GRAND COUNTY
LEARNING BY DOING

Learning By Doing 2020 Aquatic Resource Monitoring Plan

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Contents

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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 2020 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;
- Assess the impacts of the Fraser Flats River Habitat Project;
- 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;
- Support restoration efforts on the Colorado River by Irrigators of Lands in the Vicinity of Kremmling (ILVK);
- Document riparian vegetation monitoring in the CEA;
- Document progress related to construction of the Upper Colorado River Headwaters Project (aka Windy Gap Connectivity Channel).

A detailed sampling plan for each objective follows. Unforeseen circumstances outside of our control can cause changes to the sampling plans.

Summary of Existing Monitoring Efforts

A summary of all monitoring efforts conducted within the CEA is compiled every 2-3 years. Refer to Appendix B – 2018 Monitoring Summary for the most recent summary maps and monitoring schedules. 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
- 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
Cabin Creek North Channel	CBN	Fraser
Cabin Creek South Channel	CBS	Fraser
Little Cabin Creek	LCB	Fraser
Church Creek	CH	Upper Co
Colorado River	CR	Colorado
North Fork of Colorado	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
Granby Pump Canal	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
Ranch Creek Canal	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
Vasquez Creek Canal	VCC	Fraser
Little Vasquez Creek	LVC	Fraser
Williams Fork	WF	Williams Fork
Upper South Fork Williams Fork	USF	Williams Fork
South Fork Williams Fork	SWF	Williams Fork
Willow Creek Reservoir	WC	Upper Co
Willow Creek Pump Canal	WCP	Upper Co
Windy Gap Reservoir	WG	Middle Co
Windy Gap Pump Canal	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.

Existing Monitoring Summary

The existing monitoring summary site list includes 229 entity-specific sampling locations by 11 different entities. After assigning river mile IDs and grouping the sites accordingly, there are 117 sampling locations with unique river mile IDs. A complete list of the existing 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 – 2018 Monitoring Summary.

2020 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 65 sites in the CEA (one location is monitored by two entities as a quality control check point). Several entities maintain these sites: BLM, GCWIN, LBD, Northern Water and the USGS. 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 2020 monitoring sites is shown in Figure 1 and details of the program are included in the 2018 Monitoring Summary in Appendix B.

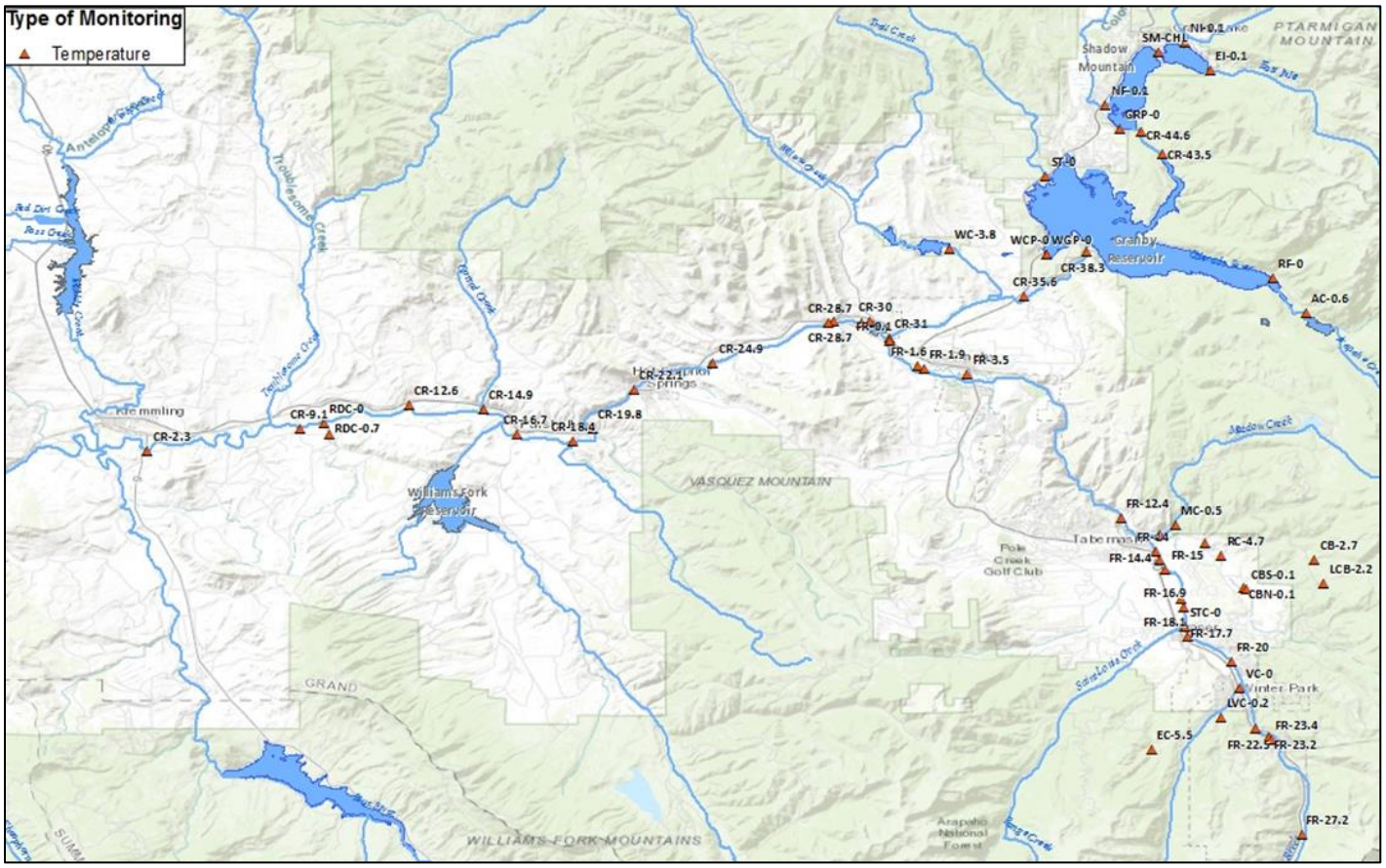

Figure 1 - Temperature Monitoring Sites in the CEA

2020 Changes to Temperature Monitoring Plan

The existing stream temperature monitoring network was analyzed for data gaps with respect to timeliness of data availability, Colorado's list of 303(d) impaired waters (Colorado Department of Public Health and Environment, Water Quality Control Commission. Reg #93., 2020), spatial coverage, diversions, and baseline data needs. Based on these assessments, only minor changes were made to the 2020 LBD stream temperature monitoring plan which includes the addition of two new sites.

Changes to Monitoring Locations

LBD retained every one of its 9 temperature sites that were monitored in 2019. Review of the temperature monitoring network showed the need to add two new monitoring locations on Ranch Creek. These locations were added to collect data upstream and downstream of a riparian revegetation effort near Quad Ranch. These data will be used to assess the effectiveness of the vegetation, once established, on stream temperature.

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.

2020 LBD Temperature Monitoring

The 2020 LBD temperature monitoring program consists of 11 sites (Table 2). At three sites, data are downloaded, compiled, and distributed to the LBD Operations Subcommittee on a weekly basis from June 17 - September 15. At the remaining 8 sites, data are download biweekly from April – October and the data are compiled and shared at the end of the monitoring season.

Table 2 – 2020 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	Weekly (Jun - Sep)
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 in cooperation with GCWIN and LBD.

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.

Below is a summary of the protocols:

- GCWIN utilizes HOBO Water Temp Pro v2 Dataloggers (Part # U22-001, Onset Computers) for water temperature monitoring.
- 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 must be 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 record battery voltage.
- Ideally the sensor is placed in the thalweg or mid-50% of stream width, assuming these locations are in flowing water. Above all, the sensor needs to be located in flowing, deep water.
- If the 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 the sensor and flow is comparable to that seen in the thalweg.

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.

