
Grand Lake	GL	Upper Co
Granby Reservoir	GR	Upper Co
<i>Granby Pump Canal</i>	GRP	Upper Co
Hurd Creek	HC	Fraser
McQuery Creek	MQC	Williams Fork
Meadow Creek	MC	Fraser
North Inlet	NI	Upper Co
Ranch Creek	RC	Fraser
<i>Ranch Creek Canal</i>	RCC	Fraser
Reeder Creek	RDC	Lower Co
Roaring Fork	RF	Upper Co
Shadow Mountain Reservoir	SM	Upper Co
Saint Louis Creek	STC	Fraser
Steelman Creek	SC	Williams Fork
Stillwater Creek	ST	Upper Co
Trail Creek	TR	Upper Co
Vasquez Creek	VC	Fraser
<i>Vasquez Creek Canal</i>	VCC	Fraser
<i>Little Vasquez Creek</i>	LVC	Fraser
Williams Fork	WF	Williams Fork
<i>Upper South Fork Williams Fork</i>	USF	Williams Fork
<i>South Fork Williams Fork</i>	SWF	Williams Fork
Willow Creek Reservoir	WC	Upper Co
<i>Willow Creek Pump Canal</i>	WCP	Upper Co
Windy Gap Reservoir	WG	Middle Co
<i>Windy Gap Pump Canal</i>	WGP	Upper Co



Since the CEA is large, the monitoring summary is geographically sectioned into smaller groups. The following groups are used:

1. Lower Colorado River – Blue River to Williams Fork
2. Middle Colorado River -Williams Fork to and including Windy Gap Reservoir
3. Upper Colorado River - Upstream of Windy Gap Reservoir to Headwaters and including the Three Lakes and Willow Creek Reservoir
4. Fraser River and Tributaries
5. Williams Fork and Tributaries

There are several types of monitoring that can occur at any given site. The monitoring summary uses four categories to group the type of sampling done at a site:

1. Water Quality – Includes analysis done at a laboratory (metals, nutrients, ions, etc.). This also includes measurements taken in the field (pH, temperature, flow, etc.).
2. Temperature – Time series data collected with a sensor placed in the stream.
3. Habitat – This includes macroinvertebrate, fish, sediment, and riparian area data collection.
4. Flow – Sites where there is a gaging station.

The monitoring summary includes four parts for each geographic section:

1. Map – The map shows the sites in the geographic section, labeled with the river mile ID and indicates what type of sampling is done at each site.
2. Station List – A list of the stations, which includes the river mile ID, the entity ID, a site description, the entity collecting data, and what type of data are collected at that site.
3. Parameter List – A table of parameters that are collected in the geographic section. Parameters are grouped by sampling entity.
4. Monitoring Plan – The sampling schedule, which shows when each parameter group is collected at each site. The plan is on a weekly schedule to account sampling that occurs several times during a month. The monitoring plan indicates where temperature and flow data are collected. Changes can occur in timing and frequency of sampling events; the timing of the sampling is estimated in the monitoring plan.

Monitoring Summary

A complete list of the monitoring sites with river mile ID and the corresponding Entity ID is found in Appendix A.

Although effort is made to get the most accurate information pertaining to other entities monitoring efforts, some assumptions still need to be made when putting

together the monitoring summary. In the existing monitoring summary these assumptions include:

- Denver Water collects quarterly and bi-annual samples at several sites. The quarterly samples were put into the monitoring summary in January, April, July and October. The biannual sampling was put into the monitoring summary in June and September.
- CPW collects fish data bi-annually and annually. The bi-annual sampling was put into the monitoring summary in April and September. The annual sampling was put into the monitoring summary in September.
- CPW monitoring is based on input from CPW, Fish Survey Reports and the Colorado River Ecology and Water Project Mitigation Investigations annual report.
- Information on monitoring efforts was not obtained from BLM. Monitoring done at sites in previous years was assumed to be continued. This includes monitoring at RDC-0.7 and WF-13.1.

One of the goals of the monitoring summary is to see where monitoring overlaps and try to streamline efforts. In the existing monitoring summary, there are only a few locations where there was duplicate monitoring:

- CR-22.1, CR-28.7, CR-31 – These locations are in the Colorado River downstream of and around Windy Gap Reservoir. CPW is collecting additional macroinvertebrate data at these sites prior to the start of the river habitat restoration project.
- RC-1.1 – There are two temperature monitoring locations in Ranch Creek, one maintained by the USGS and the other by GCWIN.
- FR-24 – Both the EGWQB and Denver Water collect water quality samples at this location.

The complete existing monitoring summary is found in Appendix B – Monitoring Summary.



2022 Stream Temperature Monitoring Plan

Stream temperature is critical to aquatic life health. The streams in the CEA support cold water fish and macroinvertebrate communities. Each cold-water fish species has a unique range of temperatures in which individuals can survive, and an even smaller range that supports optimal growth, survival, and reproduction. If frequent or sustained, above optimum temperatures can limit individual growth, and even higher temperatures can increase mortality, limit populations, and alter community structure. A robust stream temperature monitoring network in the CEA provides continuous temperature data to help assess thermal regimes and aid in aquatic life protection.

The LBD stream temperature monitoring program objectives are to:

- Complement existing stream temperature monitoring efforts;
- Provide the LBD Operations Subcommittee with timely data to make informed decisions about releases of environmental water;
- Provide continuous stream temperature data to evaluate effectiveness of environmental water releases;
- Identify critical stream reaches for water temperature;
- Assess compliance with Colorado's stream temperature standards;
- Monitor and assess impacts of restoration efforts performed by LBD.

Data collected through this program are collected in accordance with and assessed against the state of Colorado's temperature standard criteria (Colorado Department of Public Health and Environment, Water Quality Control Division, March 2019) (Colorado Department of Public Health and Environment, Water Quality Control Commission, June 2019).

This program is reviewed annually.

Existing Temperature Monitoring Network

The existing temperature monitoring network consists of 67 locations in the CEA (one location is monitored by two entities). Several entities maintain these sites: The Bureau of Land Management, Grand County Water Information Network (GCWIN), Northern Water and the U.S. Geological Survey. Many stakeholders provide financial support to maintain the existing program; these stakeholders include LBD members as well as non-LBD members. A map of the 2022 monitoring sites is shown in Figure 1.

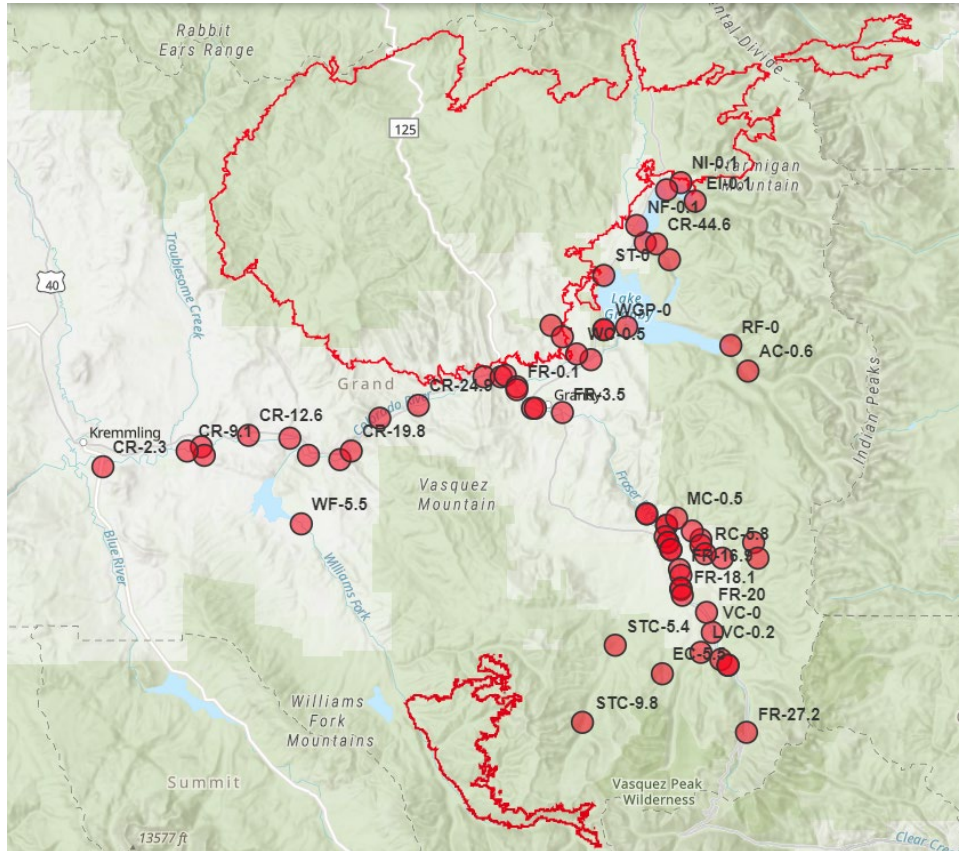


Figure 1 - Temperature Monitoring Sites in the CEA

2022 Changes to Temperature Monitoring Plan

The existing stream temperature monitoring network was analyzed for data gaps with respect to timeliness (is the data available when it is needed), impaired waters designation, spatial coverage, diversions, historical data, and the need for baseline data. Based on this assessment, all sites monitored in 2021 will be monitored again in 2022. There are no additional sites to add in 2022.

A contingency budget will be kept for additional visits to some sites potentially effected by heavy debris in fire impacted areas. The two sites are WC-0.5, and WC-2.3. The visits will include the continuation of photo documentation for each visit to the potentially effected sites. Maps of the fire perimeter and these three site locations are shown below in Figures 2 and 3.

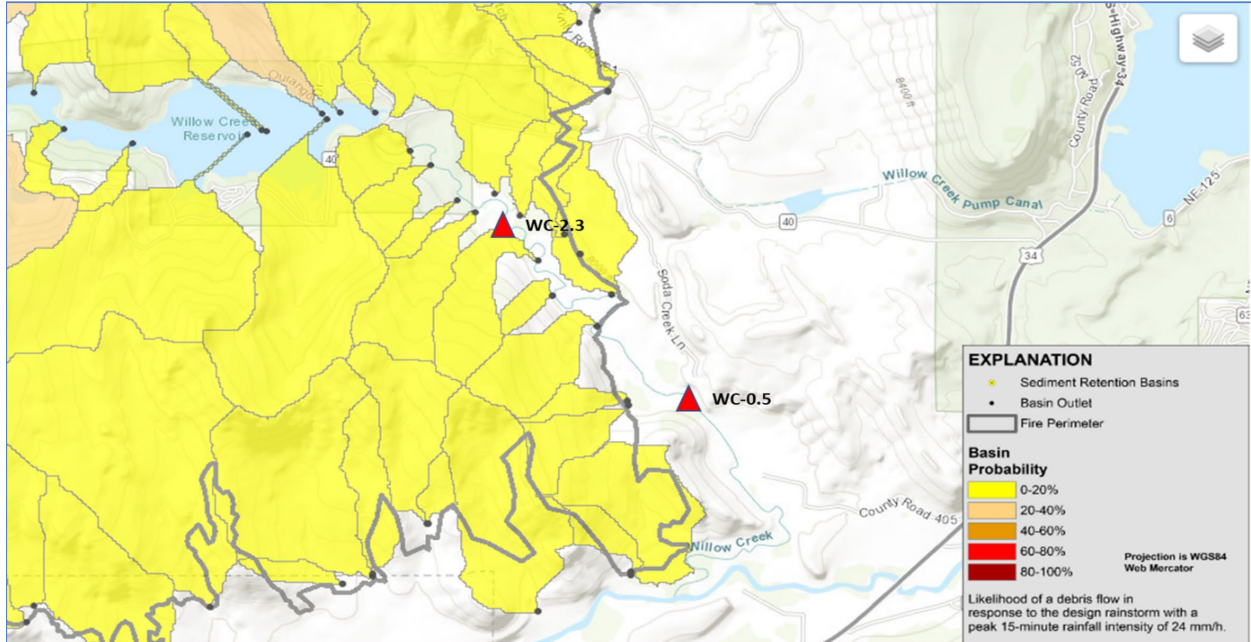


Figure 2 – East Troublesome Fire perimeter in relation to stream temperature sites on Willow Creek.