Funding

Costs for the 2020 temperature monitoring are shared among some LBD partners. The partners each pay a percentage of the total cost. The cost distribution for 2020 is:

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

2020 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 2020 Sediment Monitoring Plan within the CEA. The objectives of the 2020 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 Sample Collection

Core sampling is used to measure particle size distributions, particularly percent fines. It is a quantitative method used to assess fine sediment in trout spawning beds and involves identifying trout spawning bars from fish redd surveys in the fall. Samples are

collected with a McNeill-Ahnell core sampler, which is 15 cm in diameter and 6 inches deep. The method is best suited for evaluating salmonid spawning sites with smaller substrate, such as pebbles and gravel.

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.

Table 3 - LBD Core Sampling Reaches and Sampling History

Stream Reach	Stream Reach Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
F9	Fraser River between the Fraser Canyon and Granby	x	x	x	x	x	x	x	x		
F-RC2	Fraser River Tributary, Ranch Creek (lower)	x	x	x		x			x		
CR4	Chimney Rock (X^1), Paul Gilbert (X^2), or Pioneer Park (X^3) depending on site conditions	x^1	x^1	x^2	x^2	x^3	x^3	x^3	x^3	x^3	
CR5	Downstream of Williams Fork confluence and Parshall	x	x	x	x	x	x	x	x	x	
CR6	Downstream of KB Ditch	x	x	x	x	x	x	x	x	x	

**No core samples in 2019*

Pebble Counts

Pebble counts are a rapid method used to document the cumulative distribution of grain sizes and the degree of embeddedness. It is a geomorphic measure and is a good method for identifying median bed particle size.

In 2019, pebble counts were conducted at all macroinvertebrate sites with the sampling grid method 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).

Percent algal cover and percent embeddedness were estimated concurrent with pebble counts in 2019 by GEI Consultants. For assessment of algae, a viewing bucket (a bucket with a 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.

Table 4 - LBD Pebble Count and Algae Assessment Sites

River Mile ID	Station Description	Monitoring Frequency	2017	2018	2019
FR-27.2	Fraser River upstream Jim Crk/Mary Jane entrance	1x/2-3 yrs		XNew	
FR-25.1	Fraser River upstream of UP Railroad discharge	Annually			XNew
FR-23.2	Fraser River upstream of Winter Park San District	Annually	X	X	X
FR-20	Fraser River at Rendezvous Bridge	Annually	X	X	X
FR-15	Fraser River upstream of Fraser Flats restoration	Annually	X	X	X
FR-14	Fraser River upstream of Tabernash	Annually	X	X	X
FR-12.4	Fraser River upstream of Fraser Canyon	1x/2-3 yrs	X		
FR-1.9	Fraser River upstream Granby Sanitation District	1x/2-3 yrs	X		X
STC-0	Saint Louis Creek at Fraser River	1x/2-3 yrs		XNew	X
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	X	X	X
CR-31	Colorado River upstream Fraser and Windy Gap	Annually	X	X	X
CR-28-7	Colorado River downstream of Windy Gap	Annually	X	X	X
CR-22.9	Colorado River upstream of Hot Sulphur Springs	Annually	X	X	X
CR-16.7	Colorado River upstream of Williams Fork	Annually	X	X	X
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	1x/2-3 yrs*	X	X	X
CR-7.4	Colorado River downstream Troublesome Creek	TBD		XNew	X
CR-1.7	Colorado River upstream of the Blue River	TBD		XNew	X

**Site will be sampled annually during the ILVK restoration project*

Riffle Stability Index

The RSI estimates mobile sediment fraction in a river's riffle. It is geomorphic measure, not a habitat measure. A river receiving excessive fine sediment will have smaller, finer particles accumulated in the riffle when compared to a river in dynamic equilibrium without excessive sedimentation. RSI 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.

When flows are adequate, RSI evaluations are made to help determine whether spring runoff flows were sufficient to mobilize coarse bed particles and facilitate bar dynamics. The RSI can be compared between sites to determine relative rates of sedimentation. Flows allowed for the RSI to be measured in 2019.

2020 Changes to Sediment Monitoring Plan

In addition to the 400-pebble counts, 100-pebble counts will be conducted at spawning sites, following the modified method outlined in WQCD 98-1, Appendix B. The smaller pebble count is conducted only over the spawning area (not the whole stream width or stream segment). The purpose of this additional pebble count is to see if there

is a correlation between the sediment core sampling results and the 100-pebble count. Ultimately, if there is a strong relationship, the simpler and more cost-effective 100 pebble count method could be used as a surrogate measurement to assess substrate in spawning areas instead of the sediment core sampling.

Core sampling will resume at the historic core sampling sites in the CEA. Core sampling was last conducted in 2018.

RSI evaluations in the past have been conducted at core sampling sites, which are trout spawning areas. However, riffles are shallower sites with fast moving water that are not where trout spawn. The RSI is more appropriate in riffles, which are macroinvertebrate habitat. To be able to compare to historic data and move towards sampling in riffles, RSI measurements will be conducted at three of the historical sediment core sample sites and six macroinvertebrate sites.

Estimations of algae presence will be documented. In the viewing bucket, photographs will be taken during the survey to visually record representative observations and to calibrate surveys over time.

2020 LBD Sediment Monitoring

Methods for sediment monitoring in 2020 will be the same that were used in 2019 and will build on historic monitoring efforts in the CEA. The changes outlined above are additional monitoring efforts to build correlation relationships in hopes of reducing the number of monitoring methods used to increase efficiency and save cost. Sediment monitoring in 2020 will be a comprehensive measure of the trout spawning and macroinvertebrate habitat.

Monitoring Sites and Sampling Frequency

The proposed sediment monitoring plan includes:

- 400-pebble count collected in compliance with Water Quality Control Commission Policy 98-1, and algae assessment at each of the ten 2020 macroinvertebrate sites;
- Sediment core sampling at all 5 of the historical core sample sites;
- 100-pebble count collected at 3 of the core sampling sites;
- RSI at 3 of the historical core sampling sites and 6 riffle sites.

In 2020, 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 SubCommittee.

All sampling will be conducted once in the early fall and within 2 weeks of the macroinvertebrate monitoring.

Table 5 - Summary of 2020 LBD Monitoring Sites and Type of Sediment Data Collected

River Mile ID	Station or Stream Reach Description	Pebble Count	Spawning Pebble Count	RSI	Core Sample	Entity
FR-27.2	Fraser River upstream Jim Creek/Mary Jane entrance					LBD
FR-25.1	Fraser River upstream of UP Railroad discharge	X				LBD
FR-23.2	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
FR-12.4	Fraser River upstream of Fraser Canyon	X				LBD
FR-1.9	Fraser River upstream of Granby Sanitation District					LBD
STC-0	Saint Louis Creek at Fraser River					LBD
RC-1.1	Ranch Creek downstream of Meadow Creek	X		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-22.9	Colorado River upstream of Hot Sulphur Springs	X				LBD
CR-16.7	Colorado River upstream of Williams Fork	X		X		LBD
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	X		X		LBD
CR-7.4	Colorado River downstream Troublesome Creek	X				LBD/ILVK
CR-1.7	Colorado River upstream of the Blue River	X				LBD/ILVK
F9	Fraser River between the Fraser Canyon and Granby		X	X	X	LBD
F-RC2	Fraser River Tributary, Ranch Creek (lower)		X	X	X	LBD
CR4	Paul Gilbert or Pioneer Park (depends on site conditions)				X	LBD
CR5	Downstream of Williams Fork confluence and Parshall				X	LBD
CR6	Downstream of KB Ditch		X	X	X	LBD

Data Reporting

Data analysis will be completed by the end of 2020, and a final report will be provided to LBD in early 2021.

Funding

Costs for the 2020 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-1.7). The remaining costs at these two sites were covered by the above LBD partners at their respective contribution percentage.