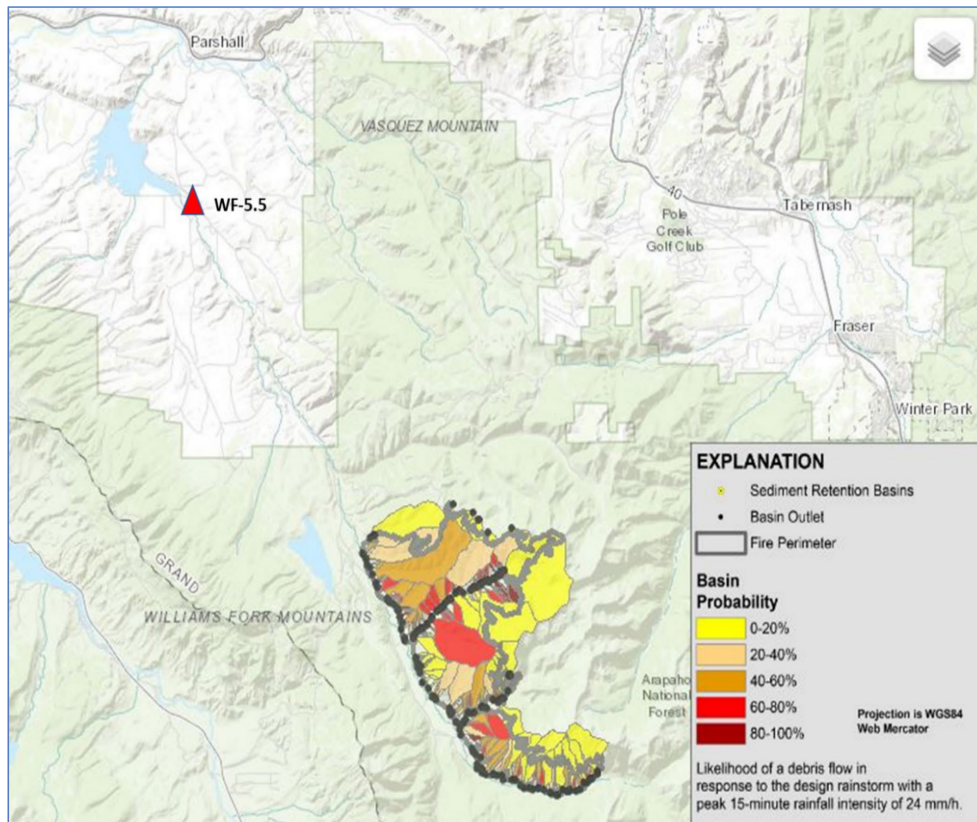


Figure 3 – Williams Fork Fire perimeter in relation to the stream temperature site on the Williams Fork River.



Changes to Monitoring Locations

LBD will retain its 11 temperature sites that were monitored in 2021 (Table 2). No changes to monitoring locations will occur in 2022.

Changes in Timeliness of Data Transmission

Review of the current schedule for data downloads and processing showed that there was sufficient information available to inform operation discussions during the weekly LBD Operations Subcommittee calls. Therefore, no changes were made to the frequency of data transmission for 2022. A contingency budget will be kept so that two more sites can be monitored on a weekly basis. These sites are located within or downstream of fire impacted areas.

2022 LBD Temperature Monitoring

The 2022 LBD temperature monitoring program consists of 11 sites (Table 2). At two sites, data are downloaded, compiled, and distributed to the LBD Operations Subcommittee on a weekly basis from June 17 - September 15. At the remaining 9 sites, data are download biweekly from April – October and the data are compiled and shared at the end of the monitoring season.

Table 2 – 2022 LBD Temperature Monitoring Plan

River Mile ID	Station Description	Latitude	Longitude	Download Frequency
STC-5.4	St Louis Creek at Fraser Experimental Forest HQ	39.907710	-105.87951	Bi-weekly
STC-0	St Louis Creek upstream of confluence with Fraser River	39.95175	-105.81471	Weekly (Jun - Sep)
RC-5.8	Ranch Creek upstream of revegetated area	39.978214	-105.79187	Bi-weekly
RC-5.1	Ranch Creek downstream of revegetated area	39.984244	-105.79467	Bi-weekly
FR-15	Fraser River upstream of Fraser Flats River Habitat Project	39.981338	-105.82494	Bi-weekly
FR-14.4	Fraser River downstream of Fraser Flats River Habitat Project	39.986438	-105.82738	Bi-weekly
FR-3.5	Fraser River at Hwy40 in Granby	40.081027	-105.93127	Weekly (Jun - Sep)
WC-2.3	Willow Creek upstream of Bunte Highline Ditch	40.136965	-105.92881	Bi-weekly
WC-0.5	Willow Creek upstream of confluence with Colorado River	40.123601	-105.91284	Bi-weekly
CR-2.3	Colorado River upstream Hwy 9 Bridge in Kremmling	40.0421	-106.3714	Bi-weekly
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	39.999510	-106.17946	Bi-weekly

Station Operation, Maintenance and Data Delivery

Except for CR-2.3, GCWIN maintains all the stations in the LBD temperature monitoring program. CR-2.3 is maintained by the BLM.

Station Operation

Stream temperature monitoring follows guidelines set forth in the SOP, [2020 GCWIN Stream Temperature Monitoring Protocols](#). The manual includes quality assurance and quality control (QAQC) protocols. A field logbook is filled out for each site visit.

Station Maintenance Protocol:

- GCWIN/BLM will install HOBO Water Temp Pro v2 Data-loggers (Part # U22-001, Onset Computers, Inc., Bourne, Massachusetts) All sensors will be calibrated using the 2-point water bath method. Sensors outside of the range including +/- 0.1 °C annual drift will not be used.
- Sensors with a battery voltage below 2.4 V will not be used.
- All sensors use the same shuttle for downloading data to a computer – Onset's Hobo Optic USB Base Station U-4.
- Sensors are set to record data every 15 minutes, i.e. at 0:00, 0:15, 0:30, and 0:45 minutes on the hour. They record temperature in °C as well as recording battery voltage.
- For sensors not deployed year-round, place in river before May 1st.
- Ideally sensor is placed in the thalweg, or mid-50% of stream width, assuming these locations are in flowing water. Above all, sensor needs to be located in flowing, deep water.
- If sensor is not in the thalweg/mid 50%, it needs to be placed in a minimum of 18" of flowing water, preferably in the river "bubble line". The water needs to be sufficiently flowing so silt does not accumulate on sensor and flow is comparable to that seen in thalweg.
- Data handling includes download, QA/QC, post-processing, storage, and distribution of temperature data.

Additional Protocols Added for 2022 Monitoring:

- Field technician will take photos at any site where the rig is found displaced, or anytime photo documentation would provide helpful visual information.
- At stream temperature sites potentially impacted by the fire area, photos will be taken each site visit.
- Three photos will be taken. Looking upstream, looking downstream, and looking across the river/site.
- Field technician will take additional written notes regarding field conditions.

Data Management

Data management includes download, QAQC, storage, and distribution of temperature data. GCWIN's Executive Director conducts final QAQC on all stream temperature data. Data from sites with weekly downloads are provided to the LBD Operations Subcommittee in an agreed upon timeframe to support operational

decisions regarding environmental water releases. The final stream temperature data are provided to LBD in an Excel spreadsheet by December 1 of each year. The data are stored in GCWIN's database, which is publicly accessible.

Rig construction

Rig considerations for potential increased debris during spring runoff.

- Field staff will add an extra rope to secure the rig to the riverbank. This gives the rig two tie down points for added security.
- Field staff have drilled larger holes into all sensor housing rigs.
- 3 fail safe attachments for rig housing.
 - U-bolt
 - Wire cable (attached to rope and sensor)
 - Zip tie



Photo 1. Stream temperature sensor rig and housing



Photo 2. Wire cable and rope. Not pictured: sensor tied to rope

Funding

Costs for the 2022 temperature monitoring are shared among some LBD partners. The partners each pay a percentage of the total cost. The cost distribution for 2022 is:

LBD Partner	Contribution %
Grand County	25%
Denver Water	25%
Northern Water/Subdistrict	25%
River District	8.3%
TU	8.3%
LBD	8.3%

2022 Sediment Monitoring Plan

Aquatic life can be impacted by human-caused deposition of excessive sediment on stream and river bottoms, resulting in the loss of critical habitat for fish and macroinvertebrates, disrupting food-web dynamics, and reducing reproductive success. Harmful impacts can include smothering of gravels and cobbles in important spawning and feeding habitats, and the filling of interstitial spaces and pool habitat with fine sediments. These conditions may result in habitat loss for macroinvertebrates, a resultant reduction in fish food sources, and smothering and loss of oxygenation in important fish spawning habitats. Other undesirable impacts of sedimentation can include population changes to more pollution tolerant macroinvertebrate species, and extirpation of sensitive species (Colorado Water Quality Control Commission, Department of Public Health and the Environment, 2014).

The following is a summary of the LBD 2022 Sediment Monitoring Plan within the CEA. The objectives of the 2022 LBD sediment monitoring program are to:

- Collect data as needed to evaluate flushing flows in key reaches within the CEA;
- Report on physical conditions in the riffles at macroinvertebrate monitoring locations;
- Assess sediment size and embeddedness in trout spawning habitat in a manner that is compliant with the [Colorado Water Quality Control Commission Narrative Sediment Policy 98-1](#);
- Monitor changes in particle distribution within the CEA, including the accumulation of fine sediment in interstitial spaces;
- Evaluate algal conditions within the streambeds of the CEA.

Existing Sediment Monitoring

In 2010, monitoring of river “substrate” began “...to document the habitat quality of select trout spawning bars along the Fraser and Colorado Rivers within Grand County in response to the annual stream flow regimes” (Tetra Tech and HabiTech, 2018). In 2019, what was formerly termed “substrate” sampling was changed to “sediment” sampling in order to be consistent with the Colorado Water Quality Control Commission (WQCC) *Guidance for Implementation of Colorado’s Narrative Sediment Standard Regulation #31, Section 31.11(1)(a)(i), Policy 98-1*. Sediment sampling has historically consisted of core sampling and pebble counts associated with fish spawning habitats, pebble counts associated with macroinvertebrate habitat, Riffle Stability Index (RSI) measurements and evaluation of algal conditions.

Core Sampling in Trout Spawning Habitat:

A quantitative method used to assess fine sediment in trout spawning beds involves identifying trout spawning bars from fish redd surveys in the fall and sampling with a



McNeill-Ahnell¹ core sampler, which is 15 cm in diameter and 6 inches deep. The sampler is pushed into the gravel bed as far as it will go, and then the core is removed and sifted and sieved to identify particle size in the sample. The method is best suited for evaluating salmonid spawning sites with smaller substrate, such as pebbles and gravel. Samples can be sorted on site with sieves ranging from 75 to 0.074 mm, or sent to a lab for dry sieve analysis.

A 150 ml suspended sediment sample should also be collected from the water/fine sediment mixture remaining in the core sampler, and results should be reported in mg/L. This provides an estimate of the fine sediments, such as silt and clay that are also within the spawning bed.

Several years of core sample collections during high flow years have yielded similar results and have resulted in a recent emphasis on core sampling only during low flow years. Data collected will be compared to past data from the CEA.

¹ McNeil, W.J. and W.H. Ahnell (1964) Success of pink salmon spawning relative to size of spawning bed materials. US Fish and Wildlife Special Scientific Report, Fisheries No. 469. US Department of Interior, Washington DC

Table 3: Core Sampling Site Locations

River Mile ID	Site Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
FR-5.5	Fraser River between the Fraser Canyon and Granby (Granby Ranch)	X	X	X	X	X	X	X	X			X	X	X
RC-1.1	Ranch Creek below Meadow Creek (Miller Property)	X	X	X		X			X			X	X	X
CR-22.9	Colorado River upstream of Hot Sulphur Springs WTP (X ⁴)	X ¹	X ¹	X ²	X ²	X ³	X ³	X ³	X ³	X ³		X ⁴	X ⁴	X ⁴
CR-14.9	Downstream of Williams Fork confluence and Parshall	X	X	X	X	X	X	X	X	X		X	X	X
CR-9.1	Downstream of KB Ditch	X	X	X	X	X	X	X	X	X		X	X	X

No core sampling in 2019

X¹ CR4 Chimney Rock was discontinued in 2011 due to absence of spawning beds.

X² CR4 Paul Gilbert discontinued in 2014 due high flows cut off and dewatered the spawning channel site.

X³ below Hot Sulphur Springs Resort sampled until 2018. Due to consultant changes this site has been sampled at CR-22.9(X⁴) since 2020.

Modified Wolman Pebble Counts^{2,3}:

This widely used method samples coarse riverbed material in streams as a way of estimating cumulative distribution of grain sizes and the degree of embeddedness. It is a geomorphic measure, which is a good method for identifying median bed particle size.

Pebble counts will be conducted at all macroinvertebrate sites with the sampling grid method and a Gravelometer as required by Colorado WQCD Policy 98-1 (Table 4). Pebble counts are also used to assess salmonid spawning bars and macroinvertebrate habitats by utilizing the Sediment Tolerance Indicator Value (TIV_{SED}) as defined in Policy 98-1 (Colorado Water Quality Control Commission, Department of Public Health and the Environment, 2014).

Algae Presence and Embeddedness:

Percent algal cover and percent embeddedness will be estimated concurrent with pebble counts in 2022. For assessment of algae, a viewing bucket (a bucket with a

² Wolman, M.G. (1954) A method of sampling coarse river-bed material. Transactions American Geophysical Union 35(6) p. 951-956

³ Bevenger, G.S. and R.M. King (1995) A Pebble Count Procedure for Assessing Watershed Cumulative Effects. USDA Forest Research Paper, RM-RP-319

clear bottom and intersection markings) was employed which measures the percentage of grid intersections where algae are present. A subset of the 400 particles picked up during the pebble counts across 10 transects were measured to find the depth to which they were buried in sediment to estimate the percent embeddedness. Photographs will be taken at each site during the survey to document representative observations and to calibrate surveys over time.

Table 4: Pebble Count and Algae Assessment Site Locations

River Mile ID	Station Description	Monitoring Frequency	Years Monitored						
			2017	2018	2019	2020	2021	2022	
FR-27.2	Fraser River upstream Jim Creek/Mary Jane entrance	1x/2-3 yrs		X					X
FR-25.1	Fraser River upstream of UP Railroad discharge	1x/2-3 yrs			X	X	X		
FR-23.4	Fraser River upstream of Winter Park San District	Annually	X	X	X	X	X	X	
FR-20	Fraser River at Rendezvous Bridge	Annually	X	X	X	X	X	X	
FR-15	Fraser River upstream of Fraser Flats restoration	1x/2-3 yrs	X	X	X	X	X		
FR-14	Fraser River upstream of Tabernash	Annually	X	X	X	X	X	X	
FR-12.4	Fraser River upstream of Fraser Canyon	1x/2-3 yrs	X			X			
FR-1.9	Fraser River upstream of Granby Sanitation District	1x/2-3 yrs	X		X			X	
STC-0	Saint Louis Creek at Fraser River	1x/2-3 yrs		X	X				X
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	X	X	X	X	X	X	X
CR-31	Colorado River upstream Fraser and Windy Gap	Annually	X	X	X	X	X	X	X
CR-28-7	Colorado River downstream of Windy Gap	Annually	X	X	X	X	X	X	X
CR-24.9	Colorado River at Sheriff Ranch	1x/2-3 yrs							X ^{new}
CR-22.9	Colorado River upstream of Hot Sulphur Springs WTP	Annually	X	X	X	X	X	X	X
CR-16.7	Colorado River upstream of Williams Fork	Annually	X	X	X	X	X	X	X
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	Annually	X	X	X	X	X	X	X
CR-7.4	Colorado River downstream Troublesome Creek	Annually		X	X	X	X	X	X
CR-1.7	Colorado River upstream of the Blue River	Discontinued		X	X	****		X	
CR-TBD	Colorado River in ILVK Project Area	1x/2-3 yrs							X ^{new}
WC-TBD	Willow Creek in Project Area	TBD – project based							X ^{new}

****Site was sampled qualitatively. Reach not wadeable due to being entirely soft, fine substrate.
X^{new} New sampling sites approved for 2022.

Riffle Stability Index (RSI):

This method estimates the mobile sediment fraction in a river's riffle, that is, how the riverbed is shifting in response to flow. It is another geomorphic measure, revealing how substrate is moving in riffles, not a habitat measure that provides a metric that estimates the quality of habitat. A river receiving excessive sediment will have smaller, finer particles accumulated in the riffle when compared to a river in dynamic equilibrium without excessive sedimentation. Riffle Stability Index values greater than 70 indicate a riffle that is somewhat loaded with sediment, and values greater than 85 indicate excess sediment. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for aquatic life.

To be able to compare historic data and move towards sampling in riffles, RSI measurements are recommended at three of the historical sediment core sample sites and six macroinvertebrate sites.

Table 5: Riffle Stability Index Site Locations

River Mile ID	Site Description	2014	2015	2016	2017	2018	2019	2020	2021	2022
FR-5.5	Fraser River between the Fraser Canyon and Granby (Granby Ranch)	x	x	x	x			x		x
RC-1.1	Ranch Creek below Meadow Creek (Miller Property)	x	x	x	x			x		x
CR-22.9	Colorado River upstream of Hot Sulphur Springs WTP	x	x	x	x		x	x	x	x
CR-14.9	Downstream of Williams Fork confluence and Parshall	x	x	x	x				x	
CR-9.1	Downstream of KB Ditch	x	x	x	x		x	*	x	
FR-27.2	Fraser River upstream Jim Creek/Mary Jane entrance									x
FR-25.1	Fraser River upstream of UP Railroad discharge									
FR-23.4	Fraser River upstream of Winter Park San District						x	x		x
FR-20	Fraser River at Rendezvous Bridge						x		x	
FR-15	Fraser River upstream of Fraser Flats restoration						x	x		x
FR-14	Fraser River upstream of Tabernash						x		x	
FR-12.4	Fraser River upstream of Fraser Canyon									
FR-1.9	Fraser River upstream of Granby Sanitation District						x		*	x
STC-0	Saint Louis Creek at Fraser River									x
RC-1.1	Ranch Creek downstream of Meadow Creek							x		
CR-31	Colorado River upstream Fraser and Windy Gap						x		x	
CR-28-7	Colorado River downstream of Windy Gap						x	x	x	x



CR-16.7	Colorado River upstream of Williams Fork							x		x
CR-7.4	Colorado River downstream Troublesome Creek							x		
CR-1.7	Colorado River upstream of the Blue River – (discontinued)							x		

No RSI sampling in 2018
 *Site was supposed to be included but was erroneously omitted and was sampled in 2021 at no cost.

2022 Changes to Sediment Monitoring Plan

Generally, monitoring sites are intended to provide a long-term record. It is anticipated that only minor changes in the location of the sites would occur from one year to the next. During the annual review of the monitoring program, sites may be added or removed, especially in the short-term. As the sediment monitoring program for LBD is evolving, changes may need to take place in the list of sites to better meet the objectives of the program.

In 2022, annual monitoring was removed from FR-15 and FR-25.1, which will be monitored every 2-3 years due to a low likelihood of change at these sites and a need to monitor new projects. CR-1.7 was removed from monitoring entirely due to the site being dominated by fine substrate.

Three sampling sites were added this year. CR-24.9 was added to monitor the effectiveness of the Connectivity Channel as well as post-fire impacts from Drowsy Water Creek and Kinney Creek. WC-TBD will be located on Northern Water’s property in a section of Willow Creek where there is planned restoration. Data collected at WC-TBD in 2022 will represent pre-project conditions. CR-TBD will replace CR-1.7 as a monitoring site in the ILVK project area.

Historic core sampling at spawning beds will occur at all 5 sampling sites. Core sampling is our longest running dataset, and it is integral to maintain continuity.

2022 LBD Sediment Monitoring

Methods for sediment monitoring in 2022 will be the same that were used in 2021 and will build on historic monitoring efforts in the CEA. The changes outlined above are additional monitoring efforts to build upon the current monitoring program. Sediment monitoring in 2022 will be a comprehensive measure of the trout spawning and macroinvertebrate habitat.

Monitoring Sites and Sampling Frequency

The sediment monitoring plan includes:

- Sediment core sampling at all 5 of the historical core sample sites (Table 3).

- 400 count pebble counts that are compliant with Water Quality Control Commission Policy 98-1, and algae assessment at each of the 2021 macroinvertebrate sites (Table 4).
- RSI at 3 of the historical core sampling sites and at 6 riffle sites (Table 5).

In 2022, pebble counts will be collected to accompany all macroinvertebrate sampling sites, regardless of whether the macroinvertebrate site is part of a permit requirement, part of an existing monitoring program, or a new site as recommended by the LBD monitoring committee. All sampling will be conducted once in the early fall and within 2 weeks of the macroinvertebrate monitoring.

Table 6. Summary of 2022 Sediment Monitoring

River Mile ID	Station Description	400 Pebble Count/Algae/Embeddedness	RSI	Core Sample	Entity
FR-27.2	Fraser River upstream Jim Creek/Mary Jane entrance	X	X		LBD
FR-23.4	Fraser River upstream of Winter Park San District	X	X		LBD
FR-20	Fraser River at Rendezvous Bridge	X			LBD
FR-15	Fraser River upstream of Fraser Flats restoration	X	X		LBD
FR-14	Fraser River upstream of Tabernash	X			LBD
STC-0	Saint Louis Creek at Fraser River	X	X		LBD
RC-1.1	Ranch Creek downstream of Meadow Creek	X			LBD
CR-31	Colorado River upstream Fraser and Windy Gap	X			LBD
CR-28-7	Colorado River downstream of Windy Gap	X	X		LBD
CR-24.9	Colorado River at Sheriff Ranch	X			LBD
CR-22.9	Colorado River upstream of Hot Sulphur Springs Resort	X			LBD
CR-16.7	Colorado River upstream of Williams Fork	X			LBD
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	X			LBD
CR-7.4	Colorado River downstream Troublesome Creek	X	X		LBD/ILVK
CR-TBD	Colorado River TBD	X			LBD/ILVK
WC-TBD	Willow Creek TBD	X			LBD
FR-5.5	Fraser River between the Fraser Canyon and Granby (Granby Ranch)		X	X	LBD
RC-1.1	Ranch Creek below Meadow Creek (Miller Property)		X	X	LBD
CR-22.9	Colorado River upstream of Hot Sulphur Springs WTP		X	X	LBD
CR-14.9	Downstream of Williams Fork confluence and Parshall			X	LBD
CR-9.1	Downstream of KB Ditch			X	LBD



Data Reporting

Data analysis will be completed by the end of 2022, and a final report will be provided to LBD in early 2023.

Funding

Costs for the 2022 sediment monitoring are shared among some LBD partners. The partners have agreed to pay a percentage of the total monitoring cost based on the following allocation:

LBD Partner	Contribution %
Grand County	25%
Denver Water	25%
Northern Water/Subdistrict	25%
River District	8.3%
TU	8.3%
LBD	8.3%

In addition, ILVK funds 50% of the monitoring costs for the two sites in the Colorado River that are associated with the ILVK restoration project (CR-7.4 and CR-TBD). The remaining costs at these two sites were covered by the above LBD partners at their respective contribution percentage.



2022 Macroinvertebrate Monitoring Plan

Macroinvertebrate (aquatic organisms) communities are a good indicator of overall stream health. Macroinvertebrate communities are sensitive to a wide range of environmental disturbances and pollution. While water quality monitoring provides a snapshot of conditions at a specific time, it can fail to capture changes in water quality that may occur between sampling events. The effects of changes in water quality on macroinvertebrate communities can linger, making macroinvertebrate monitoring a good tool for detecting fluctuating environmental conditions. Changes in macroinvertebrate communities can signal impacts from urban development as well as changes in land use, the riparian habitat, or stream channel. Community diversity and presence (or absence) of certain sensitive species are indicators of the biological and ecological integrity of the rivers.

The following is a summary of the LBD 2022 macroinvertebrate monitoring plan within the CEA. The objectives of the 2022 LBD macroinvertebrate monitoring program are to:

- Complement existing monitoring efforts;
- Assess the existing state of macroinvertebrate communities in the CEA;
- Monitor trends and changes to the health of the macroinvertebrate communities;
- Assess compliance with Colorado's aquatic life standard;
- Monitor and assess impacts of restoration efforts performed by Learning by Doing.

Data collected through this program are assessed using the Colorado Water Quality Control Division's (Division's) Multi Metric Index (MMI) to determine compliance with Colorado's aquatic life standard (Colorado Department of Public Health and Environment, Water Quality Control Commission, Aug 2017). LBD has elected to compute additional standard metrics, including several key measurable indicator metrics, as a part of this program to provide a complete assessment of the macroinvertebrate community. The methods utilized are consistent with the Division's protocols for collection and analysis of macroinvertebrates.

This program is reviewed annually.

Existing Macroinvertebrate Monitoring

Existing macroinvertebrate monitoring consists of 29 sites in the CEA. Locations of the sites are included in Appendix A – Existing Monitoring Sites with River Mile and Entity Station Name.

Moffat Project and WGFP 401 Certification Compliance Monitoring

Denver Water and the Subdistrict are both required to conduct annual macroinvertebrate monitoring at 7 sites in the LBD CEA to comply with the conditions of the Moffat Project and Windy Gap Firming Project 401 Certifications (Colorado Department of Public Health and Environment, Water Quality Control Division, Moffat, 2016) (Colorado Department of Public Health and Environment, Water Quality Control Division, WGFP, 2016).