2020 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 2020 macroinvertebrate monitoring plan within the CEA. The objectives of the 2020 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 the 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 in the area of 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 is scheduled to begin in 2021. The Subdistrict is working with the Division on site selection. It is anticipated that monitoring will occur at 2 additional sites in 2020 to obtain pre-project data.

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. Northern Water's baseline monitoring was conducted in 2018; sampling will not be conducted in 2020.

2020 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 2020, no changes were made to the LBD sites established sampling frequency.

New Monitoring Sites

After reviewing the spatial distribution of site locations and areas of known watershed disturbances, no new sites will be added to LBD macroinvertebrate sampling program.

2020 LBD Macroinvertebrate Monitoring

The 2020 LBD macroinvertebrate monitoring program consists of 15 sites; 3 sites in the Colorado River, 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 the 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 2020, macroinvertebrate sampling will be conducted at 10 out of the15 LBD sites. The locations of the 2020 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 this timing of sample collection will be different.

Table 7 - LBD Macroinvertebrate Sampling Sites and Years Monitored

River Mile ID	Station Description	Monitoring Frequency	Years Monitored 2017	2018	2019	2020	Project Specific
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane entrance	1x per 2-3 years		X[New]			No
FR-25.1	Fraser River upstream of UP Moffat Tunnel discharge	Annually			X[New]	X	No
FR-TBD	Fraser River downstream of UP Moffat Tunnel discharge	As needed			X[New]	X[1]	No
FR-15	Fraser River upstream of Fraser Flats restoration	Annually	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		No
STC-0	Saint Louis Creek at Fraser River	1x per 2-3 years		X[New]			No
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	X	X	X	X	No
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	1x per 2-3 years[2]	X	X	X	X	No
CR-7.4	Colorado River downstream of Troublesome Creek	TBD		X[New]	X	X	Yes
CR-1.7	Colorado River upstream of the Blue River	TBD		X[New]	X	X	Yes
WF-13.1	Williams Fork downstream of Henderson Mill	1x per 2-3 years		X[New]			No
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	TBD		X[New]	X	X	Yes
WF-2	Williams Fork downstream of Williams Fork Reservoir	TBD		X[New]	X	X	Yes
WF-0.5	Williams Fork downstream of Williams Fork Reservoir at Kemp Breeze	TBD			X[New]	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 was not needed.*

[2] *Site will be sampled annually during the ILVK restoration project*

Table 8 - 2020 LBD Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Latitude	Longitude
FR-25.1	Fraser River upstream of UP Railroad discharge	39.8775	-105.7535
FR-15	Fraser River upstream of Fraser Flats restoration	39.9813	-105.8249
FR 12.4	Fraser River upstream of Fraser Canyon	40.0087	-105.8480
RC-1.1	Ranch Creek downstream of Meadow Creek	39.9991	-105.8275
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	40.05377	-106.28945
CR-7.4	Colorado River downstream of Troublesome Creek	40.0509	-106.3112
CR-1.7	Colorado River upstream of Blue River	40.0465	-106.3730
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	40.0004	-106.17975
WF-2	Williams Fork downstream of Williams Fork Reservoir	40.03620	-106.20489
WF-0.5	Williams Fork downstream WF Reservoir at Kemp Breeze	40.0561	-106.1825

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 2020 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, March 2019). Samples are collected with a Hess Sampler which is 13 inches in diameter and 16 inches tall with 500µm 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 2).

Figure 2 - Sample Collection with a Hess Sampler

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.

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 2020 macroinvertebrate monitoring will be shared among some LBD partners. The partners each pay a percentage of the total cost. The cost distribution for 2020 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). The remaining costs at these two sites will be covered by the LBD partners at their respective contribution percentage.

Denver Water, Subdistrict Monitoring and Northern Baseline Monitoring

Denver Water, the Municipal Subdistrict and Northern Water will fully fund sampling for the Moffat Project and WGFP 401 Certification Compliance Monitoring.

2020 Fraser Flats River Habitat Project Monitoring Plan

The following plan has been approved by the LBD Management Committee for 2020 monitoring of the Fraser Flats River Habitat Project. While not required as part of its 404 Permit for the project, LBD has voluntarily elected to create a temporary monitoring program, which will follow the measures in the *Monitoring at-a-Glance* table provided in Figure 4 at the end of this section.

Program Objectives

The objectives of the Fraser Flats River Habitat Project monitoring program include documentation of the following parameters:

- Aquatic habitat features and substrate conditions
- Benthic macroinvertebrate abundance and diversity
- Estimates of trout population and quality trout densities
- Riparian woody habitat
- Instream temperature monitoring

Construction of the project was completed in September 2017. This temporary monitoring program will be performed annually for at least 3 years post-project according to the program's guidelines finalized on October 20, 2017[1].

Scope of 2020 Monitoring Program Proposal

The scope of the 2020 monitoring program is to document and compare the 2018, 2019, and 2020 post-project conditions with the pre-project (baseline) conditions of the project site.

Monitoring Program Components

The following describes the sampling and/or monitoring for 2020. A map showing the locations of the sampling sites is provided in Figure 3.

[1] LBD Monitoring Subcommittee, 2017. Fraser Flats River Habitat Project Monitoring Program Guidelines. Revised October 20, 2017 based on the August 16, 2016 monitoring plan.

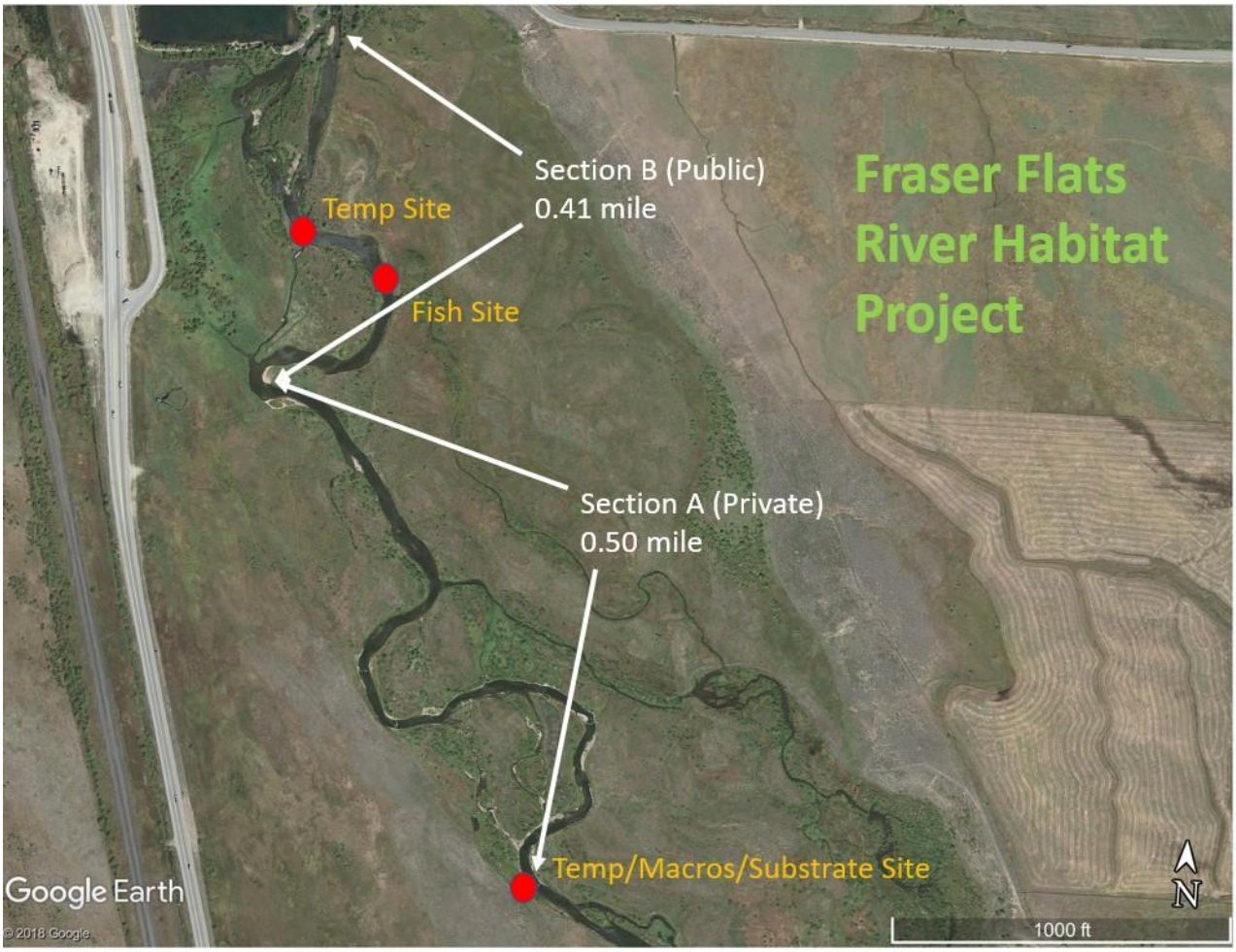

Figure 3 - Map of 2019 Fraser Flats Monitoring Sites Fraser Flats Monitoring Sites