Denver Water's 401 Certification requirement includes 4 sites; 3 in the Fraser River and 1 in Vasquez Creek, upstream of Winter Park. The Subdistrict's 401 Certification requirement includes 3 sites on the Colorado River downstream of Windy Gap Reservoir. In addition, the Subdistrict annually monitors a site that is not part of its 401 Certification requirement but was deemed important to provide contextual information for the other 3 sites. In total, eight sites are included in the monitoring programs for Denver Water and the Subdistrict as shown in Table 6.

Table 6 - Denver Water and Northern Water's Subdistrict's Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Entity	401 Permit
FR-23.2	Fraser River upstream of Winter Park San District	Denver Water	Yes
FR-20	Fraser River at Rendezvous Bridge	Denver Water	Yes
FR-14	Fraser River upstream of Tabernash	Denver Water	Yes
VC-0	Vasquez Creek at the Town of Winter Park	Denver Water	Yes
CR-31	Colorado River upstream of Fraser and Windy Gap	Subdistrict	Yes
CR-28.7	Colorado River downstream of Windy Gap	Subdistrict	Yes
CR-22.9	Colorado River upstream of Hot Sulfur Springs	Subdistrict	Yes
CR-16.7	Colorado River upstream of Williams Fork	Subdistrict	No

Subdistrict's Habitat Project Macroinvertebrate Monitoring

The Windy Gap Firming Project 401 Certification requires macroinvertebrate monitoring within the Kemp Breeze Habitat Project to assess the effects of restoration. This condition requires pre-project monitoring at 2 sites. (Colorado Department of Public Health and Environment, Water Quality Control Division, WGFP, 2016). Restoration in the Kemp Breeze area downstream of Parshall, CO began in 2021. The Subdistrict collected samples at 3 sites in 2020. Sampling will occur at the same 3 sites 2 years after the project is complete.



Northern Water's Baseline Macroinvertebrate Monitoring

In addition to the macroinvertebrate monitoring the Subdistrict does to comply with the WGFP 401 Certification, Northern Water conducts baseline macroinvertebrate monitoring for the C-BT and Windy Gap Projects every 3-5 years. The last time Northern Water conducted baseline was in 2021. No baseline monitoring occurred in 2022.

2022 Changes to Macroinvertebrate Monitoring Plan

Generally, monitoring sites are intended to provide a long-term record. It is anticipated that only minor changes in the location of the sites would occur from one year to the next. During the annual review of the monitoring program, sites may be added or removed, especially in the short-term. As the macroinvertebrate monitoring program for LBD is evolving, changes may need to take place in the list of sites to better meet the objectives of the program. Sites that are established specifically to assess the effectiveness of restoration projects might be monitored on a short-term basis and have reduced sampling frequency or be discontinued once a post project baseline is established.

Criteria for Determining Sampling Frequency

Changes in macroinvertebrate communities can occur as a result of a variety of factors, such as land-use changes, pollution, hydrology, stream restoration, agricultural diversions, highway maintenance activities, and natural events such as droughts, floods and wildfire. Knowledge and understanding of activities taking place in the watershed should therefore inform the need for and frequency of sampling at any given site. Some amount of inter-annual variability is to be expected due to varying hydrology even at sites subject to stable watershed influences.

Assessment of the macroinvertebrates present can provide a good understanding of the current health of the community. The LBD program includes several metrics that are considered key measurable indicators of macroinvertebrate health; each has a defined numeric threshold that indicates the level of health of a community. (See *Reporting and Assessment Metrics* below).

Based on knowledge of activities in the watershed and scores of the key measurable indicators, the following guidelines can be used to inform monitoring decisions:

- Sites where there are good scores for the key measurable indicators and have no known/identified stressors likely to adversely impact macroinvertebrate communities can be sampled every 2–3 years.
- When available, historical data should be reviewed to evaluate potential changes or lack thereof. Sites displaying no changes in key measurable indicator



scores can be sampled every 2–3 years. Sites displaying a range of key measurable indicator scores should be sampled annually.

- Where impacts from changes in land-use, known stressors and/or restoration are expected, samples should be collected annually.

Changes to Sampling Frequency

In 2022 the monitoring frequency at FR-25.1 and FR-15 were changed from annually to once every 2 – 3 years. Although there are known water quality issues at FR-25.1 related to the unauthorized discharges from Union Pacific Railroad, there are man-made structures at this location that impede water movement. It is unlikely that the data will show significant changes from year to year. FR-15 was monitored to assess the effectiveness and improvements of the Fraser Flats Restoration Project, which was completed in 2017. A baseline of post-restoration data has been established.

New Monitoring Sites

After reviewing the spatial distribution of site locations and areas of known watershed disturbances, two new sites were added to LBD macroinvertebrate sampling program. Colorado River at Sheriff Ranch (CR-24.9) was added to monitor post-fire impacts from Drowsy Water Creek and Kinney Creek. Willow Creek in project area (WC-TBD) will be located on Northern Water's property in a section of Willow Creek where there is planned restoration. Currently, the restoration project is in the design phase, but will be a potential LBD project once the design phase is complete. Data collected in 2022 will represent pre-project conditions.

2022 LBD Macroinvertebrate Monitoring

The 2022 LBD macroinvertebrate monitoring program consists of 17 sites; 4 sites in the Colorado River, 1 site in a Colorado River tributary (Willow Creek), 6 sites in the Fraser River, 2 sites in Fraser River tributaries (Ranch Creek and Saint Louis Creek) and 4 sites in Williams Fork (Table 7). The monitoring frequency is site specific and varies from annual sampling to sample collection every 2–3 years. Several of the sampling locations are sites that will be monitored long-term to provide a baseline of data to track changes. Other sites are specific to restoration or anticipated restoration projects and may be monitored only for the duration of the project.

Table 7 lists all the macroinvertebrate sites monitored by LBD, indicates sampling frequency at each site, what years the sites were monitored, and which sites are project specific. For some of the new sites (added to the program in 2018 or 2019), a baseline data set needs to be established prior to determining what frequency monitoring will occur.

For 2022, macroinvertebrate sampling will be conducted at 11 out of the 15 LBD sites. The locations of the 2022 sampling sites are shown in Table 8. In the case of an unauthorized discharge event by UPRR, an additional sample will be collected at the site downstream of the discharge, but the timing of sample collection will be different.

Table 7 - LBD Macroinvertebrate Sampling Sites and Years Monitored

River Mile ID	Station Description	Monitoring Frequency	2017	2018	2019	2020	2021	2022	Project Specific
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane entrance	1x per 2-3 years		X ^{New}				X	No
FR-25.1	Fraser River upstream of UP Moffat Tunnel discharge	Annually			X ^{New}	X	X		No
FR-TBD	Fraser River downstream of UP Moffat Tunnel discharge	As needed			New		X ¹	X	No
FR-15	Fraser River upstream of Fraser Flats restoration	Annually	X	X	X	X	X		Yes
FR-12.4	Fraser River upstream of Fraser Canyon	1x per 2-3 years	X			X			No
FR-1.9	Fraser River upstream of Granby Sanitation District	1x per 2-3 years	X		X		X	X	No
STC-0	Saint Louis Creek at Fraser River	1x per 2-3 years		X ^{New}				X	No
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	X	X	X	X	X	X	No
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	Annually	X	X	X	X	X	X	No
CR-7.4	Colorado River downstream of Troublesome Creek	TBD		X ^{New}	X	X	X	X	Yes
CR-1.7	Colorado River upstream of the Blue River	TBD		X ^{New}	X	X	X		Yes
WF-13.1	Williams Fork downstream of Henderson Mill	1x per 2-3 years		X ^{New}			X		No
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	TBD		X ^{New}	X	X	X	X	Yes
WF-2	Williams Fork downstream of Williams Fork Reservoir	TBD		X ^{New}	X	X	X	X	Yes
WF-0.5	Williams Fork downstream of Reservoir at Kemp Breeze	TBD			X ^{New}	X	X	X	Yes
CR-24.9	Colorado River at Sheriff Ranch	TBD						X	No
WC-TBD	Willow Creek in restoration project area	TBD						X	Yes

¹ Sample collected only in the event of an unauthorized discharge from UPRR. This site was added to the program in 2019 but monitoring has not been needed to date.

Table 8 - 2022 LBD Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Latitude	Longitude
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane entrance	39.84583	-105.7518
FR-TBD	Fraser River downstream of UP Moffat Tunnel discharge	-	-
FR-1.9	Fraser River upstream of Granby Sanitation District	40.08453	-105.955
STC-0	Saint Louis Creek at Fraser River	39.95175	-105.815
RC-1.1	Ranch Creek downstream of Meadow Creek	39.99912	-105.827
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	40.05377	-106.289
CR-7.4	Colorado River downstream of Troublesome Creek	40.0509	-106.311
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	39.99229	-106.171
WF-2	Williams Fork downstream of Williams Fork Reservoir	40.04308	-106.198
WF-0.5	Williams Fork downstream WF Reservoir at Kemp Breeze	40.0561	-106.183
CR-24.9	Colorado River at Sheriff Ranch	40.0874	-106.068
WC-TBD	Willow Creek in restoration project area	-	-

Collection Methods and Macroinvertebrate Analysis

Results obtained by consistent sampling practices and accurate identifications provide valuable information regarding short- and long-term changes in aquatic conditions. In addition, using analytical procedures that result in quantitative data (counting all bugs in a sample) provides an accurate and dependable dataset that makes changes more apparent. Quantitative data are especially useful when evaluating the effectiveness of restoration projects and/or mitigation of known stressors.

Changes in data collection methods introduce inconsistencies in a dataset and make it difficult to perform trend analyses or compare data between sites sampled through separate programs. In order to preserve the integrity of the dataset being developed by LBD, the sampling and analytical method used in 2022 are the same as those used in previous years. These methods are consistent with those used by Denver Water and the Subdistrict, which allows for integration with and comparison to these datasets.

Timberline Aquatics performs the sampling methods as follows:

- Sampling occurs during the period from late September to early October (fall) to target macroinvertebrate communities during annual periods of high density. This sampling period is consistent with the Colorado Water Quality Control Division's methodology for macroinvertebrate sampling (Colorado Department of Public Health and Environment, Water Quality Control Commission, Aug 2017).

Timberline Aquatics collects the samples utilizing protocols approved by the Division's Section 303(d) Listing Methodology 2020 Listing Cycle (Colorado Department of Public Health and Environment, Water Quality Control Division,



Figure 4 - Sample Collection with a Hess Sampler

March 2019). Samples are collected with a Hess Sampler which is 13 inches in diameter and 16 inches tall with 500 μ m mesh. Three quantifiable Hess samples will be taken from riffle habitat at each of the sites. Each sample is taken from an area of similar size substrate and velocity (if possible) to avoid any bias from these physical parameters when making comparisons among sites (Figure 4).

Timberline Aquatics performs the macroinvertebrate analysis for all samples as follows:

- Identification and enumeration are done for the entire sample (i.e. all macroinvertebrates in the sample are counted).
- Macroinvertebrates are identified to the lowest practical taxonomic level consistent with the Operational Taxonomic Unit (OTU) developed by the Division, which consists of genus or species for mayflies, stoneflies, caddisflies, and many dipterans. Chironomidae will be identified to the genus level.
- As part of the quality control protocols, all sorted macroinvertebrate samples and approximately 10% of identifications are checked by another qualified taxonomist.

Assessment Metrics

The LBD macroinvertebrate data is assessed by looking at a set of 13 metrics or biological indicators. Together, these metrics provide the information needed to best meet the objectives of the program. Six of the 13 metrics are considered key

measurable indicators; these have vetted thresholds that demonstrate whether the community is healthy or stressed. Table 9 provides a description of each of the metrics. Table 10 shows the key measurable indicators and which metrics apply to each of the specific program objectives.

Reporting

Timberline Aquatics provides sampling results to the LBD Monitoring Subcommittee. The final data files/reports include:

- An Excel file that includes a species list and count of all identified macroinvertebrates for each of the three samples at each site;
- Multi-Metric Index (MMI) scores as well as the full Ecological Data Application System (EDAS; a Microsoft Access database) output in Excel Spreadsheet format;
- Calculation of 13 metrics for each site (Table 10). Except for MMI and TIV, the metrics are calculated based on the full data set, not the subsampled (300 count) datasets;
- A written summary of the macroinvertebrate sampling including sampling for Denver Water's and Northern Water's 401 Certifications.