Aquatic Habitat and Substrate Conditions

Aquatic Habitat Features Data Collection

The purpose of this task is to compare the number and condition of the aquatic habitat features present in the project reach to pre-project conditions. For 2020 monitoring, a blend of both field observations and field measurements will be performed as resources and time allow (refer to methods 1 and 2 described below).

> Method 1 – Field Observations. A site visit will occur in late summer/early fall of 2020 during low flow conditions to conduct field observations of the aquatic habitat features in the project reach. This field visit will be performed by members of the LBD Monitoring Subcommittee.

During the 2020 field visit, the as-built design drawings[2], as-built photographs, and aerial photography (if available from Lighthawk) will be used to identify the location of the aquatic habitat features in the project reach. Field notes and photographs will be used to record the condition of these aquatic habitat features and any changes from the as-built design drawings, if applicable.

Photo points capturing visible aquatic habitat features in the project reach may be established for visual comparison year to year.

Method 2 – Field Measurements. This method includes performing field measurements using survey equipment to capture cross-sections of the project reach. A set of 5 or 6 cross sections would be established at locations along the project reach based on the pre-project (baseline) cross-sections performed by Tetra Tech and refined by Freestone Aquatics. A laser level will be used to measure the condition of width-to-depth ratios of habitat features and the depth of pools in each cross-section. Jon Ewert (CPW) offered to collect the cross-section field measurements and he may be assisted by members of the Monitoring Subcommittee.

These measurements will be used to compare the conditions of the cross-sections to the as-built design drawings to evaluate whether any changes are occurring over time, such as shifts in the width-to-depth ratios of habitat features or sedimentation filling in pools.

Substrate Conditions Data Collection

The purpose of this task is to compare the substrate conditions of the project reach to pre-project conditions. Field sampling of pebble counts (i.e. material sizes, presence of fine sediment, and embeddedness) will be performed by GEI in late summer/early fall of 2020 during low flow conditions.

The pre-project pebble count data will be extracted from Tetra Tech's 2017 report prepared for LBD to be used to compare to the 2018, 2019, and 2020 post-project data measured in the project reach.

Summary Table

A table summarizing the field data on aquatic habitat features and substrate conditions will be created to provide a concise comparison between the 2017 pre-project and 2018, 2019, and 2020 post-project conditions. This table will be used to document progress made with regards to *Objective #1 - An increase in aquatic habitat features and improved substrate conditions.*

[2] Freestone Aquatics, 2017. Fraser Flats Aquatic Habitat Restoration Project As-Built Set. September 29, 2017.

Macroinvertebrates

Macroinvertebrate Sampling Data Collection

The purpose of this task is to compare the macroinvertebrate community present in the project reach to pre-project conditions. The macroinvertebrate field sampling will be performed by Timberline Aquatics in fall of 2020.

The pre-project sampling results on macroinvertebrate abundance and diversity will be extracted from Timberline Aquatic's 2017 data prepared for LBD to be used to compare to the 2018, 2019, and 2020 macroinvertebrate sampling results.

Summary Table

A table summarizing the field data on abundance and diversity of macroinvertebrates will be created to provide a concise comparison between the 2017 pre-project and 2018, 2019, and 2020 post-project data. This table will be used to document progress made with regard to *Objective #2 - An increase in benthic macroinvertebrate abundance and diversity*.

Fish

CPW Electrofishing Survey Data Collection

The purpose of this task is to compare the fish community present in the project reach in terms of trout population estimates and density of quality trout (defined as greater than 14 inches) to pre-project conditions. An electrofishing survey will be performed by Colorado Parks and Wildlife (CPW) in fall of 2020. Members of the Learning By Doing Monitoring Subcommittee may participate in the fish survey.

CPW will monitor the project reach with the goal of documenting changes in[3]:

- biomass (pounds per surface acre of water),
- density of trout greater than 14 inches, and
- densities of sculpin.

The 2020 fish survey will be performed at CPW's established electrofishing site in Section B (Grand County Water and Sanitation District #1 property) of the project reach. Precise estimates of sculpin are difficult to obtain because this species is more difficult to capture by electrofishing. Therefore, a simple index of the number of sculpin captured in the fish survey each year, rather than a calculated population estimate, will be tracked over time and monitored for trends.

[3] LBD Monitoring Subcommittee, 2017. Fraser Flats River Habitat Project Monitoring Program Guidelines. Revised October 20, 2017 based on the August 16, 2016 monitoring plan.

The pre-project survey results quantifying fish biomass, density of trout greater than 14 inches, and number of sculpin will be extracted from CPW's 2016 and 2017 data to be used to compare to the 2018, 2019, and 2020 fish survey results.

Comparisons of fish species composition, age class, and body condition may also be considered in the assessment of pre- and post-project data.

Summary Table

A table summarizing the fish survey results quantifying fish biomass, density of trout greater than 14 inches, and number of sculpin will be created to provide a concise comparison between the 2016 and 2017 pre-project data and the 2018, 2019, and 2020 post-project data. This table will be used to document progress made with regard to *Objective #3 - An increase in fish counts and quality trout.*

Riparian Woody Habitat

Riparian Woody Vegetation Survey Data Collection

The purpose of this task is to compare the riparian woody habitat present in the project reach to pre-project conditions. The canopy of willow and cottonwood stakes planted in the revegetated areas in May 2017 is expected to mature over time to provide bank stabilization and increased shade cover, which will benefit the river by helping to provide cool instream habitat.

A field visit to conduct woody stem counts in the revegetated areas will be conducted by the Trout Unlimited Colorado Headwaters Chapter and LBD Monitoring Subcommittee members in the fall of 2020. Prior to the field visit, the riparian revegetation design plan prepared by Anna Drexler-Dreis[4] will be reviewed to determine the locations of the revegetated areas and the numbers of willow and cottonwood stakes planted in each area in 2017.

During the 2020 field visit, as time is available, photographs will be taken at the established photo points documented in the revegetation plan. Woody stem counts will be performed in the revegetated areas. Field notes on the condition and survival rate of the plantings will be recorded.

The pre-project and post-project revegetation data will be evaluated in two ways: (i) spatially using aerial photographs (if available) and photos taken at the established photo points for year to year comparisons of the canopy re-establishment; and (ii) quantifying the number and condition of the willow and cottonwood plantings for year to year comparisons of the survival rate and health of the vegetation community.

[4] Drexler-Dreis, Anna. 2017. Fraser Flats River Habitat Project Vegetation Plan. Approved by the LBD Governance Committee on September 28, 2016. Updated on March 8, 2017.

Summary Table

A table summarizing the field data on the riparian woody habitat will be created to provide a concise comparison between the 2017 pre-project and 2018, 2019, and 2020 post-project data. This table will be used to document progress made with regard to *Objective #4 - An increase in riparian woody habitat*.