Table 9 – Timberline Aquatics Reported Metrics and Description

Metric	Description
Multi-Metric Index (MMI)*	Colorado WQCD assessment tool. Provides a score from 0-100 which determines general health of aquatic community. A value for an acceptable score varies and is dependent on what ecoregion a site is located in. MMI is sensitive to a variety of pollutants and stressors.
Ephemeroptera Plecoptera Trichoptera (EPT)*	Richness of distinguishable taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These are the most sensitive taxa in zones that transition from pristine to anthropogenic. Sensitive to many pollutants. EPT values below 20 can indicate stressors including nutrients.
Hilsenhoff Biotic Index (HBI)*	Indicator of nutrient enrichment as well as other stressors. A widely used indicator of organic pollution. High values of the index indicate a predominance of tolerant organisms (i.e., the sensitive species have been lost). Values range from 0-10 and increase as water quality decreases. Auxiliary MMI metric.
Shannon Diversity (SDI)*	Indicator of macroinvertebrate community structure and balance. Does not account for tolerance. Typical values range from 3-4, values less than 1 indicate poor water quality. Auxiliary MMI metric.
Tolerance Indicator Value (TIV_{sed})*	A biological indicator of impacts by excess fine sediments. The TIV _{sed} reflects both the reduction in relative abundance of sediment-sensitive taxa and the increase in relative abundance of sediment-tolerant taxa.

% Chironomidae (Midges)	Percent composition of chironomidae taxa. Chironomidae are tolerant to stress, a high score indicates a stressed environment. High percentage can indicate higher nutrients and sedimentation.
% EPT excluding Baetis	Percent composition of EPT taxa. These are the most sensitive taxa in zones that transition from pristine to anthropogenic. Baetis not included because they have a higher tolerance value and can skew results. Sensitive to many pollutants.
% Intolerant Taxa	% composition of intolerant taxa.
% Tolerant Taxa	% composition of tolerant taxa. Based on tolerance values of 7 or greater.
% Hydropsychidae of Trichoptera	% Trichoptera (caddisfly) that is of the family-level Hydropsychidae. Tolerance values range from 2-5. Fine sediment can interfere with feeding. Sensitive to ammonia. May be good fish food.
Total Taxa Richness	Total number of identifiable taxa, indicator of general community health and stability. Sensitive to metals.
Pteronarcys Californica Density	Pteronarcys Californica abundance, mean number per square meter.
Total Density	Macroinvertebrate abundance mean number per square meter. Useful when paired with other metrics.

*Key Measurable Indicator

Table 10 - Metric and Objectives

Metric	Key Measurable Indicator	Assess General Health	Monitor Trends and Changes	Restoration Assessment	Regulatory Compliance	Pollutant Specific	Support Fisheries
MMI	X	X	X	X	X	X	X
EPT	X		X	X		X	X
HBI	X	X	X	X	X	X	
Shannon Diversity	X	X	X	X	X		X
TIV	X		X	X	X	X	
% Chironomidae		X	X	X		X	
% EPT excluding Baetis		X	X	X		X	
% Intolerant Taxa		X	X	X		X	
% Tolerant Taxa		X	X	X		X	
% Hydropsychidae of Trichoptera			X			X	
Total Taxa Richness		X	X	X		X	
Pteronarcys Californica Density			X	X			X
Total Density			X	X			X



Funding

Costs for the 2022 macroinvertebrate monitoring will be shared among some LBD partners. The partners each pay a percentage of the total cost. The cost distribution for 2022 is:

LBD Partner	Contribution %
Grand County	25%
Denver Water	25%
Northern Water/Subdistrict	25%
River District	8.3%
TU	8.3%
LBD	8.3%

In addition, ILVK will fund 50% of the monitoring costs for two sites in the Colorado River that are associated with the ILVK restoration project (CR-7.4 and CR-1.7). Denver Water will fund 50% of the monitoring costs for three sites on William Fork that are associated with their restoration projects (WF-5.5, WF-2 and WF-0.5). The remaining costs at these five sites will be covered by the LBD partners at their respective contribution percentage.



2022 303(d) Evaluation List and Monitoring Plan

The Upper Colorado River Basin was not included in the 2022 listing cycle, so there are no changes to the 303(d) List and Monitoring Plan this year.

Learning By Doing (LBD) evaluates impairments identified in Regulation #93 – Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation (M&E) List (Colorado Department of Public Health and Environment, Water Quality Control Commission, Reg #93, 2021⁴) within the CEA. LBD strives to monitor segments with known impairments.

Regulation #93 consists of three components:

1. The list of Water-Quality-Limited Segments Requiring total maximum daily loads (TMDLs) fulfills section 303(d) requirements of the federal Clean Water Act. Which requires states to submit to the U.S. Environmental Protection Agency a list of those waters for which technology-based effluent limitations and other required controls are not stringent enough to implement water quality standards.
2. Colorado's Monitoring and Evaluation List identifies water bodies where there is reason to suspect water quality problems, except there is uncertainty regarding one or more factors, such as the representative nature of the data. For example, suppose it is unclear whether the cause of impairment is attributable to pollutants instead of pollution in impaired water bodies. In that case, they go on the Monitoring and Evaluation List. The Monitoring and Evaluation (M & E) list is a state-only document not subject to EPA approval.
3. The list of Water-Quality-Limited Segments Not Requiring a TMDL identifies segments where data indicates at least one classified use is not supported, but a TMDL is not needed.

The objectives of the 303(d) Monitoring Program are to:

- Evaluate the current 303(d), and M&E listed water bodies within the CEA;
- Evaluate current water quality sampling programs of various agencies to determine if 303(d) listed waters are being monitored appropriately;
- Develop a monitoring plan for segments that are determined to need additional sampling.

2021 Review of Impaired Segments

In June 2021, the Water Quality Control Commission adopted the most recent version of Regulation #93, which became effective on August 14, 2021. The recently adopted 303(d) and M&E list shows seventeen stream segments listed as impaired within Grand County; Ten of these segments, **COUCUC01, COUCUC02, COUCUC03, COUCUC05, COUCUC09, COUCUC10a, COUCUC10c, and five water bodies in segments COUCUC12**

and COUCUC13 are located within the LBD CEA as shown in Figure 5. The twelve listed segments within the LBD CEA the impaired uses are Recreation, Water Supply, and Aquatic Life Use. The primary analytes of concern are arsenic (total), E. coli, Copper (dissolved), Iron, Manganese, Selenium, Silver, Zinc, pH, stream/lake/reservoir temperature, and macroinvertebrates. In addition, there are two new listings within the CEA for lake/reservoir temperature. These changes are detailed below.

In regards to arsenic, it is worth noting arsenic is a national/statewide water quality issue. Arsenic is a naturally occurring, toxic element found in soil, bedrock, and water. Arsenic is colorless and odorless as well as a known carcinogen. Arsenic regulation at the federal level is under multiple agencies and seven different acts, including two associated with the Colorado Department of Public Health and Environment.⁵ In 2013, Colorado implemented a significant update to the arsenic water quality standards. These standards have led to some interesting and costly regulatory compliance solutions in Colorado. Unfortunately, at this time, there are no feasible treatment processes available to effectively treatment stream segments for arsenic.⁶

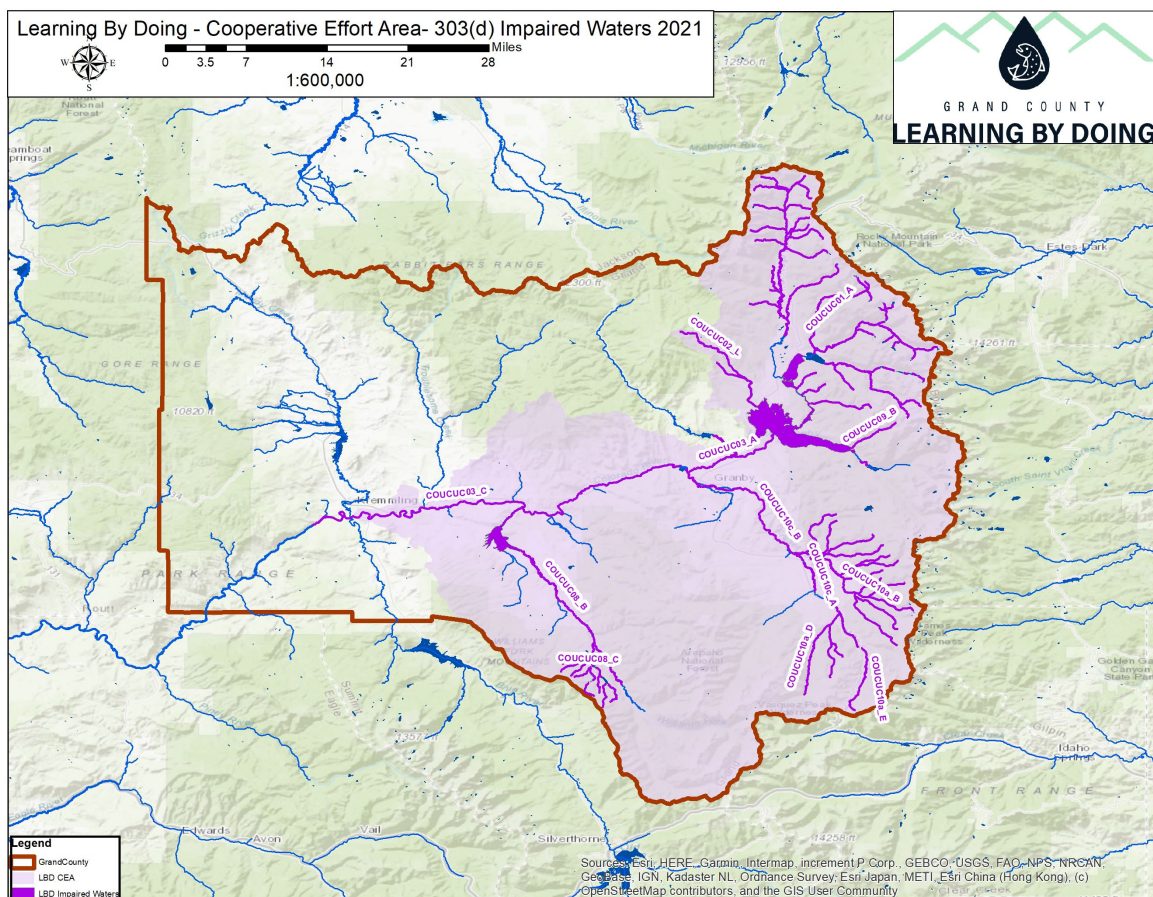


Figure 5. Grand County Impaired Waters.



Below is a detailed breakdown of the listed segment portions, analytes, and listing classifications:

1. COUCUC01 Mainstem of the Colorado River, including all tributaries and wetlands, within Rocky Mountain National Park, or which flows into Rocky Mountain Park.

- COUCUC01_A Mainstem of the Colorado River, including all tributaries and wetlands, within or flowing into Rocky Mountain National Park
Aquatic Life Use – Zinc (Dissolved) – 303(d) * *New listing 2020*

2. COUCUC02 Mainstem of the Colorado River, including all tributaries and wetlands within, or flowing into Arapahoe National Recreation Area.

- COUCUC02_C Colorado River from Shadow Mountain Reservoir to Granby Reservoir
Aquatic Life Use – Temperature – 303(d)
- COUCUC02_D Mainstem of Colorado River from North Inlet to Grand Lake
Aquatic Life Use – Zinc (Dissolved) – M&E List
Aquatic Life Use – Silver (Dissolved) – M&E List
Aquatic Life Use – Copper (Dissolved) – 303(d)
- COUCUC02_E Mainstem of East Inlet
Aquatic Life Use – Zinc (Dissolved) – M&E List
Aquatic Life Use – Silver (Dissolved) – M&E List
Aquatic Life Use – Copper (Dissolved) – 303(d)
- COUCUC02_I Arapaho Creek downstream of Monarch Lake
Aquatic Life Use – Silver (Dissolved) – M&E List
Aquatic Life Use – Temperature – 303(d)
- COUCUC02_L Stillwater Creek, including tributaries and wetlands, within or flowing into Arapaho Recreation Area
Water Supply Use – Arsenic (Total) – 303(d)
Water Supply Use – Manganese (Dissolved) – 303(d)
Aquatic Life Use – Temperature – 303(d)

3. COUCUC03 - Mainstem of the Colorado River from the outlet of Lake Granby to the confluence with Roaring Fork River.

- COUCUC03_A Colorado River from outlet of Lake Granby to Windy Gap Reservoir



Water Supply use – Arsenic – M&E List

- COUCUC03_B Colorado River from Windy Gap Reservoir to 578 Road Bridge.

Water Supply use – Arsenic – M&E List

- COUCUC03_C Colorado River from 578 Road Bridge to Gore Canyon.