Stream Temperature

Stream Temperature Data Collection

The purpose of this task is to compare instream temperatures with pre-project conditions with the goal of documenting changes in instream temperatures over time. GCWIN maintains temperature loggers at the upstream project boundary on Section A (Devil's Thumb Ranch property) and in the lower project reach on Section B (Grand County Water and Sanitation District #1 property). GCWIN will collect stream temperature data at these locations in 2020.

The pre-project stream temperature results from GCWIN's 2015-2017 data will be used to compare with the 2018, 2019, and 2020 stream temperature results.

Summary Table

A table summarizing the stream temperature data at the upstream and downstream sites from the project reach will be created to provide a concise comparison between the pre-project and 2018, 2019, and 2020 post-project data. This table will be used to document progress made towards *Objective #5 - Instream Temperature Monitoring (to evaluate reductions in stream temperature)*.

Monitoring At-A-Glance[5]

	Method	Agency	Frequency & duration	Sample Season	Site Location	Notes
Benthic macro-invertebrates	NAMC* protocol	Timberline Aquatics	annual for 3 years post construction	September of each year	1) New site in restoration area 2) County Road 83	Reach-based approach, 8 samples per site, composited, subsampled to 300. Metrics are calculated from these results.
Fish count surveys	electro-fishing	CPW	annual for 3 years post construction	September and October of each year	1) In restoration area 2) Fraser Safeway 3) Fraser, Kaibab Park in Granby	All trout species & sculpin will be totaled, and trout biomass (pounds per acre), fish >14" per surface acre, and >6" per mile will be reported.
Riparian survey	photos and woody stem counts	Trout Unlimited	every 3-5 years for 10 years.	First two years post construction	1) In restoration area	Include: percentage of woody canopy and riparian plant species, monumented photo points and photos.
Substrate conditions	pebble counts	GEI	annual for 3 years post construction	September of each year	1) New site in restoration area 2) County Road 83	Document bar material sizes, presence of fines and embeddedness.
Aquatic habitat features	photo points	LBD/CPW	annual for 3 years post construction	Low flow	To be determined	Pre- and post-construction monitoring using photographs and the inventory of # riffles, runs, pools in project reach.
Stream Temperature	temp-erature loggers	GCWIN**	15-minute interval time-series; annual	Annually during ice off	1) Upstream project boundary 2) downstream project reach	Measurable results as a result of the project are not anticipated because temperature depends upon several factors, and this is a relatively short, low gradient reach.

*Bureau of Land Management/Utah State University National Aquatic Monitoring Center
**Grand County Water Information Network

Figure 4 - Summary of LBD Monitoring Guidelines for the Fraser Flats River Habitat Project

[5] This Monitoring At-A-Glance table is based on the 2016 Monitoring Plan guidelines developed by LBD. Some of the agency names and sampling methods may change, and if so, the Subcommittee will evaluate accordingly when comparing year to year data results of the program.

2020 303(d) List Monitoring Plan

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., 2020) within the CEA to ensure that adequate monitoring is being done in segments where there are impairments.

Regulation #93 consists of 3 components:

1. The list of Water-Quality-Limited Segments Requiring total maximum daily loads (TMDLs) fulfills requirements of section 303(d) of the federal Clean Water Act, which requires that states 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, but there is also uncertainty regarding one or more factors, such as the representative nature of the data. Water bodies that are impaired, but it is unclear whether the cause of impairment is attributable to pollutants as opposed to pollution, are also placed on the Monitoring and Evaluation List. This Monitoring and Evaluation list is a state-only document that is not subject to EPA approval.

3. The list of Water-Quality-Limited Segments Not Requiring a TMDL identifies segments where data is available that indicates that at least one classified use is not being supported, but a TMDL is not needed.

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

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

2020 Review of Impaired Segments

In January 2020, the Water Quality Control Commission adopted the most recent version of Regulation #93, which became effective on March 3, 2020. The most current 303(d) and M&E list showed that 15 stream segments are currently listed as impaired within Grand County; 7 of these segments, COUCUC01, COUCUC02, COUCUC03, COUCUC08, COUCUC09, COUCUC10a, COUCUC10c and four water bodies (COUCUC12) are located within the LBD CEA as shown in Figure 5. Of the 7 listed segments within the LBD CEA, the impaired uses are for Recreation, Water Supply, and

Aquatic Life Use. The primary analytes of concern are arsenic (total), E. coli, copper (dissolved), silver, zinc, pH, stream temperature, and macroinvertebrates. There are seventeen new listings within the CEA for arsenic, pH, copper, silver, zinc, and E. Coli. Eleven segments were delisted for macroinvertberates, copper, dissolved oxygen, manganese, and iron. These changes are detailed below.

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 and a known carcinogen. Arsenic is regulated at the federal level under multiple agencies and 7 different acts including two associated with the Colorado Department of Public Health and Environment.[6] In 2013, Colorado implemented a major update to the arsenic water quality standards. These standards have led to some interesting and costly regulatory compliance solutions in Colorado. At this time, there are no feasible treatment processes available to effectively treatment stream segments for arsenic.[7]

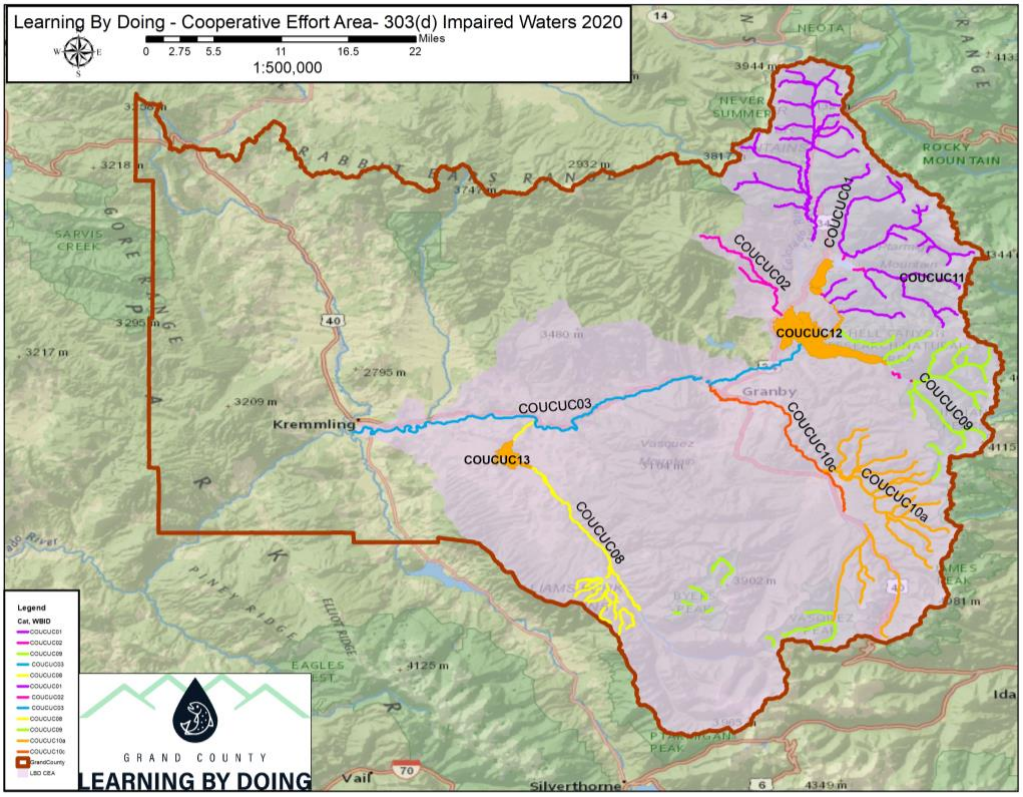

Figure 5 - Grand County Impaired Segments

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

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

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

1. **<u>COUCUC01</u> 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. **<u>COUCUC02</u> Mainstem of the Colorado River, including all tributaries and wetlands within, or flowing into Arapahoe National Recreation Area.**