Water Supply use – Arsenic – M&E List

Aquatic Life Use – Temperature – 303(d)

4. COUCUC05 - Mainstem of Willow Creek from the outlet of Willow Creek Reservoir to the confluence with the Colorado River.

- COUCUC05_B Mainstem of Willow Creek from the outlet of Willow Creek Reservoir to the confluence with the Colorado River.

Water Supply use – Arsenic – M&E List

Water Supply Use – Manganese (Dissolved)

5. COUCUC08 - Mainstem of the Williams Fork River, including all tributaries and wetlands from the source to the confluence with the Colorado River, except for those tributaries listed in Segment 9.

- COUCUC08_B Mainstem of Williams Fork River below Kinney Creek.

Water Supply use – Arsenic – M&E List

- COUCUC08_C Ute Creek and its tributaries

Water Supply use – Arsenic – M&E List

Aquatic Life Use – Zinc (Dissolved) – 303(d) List

6. COUCUC09 – All tributaries to the Colorado and Fraser Rivers, including of all wetlands, within the Never Summer, Indian Peaks, Byers, Vasquez, Eagles Nest and Flat Top Wilderness Areas.

- COUCUC09_B Roaring Fork Arapaho Creek and its tributaries.

Aquatic Life Use – Macroinvertebrates – 303(d)

7. COUCUC10a - Mainstem of the Fraser River from the source to a point immediately below the Rendezvous Bridge. All tributaries to the Fraser River, including wetlands, from the source to the confluence with the Colorado River, except for those tributaries included in Segment 9.

- COUCUC10a_B - Ranch Creek and its tributaries.

Aquatic Life Use – Temperature – 303(d)

- COUCUC10a_D - Vasquez Creek and its tributaries.



Aquatic Life Use – Macroinvertebrates– 303(d)

Aquatic Life Use – Copper – 303(d)

- COUCUC10a_E - Mainstem of Fraser River from source to Leland Creek

Aquatic Life Use – Copper (Dissolved) – 303(d)

8. COUCUC10c - Mainstem of the Fraser River from a point immediately below the Hammond Ditch to the confluence with the Colorado River.

- COUCUC10c_A - Fraser River from below the Hammond Ditch in Town of Fraser to Fraser Canyon near Tabernash.

Aquatic Life Use – pH – M&E List

Water Supply Use – Arsenic (total) – 303(d)

- COUCUC10c_B - Fraser River from Fraser Canyon near Tabernash to the Town of Granby.

Water Supply Use – Arsenic (total) – 303(d)

- COUCUC10c_C - From the Town of Granby to confluence with the Colorado River.

Recreation – E. coli – 303(d)

Water Supply Use – Arsenic (total)– 303(d)

9. COUCUC12 – Lakes and reservoirs within Arapaho National Recreation Area, including Grand Lake, Shadow Mountain Lake and Lake Granby.

- COUCUC12_B - Shadow Mountain Reservoir

Water Supply Use – Arsenic (total) – 303(d)

- COUCUC12_C – Lake Granby

Water Supply Use – Arsenic (total) – 303(d)

- COUCUC12D – Willow Creek Reservoir **new listing in 2021*

Water Supply Use – Arsenic (total) – 303(d)

- COUCUC12E – Grand Lake **new listing in 2021*

Aquatic Life Use – Temperature – 303(d)

10. COUCUC13 – All lakes and reservoirs tributary to the Colorado River from the boundary of Rocky Mountain National Park and Arapaho National Recreation Area to a point below the confluence of the Roaring Fork River, except for specific listings in Upper Colorado Segments 11 and 12 and the Blue and Eagle Rivers.

- COUCUC13_D Williams Fork Reservoir

Water Supply Use – Arsenic (total) – M&E List



2022 LBD Monitoring to Support 303(d) Listings

The Listing Methodology defines the criteria the WQCD uses to evaluate which waters are considered impaired under Section 303(d) List and the Monitoring and Evaluation List under Regulation #93. The water quality assessment process depends on the analysis of sufficient and reliable data. Generally, the WQCD only uses data from the previous five years for assessment.⁴ For a 303(d) listing, there has to be a representative data set. The LBD Monitoring Committee compares the 2022 LBD Monitoring Summary (Appendix B) with the known impairments to ensure that LBD monitors the appropriate analytes. This evaluation shows there is sufficient monitoring throughout the CEA.

⁴ Colorado Department of Public Health. Water Quality Control Division. Section 303(d) Listing Methodology 2022 Listing Cycle. May 2020.

⁵ Environmental Protection Agency. Arsenic Fact Sheet 2013.
https://www.epa.gov/sites/production/files/2014-03/documents/arsenic_factsheet_cdc_2013.pdf

⁶ Rocky Mountain Water – Updates to Colorado's Arsenic Regulations – Dan Delaughter, PE. Pg 12 -15.
https://www.apogeepublications.com/emags/RMW_March2020/



2022 CPW Fish Monitoring Plan

In cooperation with LBD monitoring efforts, CPW plans to survey fish populations at the following locations in 2022. All fish survey activities are dependent upon flow and temperature conditions, as well as staff and volunteer availability.

Fraser River

Idlewild Campground – on Forest Service property upstream of Town of Winter Park. Sampling will be conducted the week of August 30th.

Confluence Park – in town of Winter Park, surveyed periodically. Sampling will be conducted the week of August 30th.

Safeway – this site is surveyed annually and is the longest continuous data set on the Fraser River. Sampling will be conducted the week of August 30th.

Grand County Water and Sanitation #1 property – located on the public reach of the Fraser Flats River Habitat Project completed in 2017. Sampling will be conducted on October 4th.

Behler Creek – on BLM property at the mouth of Fraser River Canyon. Sampling will be conducted on September 27th.

Fraser River Ranch. Sampling will be conducted the week of August 30th.

Kaibab Park, Town of Granby. Sampling will be conducted the week of August 30th.

Colorado River

Town of Granby property behind River Run RV Park on the Colorado River. Sampling will be conducted on two sites on October 5th.

Paul Gilbert – Lone Buck – near CPW office on State Wildlife Area. Surveyed periodically, typically every third year. Sampling will be conducted in Spring 2022.

Irrigated Lands in the Vicinity of Kremmling (ILVK) – an established site downstream of the Troublesome Creek confluence will be surveyed by raft electrofishing in late April/early May.

Williams Fork River

Two sites on the Kemp-Breeze State Wildlife Area will be surveyed in Spring 2022 to assess ongoing function of the habitat project there.



Willow Creek

Several sites will be surveyed in late July/early August in order to assess ongoing impacts of burn-related flooding and debris flow events related to the East Troublesome wildfire in fall 2020.



2022 Riparian Areas and Wetlands Monitoring Plans

Revegetation at the Fraser Flats

The Colorado River Headwaters Chapter of Trout Unlimited, an LBD partner, hosted a volunteer re-vegetation effort for the Fraser Flats River Habitat Project reach in May 2021. The river restoration and initial willow plantings at the project reach were completed in 2017. Since that time, LBD has been monitoring the success of the willow plantings and their condition each year, from 2018 through 2020, consistent with LBD's voluntary post-project monitoring plan for the site. Several areas were identified from past years' surveys where supplemental plantings could improve the density of the riparian corridor along the project reach. The 2021 revegetation effort focused on filling in the vegetation gaps along the riverbanks of the project reach.

While annual surveys to assess the number and condition of the willow plantings have been performed in past years, LBD and the Headwaters Chapter will not be performing a detailed willow count survey in 2022. Surveys in future years will be performed on an as-needed basis.

Revegetation at Ranch Creek

Similar to the willow revegetation efforts performed at the Fraser Flats, LBD and the Colorado River Headwaters Chapter of Trout Unlimited, hosted an initial revegetation effort performed by volunteers on a section of Ranch Creek at Quad Ranch in 2018. In 2019, LBD performed a detailed survey of the condition of the plantings and found high success rates. A supplemental willow planting effort was performed by volunteers in the summer of 2019 to increase the density of the plantings along the riverbank. LBD and the Headwaters Chapter will not be performing a detailed willow count survey in 2022. Surveys in future years will be performed on an as-needed basis.

Northern Water's Municipal Subdistrict Riparian Vegetation Monitoring

Condition 30 of the WGFP 1041 Permit requires the Subdistrict to prepare a monitoring plan to establish baseline conditions of riparian and wetland vegetation along the Colorado River from Windy Gap Reservoir downstream to the lower terminus of the Kemp-Breeze Wildlife Area, and on Willow Creek below Willow Creek Reservoir (Grand County, 2012).

The monitoring is being conducted by ERO. The primary objectives of the Riparian Vegetation Monitoring Plan are to:

- Obtain baseline data that describes the existing conditions of riparian vegetation and communities within the study area;



- Document the conditions of riparian vegetation and communities within the study area following the WGFP Project implementation.

The data generated as part of this monitoring plan can also be used to develop more specific management objectives to determine if conditions are being maintained, improved, or are declining. Based on the baseline and future monitoring data, management actions can be designed to meet management objectives. Monitoring for this study did not occur in 2022.

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Appendix A – Monitoring Sites with River Mile ID and Entity Station Name

River Mile ID	Description	Entity	Type	Latitude	Longitude
AC-0.6	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Water Quality	40.1128	-105.7497
AC-0.6	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Temperature	40.1128	-105.7497
AC-0.6	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Flow	40.1128	-105.7497
BC-0	Bobtail Creek above diversion dam downstream of gauging station	Denver Water	Water Quality	39.76026447	-105.9064014
BC-0	Bobtail Creek above diversion dam	Denver Water	Flow	39.76026447	-105.9064014
CB-0.6	Cabin Creek upstream North and South Channels	Denver Water	Temperature	39.97497	-105.77496
CB-2.7	Cabin Creek near Fraser	DW/USGS	Flow	39.9858203	-105.7450064
CB-2.7	Cabin Creek downstream Denver Water diversion	Denver Water	Temperature	39.9858203	-105.7450064
CC-1.5	Crooked Cr Abv Pole Creek At Tabernash	EGWQB	Water Quality	39.990833	-105.849167
CH-0.5	Church Creek upstream of Willow Creek at Flume	Northern	Water Quality	40.1356	-105.9214
CLU-0	Surface drainage channel on C Lazy U pasture that drains to Willow Creek	Northern	Water Quality	40.1589	-105.9858
CLU-0.7	Upstream end of surface water drainage channel on C Lazy U pasture	Northern	Water Quality	40.1677	-105.9902
CR-1.7	Colorado River upstream of the Blue River	LBD/ILVK	Macro	40.0465	-106.373
CR-1.7	Colorado River upstream of the Blue River	LBD/ILVK	Sediment	40.0465	-106.373
CR-12.6	Colorado River at ConRitschard	GCWIN	Temperature	40.06545	-106.23097
CR-13.7	Parshall-Sunset	CPW	Fish	40.06105342	-106.213488
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	GCWIN	Temperature	40.06342	-106.19073
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	CPW	Macro	40.062913	-106.192286
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	LBD/Tetra Tech	Sediment	40.06342	-106.19073
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	Northern	Flow	40.06342	-106.19073
CR-16.7	Colorado River upstream of Williams Fork	Northern	Temperature	40.05042	-106.17296
CR-16.7	Colorado River upstream of Williams Fork	Northern	Macro	40.04689	-106.14299
CR-16.7	Colorado River north of Parshall at Bar Lazy J Ranch bridge	Denver Water	Water Quality	40.05042	-106.17296
CR-16.7	Colorado River upstream of Williams Fork	LBD	Sediment	40.05042	-106.17296
CR-16.7	Colorado River upstream of Williams Fork	GCWIN	Temperature	40.05042	-106.17296
CR-18.4	Colorado River at Lone Buck	GCWIN	Temperature	40.0471	-106.14304
CR-19.8	Colorado River downstream of Byers Canyon	CPW	Macro	40.0519855	-106.1320591
CR-19.8	Colorado River downstream of Byers Canyon	CPW	Fish	40.0519855	-106.1320591
CR-19.8	Colorado River downstream of Byers Canyon	GCWIN	Temperature	40.05328	-106.13238
CR-2.3	Colorado River upstream Hwy 9 Bridge at Kremmling	BLM/LBD	Temperature	40.0421	-106.3714
CR-2.3	Colorado River upstream Hwy 9 Bridge at Kremmling	Denver Water	Water Quality	40.0421	-106.3714
CR-21.9	Colorado River downstream of Hot Sulphur Springs.	LBD/Tetra Tech	Sediment	40.07232	-106.1116
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Macro	40.0746853	-106.1082293
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Fish	40.0746853	-106.1082293
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	Northern	Macro	40.07394	-106.10959
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	LBD	Sediment	40.073778	-106.109889
CR-22.1	Colorado River upstream Hot Sulphur Springs Resort	GCWIN	Temperature	40.073778	-106.109889
CR-22.9	Colorado River upstream Hot Sulphur Springs at WTP	Northern	Temperature	40.077342	-106.104087
CR-22.9	Colorado River upstream Hot Sulphur Springs WTP	GCWIN	Temperature	40.077342	-106.104087
CR-23.5	Colorado River upstream of Hot Sulphur Springs	Northern	Flow	40.08347062	-106.0879251
CR-24.9	Colorado River at Sheriff Ranch	CPW	Macro	40.0873995	-106.067745
CR-24.9	Colorado River at Sheriff Ranch	GCWIN	Temperature	40.08769018	-106.064547
CR-27.5	Colorado River downstream Chimney Rock at Upper Red Barn	CPW	Macro	40.10260398	-106.024221
CR-27.5	Colorado River upstream of Drowsy Water Creek	LBD/Tetra Tech	Sediment	40.10260398	-106.024221
CR-28.7	Colorado River downstream of Windy Gap Reservoir	Northern	Water Quality	40.1082	-106.0037
CR-28.7	Colorado River downstream of Windy Gap Reservoir	Northern	Temperature	40.1082	-106.0037
CR-28.7	Colorado River downstream of Windy Gap Reservoir	Northern	Macro	40.1082	-106.0037
CR-28.7	Colorado River downstream of Windy Gap Reservoir	NW/USGS	Flow	40.1082	-106.0037
CR-28.7	Colorado River downstream of Windy Gap Reservoir	LBD	Sediment	40.1082	-106.0037
CR-28.7	Colorado River downstream of Windy Gap Reservoir	CPW	Macro	40.10894755	-106.0014475
CR-28.7	Colorado River downstream of Windy Gap Reservoir	CPW	Fish	40.10894755	-106.0014475
CR-28.7	Colorado River downstream of Windy Gap Reservoir	GCWIN	Temperature	40.10894755	-106.0014475
CR-29.8	Colorado River at confluence of Windy Gap spillway and bypass	Northern	Temperature	40.1078	-105.9881
CR-30	Colorado River at Windy Gap Bypass	Northern	Flow	40.1087	-105.984
CR-30	Colorado River at Windy Gap Bypass	Northern	Temperature	40.1087	-105.984
CR-30.8	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Macro	40.102005	-105.974833
CR-30.8	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Fish	40.1013097	-105.9747973
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Temperature	40.1003	-105.9726
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Water Quality	40.1003	-105.9726
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Macro	40.1003	-105.9726
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	CPW	Macro	40.1013097	-105.9747973
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	LBD	Sediment	40.1003	-105.9726
CR-32.1	Colorado River downstream of Willow Creek	Northern	Water Quality	40.107	-105.956
CR-34.7	Colorado River upstream of Willow Creek	Northern	Water Quality	40.1196	-105.9138
CR-35.6	Colorado River downstream Granby Reservoir at flow gage	Northern	Temperature	40.1211	-105.9007