    - COUCUC02_B Willow Creek, Stillwater Creek, and Arapaho Creek
        - Aquatic Life Use – Temperature – 303(d)

    - 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* New listing 2020
        - Aquatic Life Use – Silver (Dissolved) – M&E List* New listing 2020
        - Aquatic Life Use – Copper (Dissolved) – 303(d)

    - COUCUC02_E Mainstem of East Inlet
        - Aquatic Life Use – Zinc (Dissolved) – M&E List* New listing 2020
        - Aquatic Life Use – Silver (Dissolved) – M&E List* New listing 2020
        - Aquatic Life Use – Copper (Dissolved) – 303(d) * *New listing 2020*

    - COUCUC02_I Arapaho Creek downstream of Monarch Lake
        - Aquatic Life Use – Silver (Dissolved) – M&E List* New listing 2020
        - Aquatic Life Use – Temperature – 303(d) * *New listing 2020*

    - COUCUC02_L Stillwater Creek, including tributaries and wetlands, within or flowing into Arapaho Recreation Area
        - Water Supply Use – Arsenic (Total) – 303(d) * New listing 2020
        - Water Supply Use – Silver (Dissolved) – 303(d) * New listing 2020
        - Aquatic Life Use – Temperature – 303(d) * *New listing 2020*

3. **<u>COUCUC03</u> - 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. **<u>COUCUC08</u> - 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* New listing 2020

5. **<u>COUCUC09</u> – 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) * New listing 2020

6. **<u>COUCUC10a</u> - 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 (provisional) – 303(d)
        - Aquatic Life Use – Copper – 303(d)

    - COUCUC10a_E - Mainstem of Fraser River from source to Leland Creek
        - Aquatic Life Use – Copper – 303(d) *new listing in 2020.

7. **<u>COUCUC10c</u> - 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 *new listing in 2020
        - 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 Town of Granby to confluence with the Colorado River
        - Recreation – E. coli – 303(d) *new listing in 2020
        - Water Supply Use – Arsenic (total)– 303(d)

8. **<u>COUCUC12</u> – 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
        - Water Supply Use – Arsenic (total) – 303(d)

9. **<u>COUCUC13</u> – 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*new listing in 2020

2020 LBD Monitoring to Support 303(d) Listings

The Listing Methodology sets forth criteria that will be utilized to decide which waters will be included on the Section 303(d) List and the Monitoring and Evaluation List under Regulation #93. The water quality assessment process depends on analysis of sufficient reliable data. Generally, only data from the previous five years is assessed.[8] In order for a 303(d) listing there has to be a representative data set, which is defined in the Section 303(d) Listing Methodology 2020 Listing Cycle. The impairments listed in these segments were evaluated against the 2020 Monitoring Summary (Appendix B). This evaluation showed that there is sufficient monitoring being conducted by various entities throughout the CEA. The 4 impaired segments within the CEA were evaluated against known water quality monitoring.

[8] Colorado Department of Public Health. Water Quality Control Division. Section 303(d) Listing Methodology 2020 Listing Cycle. March 2019.

2020 CPW Fish Monitoring Plan

In cooperation with LBD monitoring efforts, CPW plans to survey fish populations at the following locations in 2020. All fish survey activities are dependent upon flow and temperature conditions, as well as staff and volunteer availability.

Fraser River

Robbers' Roost – near the headwaters of the Fraser River, upstream of Mary Jane Ski Area near the base of Berthoud Pass. Sampling will be conducted the week of August 31st.

Idlewild Campground - Sampling will be conducted the week of August 31st.

Confluence Park – Town of Winter Park. Sampling will be conducted the week of August 31st.

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 31st.

Grand County Water and Sanitation #1 property – see Fraser Flats monitoring plan. Sampling will be conducted on October 2nd.

Fraser River Ranch. Sampling will be conducted the week of August 31st.

Kaibab Park, Town of Granby. Sampling will be conducted the week of August 31st.

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.

Parshall-Sunset – raft electrofishing reach. Surveyed annually.

Gilbert-Lone Buck – raft electrofishing reach on State Wildlife Area near Hot Sulphur Springs. Surveyed triennially.

2020 Riparian Areas and Wetlands Monitoring Plans

This section documents known riparian vegetation monitoring or other revegetation efforts within the CEA.

Revegetation on Ranch Creek

On May 19, and June 2 and 3, 2018, the Colorado River Headwaters Chapter of Trout Unlimited, an LBD partner, led the re-vegetation of a portion of Ranch Creek on Devil's Thumb Ranch property by donating volunteer time and resources to prepare the planting design and coordinate three volunteer work days. In total, 2,700 willow stakes were harvested and replanted along the banks of this targeted portion of Ranch Creek to improve riverbank stability, reduce solar influence on the water's surface and provide cover for trout. Over the three workdays, volunteers from communities in Grand County and on the Front Range participated.

In 2019, LBD and the Colorado River Headwaters Chapter of Trout Unlimited revisited the restoration site to count and assess the condition of the willows planted. The Headwaters Chapter organized a volunteer harvest and planting days in spring 2019 to supplement the 2018 plantings. LBD and the Headwaters Chapter will continue to monitor the success of the plantings in future years.

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 2020.

2020 ILVK Monitoring Program

This section documents monitoring and restoration efforts on the Colorado River that are managed by the Irrigators of Lands in the Vicinity of Kremmling (ILVK) and supported by a grant to the Colorado River Headwaters Project from the National Resource Conservation Service (NRCS). The following is from the May 11, 2018 ILVK proposed monitoring plan. The same sites were monitored in 2019 and 2020, in addition to more extensive vegetation monitoring. The first phase of the ILVK restoration will be completed in 2020.

ILVK Proposed Monitoring Plan

The goal of the monitoring plan is two-fold. The first goal is to monitor constructed improvements at each of the discreet project sites, including the monitoring of constructed bank and channel features, as well as plant establishment. The second goal is to monitor the effects of the project components on the aquatic species and their habitat. These two plans are outlined below.

Monitoring of Constructed Improvements

The monitoring of constructed improvements shall begin following construction of the improvements and extend for several years depending on site conditions and length of time required for stabilization. Any projects requiring a USACE permit shall be monitored in accordance with the permit requirements outside of or in addition to the monitoring outlined below.

Each site will include a temporary control point, set for construction and used to survey as-builts. Following construction, as-built surveys will be performed to confirm the project was constructed in accordance with the plans. The as-built survey will include channel cross sections and a profile of the channel thalweg through the constructed reach. Sites with riffle structures installed to control headwater at pump intakes will be surveyed at a pre-identified location, such as at the crest elevation, as well as a water surface elevation.

The post-construction monitoring shall be conducted for one year after the completion of construction and as-built surveys, generally following the list below. Note that not all items will be applicable at every site and that vegetation should be monitored more frequently during the first year.

1. Visually inspect the channel and all installed structures. Check in-stream structures from the bank or a dry location and document using digital photos;
2. Check all banks, rock, wood, and structures for accelerated weathering, displacement, or significant changes since the original construction;
3. Check for scour or excessive erosion of stream banks, bed and crossings;
4. Inspect vegetation and plantings frequently. During the first part of the growing season, check the vegetation every week or two;

5. Monitor vegetation and plantings for damage caused by animals, insects, and disease;
6. Check for vigorous growth of desirable vegetation;
7. Inspect channel upper banks for settlement or large cracks in the soil;
8. Inspect temporary fences installed to control grazing access while plants become established;
9. Inspect for trash and debris accumulation.

Following the first year, monitor as needed until vegetation is established and the site appears stable. Ocular surveys should be conducted in early spring before runoff and late summer or early fall when river flows are low, but before vegetation becomes dormant for the fall/winter following the list below:

1. Visually inspect the channel and all installed structures. Check in-stream structures from the bank or a dry location and document using digital photos;
2. Check all banks, rock, wood, and structures for accelerated weathering, displacement, or significant changes since the original construction;
3. Check for scour or excessive erosion of stream banks, bed and crossings;
4. Inspect vegetation and plantings;
5. Inspect for trash and debris accumulation.

Should the monitoring indicate remedial action is warranted, implementation should be conducted as soon as possible. This might include adjustments to rock and wood in the bank and channel to restore original grade, and/or re-stabilize; replacement of vegetation; installation of additional fencing to protect plants; reseeding, watering, weeding by hand, replanting, mulching, and removal of invasive plants when necessary; and the removal of debris and trash that could cause damage to installed structures and bank treatments, or if debris poses a safety/flooding hazard. Document inspections and remedial actions.

Monitoring Aquatic Species and Habitat

While there are many potential indicators of aquatic health, this monitoring plan focuses on four key parameters: river water levels at pump intakes, surface water temperature, fish population and macroinvertebrates. The following is a general overview of the monitoring efforts proposed to evaluate the effects of the project components on the aquatic species and their habitat. Note that detailed testing, protocol and evaluation will be developed in conjunction with the ILVK partners including Colorado Parks and Wildlife (CPW) and Learning By Doing (LBD). This proposal is pending an agreement on protocol among the partners, potentially leveraging monitoring that may be, or is being done by the ILVK partners, in combination with new monitoring that may require an outside funding source, yet to be determined.

River Temperature and Water Levels

Data from two sites currently being monitored by others will be utilized to monitor temperatures in the ILVK reach. The first site, located on the upstream end of the ILVK reach at County Road 39, is monitored by GCWIN. The second site is located at the U.S. Highway 9 Bridge and is monitored by the Bureau of Land Management (BLM). BLM has agreed to share its temperature data with ILVK. These two sites will provide important temperature baseline and post-construction information.

ILVK is also proposing to monitor surface water levels at pump intakes wherever riffle grade controls are installed. Currently there are two riffle structures in place on the Riverside Ranch property where monitoring is proposed pending final bank stabilization above and below the two riffles. It is anticipated that under the ILVK RCPP EQIP, additional riffle grade control structures will be installed, and all will include water level monitoring. ILVK proposes to engage the property owners with the monitoring effort using a technology that is appropriate and manageable. This could range from automated data, or a manually read staff gage, and is dependent on funding and input from the producers.

Fish Population Surveys

CPW has provided baseline fish surveys in a 3-mile reach generally located between the Ennis and Orr no. 2 Pumps. CPW has committed to continue conducting fish surveys for the next 5 years. 2019 was the fourth year CPW conducted fish surveys in this 3-mile stretch. For purposes of the ILVK project, this fish sampling is strategically located within the central portions of the project and will provide important and informative data on fish population and impacts from the ILVK projects.

Macroinvertebrates

Macroinvertebrate monitoring is proposed in three locations:

1. County Road 39 Bridge;
2. Downstream of the confluence with Troublesome; and
3. The Thompson Riffle.

Macroinvertebrate monitoring has been conducted at County Road 39 on the upstream end of the ILVK project reach through the Learning By Doing efforts for seven years. Learning By Doing proposes to continue macroinvertebrate sampling at County Road 39 in 2020. This will inform conditions upstream of County Road 39 and provide valuable overall trends as it is the longest running monitoring site within the ILVK project reach. Because the continuation of monitoring at this location would provide valuable feedback on the effects of the proposed projects, continued monitoring is critical.

The Thompson family recently constructed two grade control riffles on their property. ILVK recommends macroinvertebrate monitoring in this location as it is key to assessing the effects of constructed riffles. ILVK is committed to working with its partners to identify

resources for implementation of monitoring at these riffles. In addition, a third site is proposed, located downstream of the confluence of Troublesome Creek. Troublesome Creek is a major contributor of fine sediments and it will be important to understand the impacts of Troublesome Creek on the downstream reach of the Colorado River. A 100 count Pebble Count, including embeddedness, is also recommended at each of the macroinvertebrate sites, conducted at riffles used by or in the vicinity of the macroinvertebrate sampling sites. To achieve these monitoring goals, continued coordination will be required between LBD, CPW and ILVK to partner and/or seek additional funding.

2020 Connectivity Channel Monitoring

Northern Water's Municipal Subdistrict is planning to construct a connectivity channel to restore habitat connectivity between segments of the Colorado River downstream from Windy Gap Reservoir and segments of the Colorado and Fraser Rivers upstream as a habitat enhancement. To meet requirements of the Windy Gap Firming Project 1041 permit (Grand County, 2012), Northern Water is funding a study by the CPW Research Branch to monitor fish movement and determine the effects of the connectivity channel on fish communities.

Fish and fish movements around Windy Gap will be monitored with a combination of electrofishing and electronic tagging of fish. With construction anticipated to begin in 2021, CPW will construct stationary antenna installations in 2020. Passive Integrated Transponder (PIT) tags will be placed in Rainbow Trout, Brown Trout and sculpin in the Colorado and Fraser Rivers upstream and downstream of Windy Gap so that baseline movement data can be obtained before construction of the connectivity channel. The study will continue for at least four additional years during and after construction.

In addition to the fish movement study, CPW research crews are conducting sculpin and limited invertebrate monitoring in the immediate vicinity of Windy Gap in order to observe any changes in distribution to sculpin and invertebrates as a result of construction of the Colorado River Connectivity Channel.

CPW will deliver annual updates to the LBD Management Committee beginning after the first year of the study, tentatively late 2020 or early 2021.

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

River Mile ID	Description	Entity	Type	Latitude	Longitude
AC-0.6	Arapaho Creek at Monarch Lake upstream Granby Reservoir	Northern Water	Water Quality	40.1128	-105.75
AC-0.6	Arapaho Creek at Monarch Lake upstream Granby Reservoir	Northern Water	Temperature	40.1128	-105.75
AC-0.6	Arapaho Creek at Monarch Lake upstream Granby Reservoir	Northern Water	Flow	40.1128	-105.75
BC-0	Bobtail Creek above diversion dam downstream of gauging station	Denver Water	Water Quality	39.76026	-105.906
BC-0	Bobtail Creek above diversion dam	Denver Water	Flow	39.76026	-105.906
CB-0.6	Cabin Creek upstream North and South Channels	Denver Water	Temperature	39.97497	-105.775
CB-2.7	Cabin Creek downstream Denver Water diversion	DW/USGS	Flow	39.98582	-105.745
CB-2.7	Cabin Creek downstream Denver Water diversion	Denver Water	Temperature	39.98582	-105.745
CH-0.5	Church Creek upstream of Willow Creek at Flume	Northern Water	Water Quality	40.1356	-105.921
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-2.3	Colorado River upstream Hwy 9 Bridge at Kremmling	BLM/LBD	Temperature	40.0421	-106.371
CR-2.3	Colorado River upstream Hwy 9 Bridge at Kremmling	Denver Water	Water Quality	40.0421	-106.371
CR-7.4	Colorado River downstream of Troublesome Creek	LBD/ILVK	Macro	40.0509	-106.311
CR-7.4	Colorado River downstream of Troublesome Creek	LBD/ILVK	Sediment	40.0509	-106.311
CR-9.1	Colorado River downstream of KB Ditch	GCWIN	Temperature	40.05377	-106.289
CR-9.1	Colorado River downstream of KB Ditch	LBD	Macro	40.05377	-106.289
CR-9.1	Colorado River downstream of KB Ditch	LBD	Sediment	40.05377	-106.289
CR-9.1	Colorado River downstream of KB Ditch	Northern Water	Flow	40.05377	-106.289
CR-12.6	Colorado River at ConRitschard	GCWIN	Temperature	40.06545	-106.231
CR-13.7	Parshall-Sunset	CPW	Fish	40.06105	-106.213
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	GCWIN	Temperature	40.06342	-106.191
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	CPW	Macro	40.06291	-106.192
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	LBD	Sediment	40.06342	-106.191
CR-14.9	Colorado River downstream of Parshall near Kid Fishing Pond	Northern Water	Flow	40.06342	-106.191
CR-16.7	Colorado River upstream of Williams Fork	Northern Water	Temperature	40.05042	-106.173
CR-16.7	Colorado River upstream of Williams Fork	Northern Water	Macro	40.04689	-106.143
CR-16.7	Colorado River north of Parshall at Bar Lazy J Ranch bridge	Denver Water	Water Quality	40.05042	-106.173
CR-16.7	Colorado River upstream of Williams Fork	LBD	Sediment	40.05042	-106.173
CR-18.4	Colorado River at Lone Buck	GCWIN	Temperature	40.0471	-106.143
CR-19.8	Colorado River downstream of Byers Canyon	CPW	Macro	40.05199	-106.132
CR-19.8	Colorado River downstream of Byers Canyon	CPW	Fish	40.05199	-106.132
CR-19.8	Colorado River downstream of Byers Canyon	GCWIN	Temperature	40.05328	-106.132
CR-21.9	Colorado River downstream of Hot Sulphur Springs	LBD/Tetra Tech	Sediment	40.07232	-106.112
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Macro	40.07469	-106.108