CR-35.6	Colorado River downstream of Granby Reservoir	USGS	Flow	40.1211	-105.9007
CR-38.3	Colorado River downstream of Granby Reservoir	Northern	Water Quality	40.1444	-105.8672
CR-38.3	Colorado River downstream of Granby Reservoir	Northern	Temperature	40.1444	-105.8672
CR-38.3	Colorado River downstream of Granby Reservoir	Northern	Macro	40.1444	-105.8672
CR-43.5	Colorado River upstream of Granby Reservoir	Northern	Temperature	40.1945	-105.8265
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern	Water Quality	40.2059	-105.838
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern	Temperature	40.2059	-105.838
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern	Macro	40.2059	-105.838
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	USGS	Flow	40.2059	-105.838
CR-7.4	Colorado River downstream of Troublesome Creek	LBD/ILVK	Macro	40.0509	-106.3112
CR-7.4	Colorado River downstream of Troublesome Creek	LBD/ILVK	Sediment	40.0509	-106.3112
CR-9.1	Colorado River downstream of KB Ditch	GCWIN	Temperature	40.05377	-106.28945
CR-9.1	Colorado River downstream of KB Ditch	LBD	Macro	40.05377	-106.28945
CR-9.1	Colorado River downstream of KB Ditch	LBD	Sediment	40.05377	-106.28945
CR-9.1	Colorado River downstream of KB Ditch	Northern	Flow	40.05377	-106.28945
CR-19.4	Colorado River at Paul Gilbert fishing access	LBD/Tetra Tech	Sediment	40.048494	-106.131189
EC-5.5	Elk Creek near Fraser	DW/USGS	Flow	39.8894312	-105.8325098
EC-5.5	Elk Creek downstream Denver Water diversion	Denver Water	Temperature	39.8894312	-105.8325098
EI-0.1	East Inlet upstream of Grand Lake	Northern	Water Quality	40.2369	-105.801
EI-0.1	East Inlet upstream of Grand Lake	Northern	Temperature	40.2369	-105.801
EI-0.1	East Inlet upstream of Grand Lake	Northern	Flow	40.2369	-105.801
EI-0.1	East Inlet upstream of Grand Lake	Northern	Macro	40.2369	-105.801
FR-0.1	Fraser River upstream of confluence with Colorado River	EGWQB/USGS	Water Quality	40.0984	-105.9727
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern	Water Quality	40.0984	-105.9727
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern	Temperature	40.0984	-105.9727
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern	Macro	40.0984	-105.9727
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern	Flow	40.0984	-105.9727
FR-1.6	Fraser River downstream of Granby Sanitation District	GCWIN	Temperature	40.08551	-105.95767
FR-1.9	Fraser River upstream of Granby Sanitation District	GCWIN	Temperature	40.084526	-105.95464
FR-1.9	Fraser River upstream of Granby Sanitation District	LBD	Macro	40.084526	-105.95464
FR-1.9	Fraser River upstream of Granby Sanitation District	LBD	Sediment	40.084526	-105.95464
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Water Quality	40.00689167	-105.8482722
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	GCWIN	Temperature	40.00689167	-105.8482722
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	GCWIN	Macro	40.00689167	-105.8482722
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Flow	40.00689167	-105.8482722
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	LBD	Macro	40.00689167	-105.8482722
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	LBD	Sediment	40.00689167	-105.8482722
FR-14	Fraser River upstream of Tabernash	EGWQB	Water Quality	39.990333	-105.829778
FR-14	Fraser River upstream of Tabernash	EGWQB/TU	Temperature	39.990333	-105.829778
FR-14	Fraser River upstream of Tabernash	Denver Water	Macro	39.990333	-105.829778
FR-14	Fraser River upstream of Tabernash	EGWQB/USGS	Flow	39.990333	-105.829778
FR-14	Fraser River upstream of Tabernash	LBD	Sediment	39.990333	-105.829778
FR-14	Fraser River upstream of Tabernash	Denver Water	Water Quality	39.990333	-105.829778
FR-14.4	Winter Park W & S	CPW	Fish	39.986472	-105.827787
FR-14.4	Fraser River LBD Restoration Project, Downstream end	GCWIN/LBD	Temperature	39.986472	-105.827787
FR-15	Fraser River LBD Restoration Project, Upstream end	LBD	Macro	39.981338	-105.824946
FR-15	Fraser River LBD Restoration Project, Upstream end	GCWIN/LBD	Temperature	39.981338	-105.824946
FR-15	Fraser River LBD Restoration Project, Upstream end	LBD	Sediment	39.981338	-105.824946
FR-16.6	Fraser River downstream Fraser Sanitation	GCWIN	Temperature	39.966	-105.81651
FR-16.9	Fraser River upstream Fraser Sanitation	GCWIN	Temperature	39.96195	-105.81509
FR-17.7	Fraser River downstream County Rd 8 at Hammond Ditch	EGWQB/USGS	Water Quality	39.95216	-105.81445
FR-17.7	Fraser River downstream County Rd 8 at Hammond Ditch	GCWIN	Temperature	39.95216	-105.81445
FR-18.1	Fraser River downstream County Rd 804	GCWIN	Temperature	39.94689	-105.81307
FR-18.1	Fraser River at Safeway	CPW	Fish	39.94689	-105.81307
FR-20	Fraser River at Rendezous bridge	GCWIN	Temperature	39.93412	-105.7896
FR-20	Fraser River at Rendezous bridge	Denver Water	Macro	39.93412	-105.7896
FR-20	Fraser River at Rendezous bridge	LBD	Sediment	39.93412	-105.7896
FR-20.6	Fraser River Blw Vasquez Creek At Winter Park Co.	Denver Water	Water Quality	39.927778	-105.785556
FR-20.6	Fraser River Blw Vasquez Creek At Winter Park Co.	EGWQB	Water Quality	39.927778	-105.785556
FR-20.6	Fraser River Blw Vasquez Creek At Winter Park Co.	EGWQB	Water Quality	39.927778	-105.785556
FR-21	Confluence Park	CPW	Fish	39.922936	-105.7824607
FR-22.5	Fraser River downstream Winter Park Resort at Idlewild Campground	GCWIN	Temperature	39.89998695	-105.7766741
FR-22.5	Idlewild Campground	CPW	Fish	39.89998695	-105.7766741
FR-22.5	Fraser River at Winter Park	Denver Water	Water Quality	39.89998695	-105.7766741
FR-22.5	Fraser River at Winter Park	DW/USGS	Flow	39.89998695	-105.7766741
FR-23.2	Fraser River downstream Winter Park Sanitation	GCWIN	Temperature	39.89596	-105.76945

FR-23.4	Fraser River upstream Winter Park Sanitation District	LBD	Sediment	39.89596	-105.76945
FR-23.4	Fraser River upstream Winter Park Sanitation District	GCWIN	Temperature	39.89596	-105.76945
FR-23.4	Fraser River upstream Winter Park Sanitation District	Denver Water	Macro	39.89596	-105.76945
FR-23.7	Fraser River below Buck Creek	Denver Water	Water Quality	39.893028	-105.76475
FR-23.7	Fraser River below Buck Creek	EGWQB/USGS	Water Quality	39.893028	-105.76475
FR-24	Fraser River upstream Moffat Tunnel Nr Winter Park, Co	EGWQB	Water Quality	39.886558	-105.761822
FR-24	Fraser/Jim Canal at Gaging Station	Denver Water	Water Quality	39.886558	-105.761822
FR-25.1	Fraser River upstream of UP Railroad discharge	LBD	Sediment	39.8775	-105.7535
FR-25.1	Fraser River upstream of UP Railroad discharge	LBD	Macro	39.8775	-105.7535
FR-25.6	Fraser River at Sediment Pond	LBD/Tetra Tech	Sediment	39.86697222	-105.7495806
FR-27.2	Fraser River At Upper Sta, Near Winter Park, Co.	EGWQB	Water Quality	39.845833	-105.751389
FR-27.2	Fraser River upstream Mary Jane entrance to Winter Park	GCWIN	Temperature	39.845833	-105.751389
FR-27.2	Fraser River At Upper Sta, Near Winter Park, Co.	EGWQB/USGS	Flow	39.845833	-105.751389
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Macro	39.845833	105.75177
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Sediment	39.845833	-105.751389
FR-27.2	Fraser River upstream Mary Jane entrance to Winter Park	LBD	Sediment	39.845833	-105.751389
FR-3.5	Fraser River At Hwy. 40 At Granby, Co	EGWQB	Water Quality	40.081389	-105.928333
FR-3.5	Fraser River blw Highway 40 in Granby	GCWIN/LBD	Temperature	40.081389	-105.928333
FR-4.6	Fraser River at Granby Ranch downstream of golf course	GCWIN	Macro	40.07888889	-105.9041667
FR-4.6	Fraser River at Granby Ranch downstream of golf course	LBD	Sediment	40.07888889	-105.9041667
FR-5.5	Fraser River at Granby Ranch	LBD	Sediment	40.07882	-105.9042
FR-6.7	Fraser River downstream Fraser Canyon	GCWIN	Macro	40.070257	-105.88624
FR-6.7	Fraser River downstream Fraser Canyon	GCWIN	Temperature	40.070257	-105.88624
FR-TBD	Fraser River downstream of UP Railroad discharge (only in event of emergency)	LBD	Macro	TBD	TBD
GRP-0	Granby Pump Canal above Shadow Mountain Reservoir	Northern	Water Quality	40.2068	-105.8495
GRP-0	Granby Pump Canal above Shadow Mountain Reservoir	Northern	Temperature	40.2068	-105.8495
HC-0.5	Herd Creek on County Road 843	Denver Water	Temperature	39.9947	-105.8039
LCB-2.2	Little Cabin Creek downstream Denver Water diversion	Denver Water	Temperature	39.9743	-105.7402
LVC-0.2	Little Vasquez upstream Winter Park on Arapaho Road	Denver Water	Temperature	39.905489	-105.794955
MC-0.5	Meadow Creek on County Road 84/USFS 129	Denver Water	Temperature	40.0039	-105.8192
MQC-0	McQueary Creek above diversion dam 1 3/4 miles north of dorm	Denver Water	Water Quality	39.78227	-105.91604
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Water Quality	40.219	-105.8577
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Temperature	40.219	-105.8577
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Flow	40.219	-105.8577
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Macro	40.219	-105.8577
NI-0.1	North Inlet upstream of Grand Lake	Northern	Water Quality	40.2511	-105.8145
NI-0.1	North Inlet upstream of Grand Lake	Northern	Temperature	40.2511	-105.8145
NI-0.1	North Inlet upstream of Grand Lake	Northern	Flow	40.2511	-105.8145
PC-0.1	Pole Creek at mouth	EGWQB/USGS	Water Quality	39.991667	-105.851944
RC-1.1	Ranch Creek Blw Meadow Cr Nr Tabernash Co	EGWQB/CRWCD	Water Quality	39.99900556	-105.8280944
RC-1.1	Ranch Creek Blw Meadow Cr Nr Tabernash Co	GC/DW	Temperature	39.99900556	-105.8280944
RC-1.1	Ranch Creek downstream Meadow Creek	GCWIN	Temperature	39.99900556	-105.8280944
RC-1.1	Ranch Creek Blw Meadow Cr Nr Tabernash Co	EGWQB/CRWCD	Flow	39.99900556	-105.8280944
RC-1.1	Ranch Creek downstream Meadow Creek	LBD	Macro	39.99912	-105.82746
RC-1.1	Ranch Creek downstream of County Road 84	LBD	Sediment	39.99900556	-105.8280944
RC-4.7	Ranch Creek downstream County Rd 8315	GCWIN	Temperature	39.98859	-105.795
RC-5.8	Ranch Creek below Cabin Creek	EGWQB/USGS	Water Quality	39.977683	-105.791925
RC-9	Ranch Creek Near Fraser, Co.	EGWQB	Water Quality	39.94998694	-105.7655627
RC-9	Ranch Creek Near Fraser, Co.	EGWQB/USGS	Flow	39.94998694	-105.7655627
RCC-0	Ranch Canal at Gaging Station	Denver Water	Water Quality	39.88987	-105.75198
RDC-0	Reeder Creek, upper	BLM	Temperature	40.056627	-106.27641
RDC-0.7	Reeder Crk above footbridge, blw irrigation ditch	BLM	Temperature	40.050436	-106.2734752
RF-0	Roaring Fork upstream Granby Reservoir	Northern	Water Quality	40.1308	-105.7671
RF-0	Roaring Fork upstream Granby Reservoir	Northern	Temperature	40.1308	-105.7671
SC-0	Steelman Creek at bridge above diversion dam (south of dorm)	Denver Water	Water Quality	39.7571	-105.93304
ST-0	Shadow Mountain Channel at Chipmunk Lane	Northern	Water Quality	40.1829	-105.8892
ST-0	Stillwater Creek upstream Granby Reservoir	Northern	Temperature	40.1829	-105.8892
STC-0	St. Louis Creek upstream confluence with Fraser River	GCWIN/LBD	Temperature	39.95175	-105.81471
STC-0	St. Louis Creek upstream confluence with Fraser River	LBD	Macro	39.95175	-105.81471
STC-0	St. Louis Creek upstream confluence with Fraser River	LBD	Sediment	39.95175	-105.81471
STC-5.4	St. Louis Creek near Fraser	DW/USGS	Flow	39.90998657	-105.8783451
STC-5.4	St. Louis Creek at Fraser Experimental Forest HQ	LBD	Temperature	39.90998657	-105.8783451
STC-9.8	St. Louis Creek downstream Denver Water Board diversion	Denver Water	Temperature	39.85385	-105.90893
SWF-0	South fork at South Fork Campground at gauging station	Denver Water	Water Quality	39.79581958	-106.0305734
SWF-0	South fork at South Fork Campground	DW/USGS	Flow	39.79581958	-106.0305734
USF-0	Upper South Fork of the Williams Fork (3.5 miles above trail head)	Denver Water	Water Quality	39.70286	-105.97802

VC-0	Vasquez Creek at the town of Winter Park	EGWQB/USGS	Water Quality	39.92026468	-105.7852857
VC-0	Vasquez Creek at the town of Winter Park	Denver Water	Water Quality	39.92026468	-105.7852857
VC-0	Vasquez Creek at the town of Winter Park	DW/USGS	Flow	39.92026468	-105.7852857
VC-0	Vasquez Creek at the town of Winter Park	Denver Water	Macro	39.92026468	-105.7852857
VC-0	Vasquez Creek at the town of Winter Park	GCWIN	Temperature	39.92026468	-105.7852857
VC-4.3	Vasquez Ck. upstream Vasquez Tunnel	Denver Water	Water Quality	39.818601	-105.836001
VC-8	Vasquez Ck. at diversion structure	Denver Water	Water Quality	39.86379	-105.82131
VCC-0	Vasquez Canal at Vasquez #1 Gaging Station	Denver Water	Water Quality	39.88957	-105.76904
VT-0	Vasquez Tunnel outlet	Denver Water	Water Quality	39.818504	-105.835365
WC-0.5	Willow Creek upstream of confluence with Colorado River	LBD	Temperature	40.12501	-105.91491
WC-0.9	Willow Creek upstream of confluence with Colorado River	Northern	Water Quality	40.1297	-105.9181
WC-2.3	Willow Creek upstream of Bunte Highline Ditch	LBD	Temperature	40.137035	-105.92904
WC-3.8	Willow Creek directly downstream of Willow Creek Reservoir Dam	Northern	Water Quality	40.1457	-105.9409
WC-3.8	Willow Creek downstream of Willow Creek Reservoir	Northern	Flow	40.1457	-105.9409
WC-3.8	Willow Creek downstream of Willow Creek Reservoir	Northern	Temperature	40.1457	-105.9409
WC-6.3	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern	Water Quality	40.1558	-105.9808
WC-6.3	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern	Flow	40.1558	-105.9808
WCP-0	Willow Creek discharge chute to Lake Granby	Northern	Water Quality	40.143	-105.8888
WCP-0	Willow Creek Pump Canal Inflow to Lake Granby	Northern	Temperature	40.143	-105.8888
WF-0.5	Williams Fork downstream WF Reservoir at Kemp Breeze	LBD	Macro	40.0561	-106.1825
WF-13.1	Williams Fork	BLM	Water Quality	39.9092	-106.1029
WF-13.1	Williams Fork	BLM	Macro	39.9092	-106.1029
WF-13.1	Williams Fork	BLM	Habitat	39.9092	-106.1029
WF-13.1	Williams Fork downstream of Henderson Mill	LBD	Macro	39.9092	-106.1029
WF-19	WilliamsForkRiver below Kinney Creek confluence at Leal gauge	Denver Water	Water Quality	39.833875	-106.0564079
WF-19	WILLIAMS FORK NEAR LEAL, CO.	DW/USGS	Flow	39.833875	-106.0564079
WF-19.6	WILLIAMS FORK ABOVE DARLING CREEK, NEAR LEAL, CO	DW/USGS	Flow	39.79719444	-106.0256389
WF-2	Williams Fork R. below Williams Fork Reservoir	Denver Water	Water Quality	40.03592778	-106.2050139
WF-2	Williams Fork R. below Williams Fork Reservoir	DW/USGS	Flow	40.03592778	-106.2050139
WF-2	Williams Fork R. below Williams Fork Reservoir	LBD	Macro	40.04308	-106.19832
WF-22.6	Williams Fork above bridge at Sugarloaf Campground	Denver Water	Water Quality	39.78862	-106.02232
WF-28.2	WILLIAMS FORK BELOW STEELMAN CREEK, CO.	DW/USGS	Flow	39.77887549	-105.9283469
WF-5.5	Williams Fork River upstream of Williams Fork Reservoir	Denver Water	Water Quality	40.0002	-106.1803667
WF-5.5	WILLIAMS FORK NEAR PARSHALL, CO	DW/USGS	Flow	40.0002	-106.1803667
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	LBD	Macro	39.992293	-106.17079
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	LBD	Temperature	40.0002	-106.1803667
WGP-0	Windy Gap discharge chute to Granby Reservoir	Northern	Water Quality	40.1429	-105.8888
WGP-0	Windy Gap Pump Inflow to Granby Reservoir	Northern	Temperature	40.1429	-105.8888



Appendix B – Monitoring Summary

Update pending. The last time the summary was updated was in 2018.



Appendix C – 2022 List of Projects in the Cooperative Effort Area

List of Projects in the Cooperative Effort Area

Project name	Project type	Project cost	Funding sources	Project status	In IPP? (part of Basin Implem Plan)	Description	Benefits	Location
Fraser Flats River Habitat Project	River restoration; rechanneling	\$202,400	LBD partners: \$61,000; CPW grant: \$87,900; Patagonia Enviro grant: \$3,500; property owner: \$50,000	Completed 2017		River rechanneling to increase velocity and depths of flows during low flow periods; revegetation of river bank; public fishing access	Increase adult trout habitat; improve width-to-depth ratio at low flows; lower stream temperature; open 0.4-miles to public fishing	Upstream lat: 39.981338 long: -105.82494; Tabernash, CO
Williams Fork River Restoration Project	River restoration; rechanneling	\$984,000	Denver Water	Completed 2019		0.34 mile upstream of Williams Fork Reservoir, 0.88 mile directly below reservoir and 0.86 mile on Kemp Breeze State Wildlife Area (2.08 miles total)	Increase adult trout habitat; improve width - to-depth ratio at low flows	Denver Water property upstream and downstream of Williams Fork Reservoir; Kemp Breeze State Wildlife Area, Parshall, CO

Kemp-Breeze Habitat Project on the Colorado River	Process-based river restoration	\$1.2 million	Northern Water, Denver Water and CPW as described in the Fish and Wildlife Mitigation Plans associated with Windy Gap and Moffat firming projects	60% design to be complete in February 2020; construction scheduled for 2022		Process-based river restoration project incorporating habitat manipulation and strategic addition of wood and gravel/cobble substrate	Goals are to improve macroinvertebrate and small fish habitat and production, in particular for giant stonefly and mottled sculpin, and increase trout habitat	Kemp Breeze State Wildlife Area, Parshall, CO
Town of Granby Diversion Structure rebuilt	Fish passage improvement	\$279,200	US Fish & Wildlife Service; CWCB	Completed 2020		Rebuild of Town of Granby diversion structure on the Fraser River to allow for passage of all fish species present in the reach.	Reconnection of previously fragmented aquatic habitat	Kaibab Park, Town of Granby
Irrigators of Lands in the Vicinity of Kremmling Upper Colorado River Irrigation and Restoration Project	River restoration, diversion structures	\$3.8 million	CWCB; Natural Resources Conservation Service (RCPP); property owners	\$400,000 of completed work in fall 2018; additional work spread over 3-4 years		River restoration, bank repair and diversion structure/ ditch repair	River channel improvements and improved irrigation efficiency	12 miles total. Upstream end: CR 39; downstream end: 1.5 miles on the Blue River below the confluence with the Colorado River

Ranch Creek Riparian Habitat Restoration Project	Restoration of vegetation canopy along river bank	\$2,650	Patagonia Enviro grant	Completed 2021	No	Planting of willow stakes along a 1.0 mile reach of Ranch Creek to restore streamside vegetation after over-grazing	Improve stream bank stability and reduce solar influence	1.0 mile section of Ranch Creek, a tributary to the Fraser River. Upstream lat 39.9782142; long - 105.791868
Cabin Creek AOP Culvert	Fish passage and minor stream restoration	\$161,900	USF&WS grant: \$81.1K; DW \$41K in-kind; USFS \$37,600 in-kind; Grand County \$2200 in-kind	Completed 2021	No	Replace culvert with Aquatic Organism Culvert to allow fish passage	Aquatic habitat improvement project for Colorado River Cutthroat Trout	FS Road 128; Lat 39°59'1"N Long- 105°44'53.3 44"W
Connectivity Channel adjacent to Windy Gap Reservoir	Watershed health, rechanneling of river around the reservoir	Excess of \$20M	CWCB watershed; Federal; Water district	Initiated; construction scheduled Summer 2022.	Yes	Rechanneling the Colorado River around Windy Gap Reservoir	Restore the river's aquatic habitat; allow fish and macroinvertebrate passage; allow sediment transport; lower stream temperatures	Colorado River adjacent to Windy Gap Reservoir