River Mile ID	Description	Entity	Type	Latitude	Longitude
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Fish	40.07469	-106.108
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	Northern Water	Macro	40.07394	-106.11
CR-22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	LBD	Sediment	40.07378	-106.11
CR-22.7	Colorado River upstream Hot Sulphur Springs at WTP	Northern Water	Temperature	40.07734	-106.104
CR-23.5	Colorado River upstream of Hot Sulphur Springs	Northern Water	Flow	40.08347	-106.088
CR-24.9	Colorado River at Sheriff Ranch	CPW	Macro	40.0874	-106.068
CR-24.9	Colorado River at Sheriff Ranch	GCWIN	Temperature	40.08769	-106.065
CR-27.5	Colorado River downstream Chimney Rock at Upper Red Barn	CPW	Macro	40.1026	-106.024
CR-28.7	Colorado River downstream of Windy Gap Reservoir	Northern Water	Water Quality	40.1082	-106.004
CR-28.7	Colorado River downstream of Windy Gap Reservoir	Northern Water	Temperature	40.1082	-106.004
CR-28.7	Colorado River downstream of Windy Gap Reservoir	Northern Water	Macro	40.1082	-106.004
CR-28.7	Colorado River downstream of Windy Gap Reservoir	NW/USGS	Flow	40.1082	-106.004
CR-28.7	Colorado River downstream of Windy Gap Reservoir	LBD	Sediment	40.1082	-106.004
CR-28.7	Colorado River downstream of Windy Gap Reservoir	CPW	Macro	40.10895	-106.001
CR-28.7	Colorado River downstream of Windy Gap Reservoir	CPW	Fish	40.10895	-106.001
CR-29.8	Colorado River at confluence of Windy Gap spillway and bypass	Northern Water	Temperature	40.1078	-105.988
CR-30	Colorado River at Windy Gap Bypass	Northern Water	Flow	40.1087	-105.984
CR-30	Colorado River at Windy Gap Bypass	Northern Water	Temperature	40.1087	-105.984
CR-30.8	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Macro	40.10201	-105.975
CR-30.8	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Fish	40.10131	-105.975
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern Water	Temperature	40.1003	-105.973
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern Water	Water Quality	40.1003	-105.973
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern Water	Macro	40.1003	-105.973
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	CPW	Macro	40.10131	-105.975
CR-31	Colorado River upstream of Windy Gap and Fraser River confluence	LBD	Sediment	40.1003	-105.973
CR-32.1	Colorado River downstream of Willow Creek	Northern Water	Water Quality	40.107	-105.956
CR-34.7	Colorado River upstream of Willow Creek	Northern Water	Water Quality	40.1196	-105.914
CR-35.6	Colorado River downstream Granby Reservoir at flow gage	Northern Water	Temperature	40.1211	-105.901
CR-35.6	Colorado River downstream of Granby Reservoir	USGS	Flow	40.1211	-105.901
CR-38.3	Colorado River downstream of Granby Reservoir	Northern Water	Water Quality	40.1444	-105.867
CR-38.3	Colorado River downstream of Granby Reservoir	Northern Water	Temperature	40.1444	-105.867
CR-38.3	Colorado River downstream of Granby Reservoir	Northern Water	Macro	40.1444	-105.867
CR-43.5	Colorado River upstream of Granby Reservoir	Northern Water	Temperature	40.1945	-105.827
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern Water	Water Quality	40.2059	-105.838
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern Water	Temperature	40.2059	-105.838
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern Water	Macro	40.2059	-105.838
CR-44.6	Colorado River downstream of Shadow Mountain Reservoir	USGS	Flow	40.2059	-105.838

River Mile ID	Description	Entity	Type	Latitude	Longitude
CC-1.5	Crooked Cr Abv Pole Creek at Tabernash	EGWQB	Water Quality	39.99083	-105.849
EI-0.1	East Inlet upstream of Grand Lake	Northern Water	Water Quality	40.2369	-105.801
EI-0.1	East Inlet upstream of Grand Lake	Northern Water	Temperature	40.2369	-105.801
EI-0.1	East Inlet upstream of Grand Lake	Northern Water	Flow	40.2369	-105.801
EI-0.1	East Inlet upstream of Grand Lake	Northern Water	Macro	40.2369	-105.801
EC-5.5	Elk Creek near Fraser	DW/USGS	Flow	39.88943	-105.833
EC-5.5	Elk Creek downstream Denver Water diversion	Denver Water	Temperature	39.88943	-105.833
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern Water	Water Quality	40.0984	-105.973
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern Water	Temperature	40.0984	-105.973
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern Water	Macro	40.0984	-105.973
FR-0.1	Fraser River upstream of confluence with Colorado River	Northern Water	Flow	40.0984	-105.973
FR-1.6	Fraser River downstream of Granby Sanitation District	GCWIN	Temperature	40.08551	-105.958
FR-1.9	Fraser River upstream of Granby Sanitation District	GCWIN	Temperature	40.08453	-105.955
FR-1.9	Fraser River upstream of Granby Sanitation District	LBD	Macro	40.08453	-105.955
FR-1.9	Fraser River upstream of Granby Sanitation District	LBD	Sediment	40.08453	-105.955
FR-3.5	Fraser River At Hwy. 40 At Granby, Co	EGWQB	Water Quality	40.08139	-105.928
FR-3.5	Fraser River blw Highway 40 in Granby	GCWIN/LBD	Temperature	40.08139	-105.928
FR-4.5	Fraser River downstream Fraser Canyon	GCWIN	Temperature	40.00775	-105.848
FR-5.5	Fraser River at Granby Ranch downstream of golf course	LBD	Sediment	40.07882	-105.904
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Water Quality	40.00689	-105.848
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	GCWIN	Temperature	40.00689	-105.848
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Flow	40.00689	-105.848
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	LBD	Macro	40.00689	-105.848
FR-12.4	Fraser River downstream of Crooked Creek and Tabernash	LBD	Sediment	40.00689	-105.848
FR-14	Fraser River upstream of Tabernash	EGWQB	Water Quality	39.99033	-105.83
FR-14	Fraser River upstream of Tabernash	EGWQB/TU	Temperature	39.99033	-105.83
FR-14	Fraser River upstream of Tabernash	Denver Water	Macro	39.99033	-105.83
FR-14	Fraser River upstream of Tabernash	EGWQB/USGS	Flow	39.99033	-105.83
FR-14	Fraser River upstream of Tabernash	LBD	Sediment	39.99033	-105.83
FR-14.4	Winter Park W & S	CPW	Fish	39.98647	-105.828
FR-14.4	Fraser River LBD Restoration Project, Downstream end	GCWIN/LBD	Temperature	39.98647	-105.828
FR-15	Fraser River LBD Restoration Project, Upstream end	LBD	Macro	39.98134	-105.825
FR-15	Fraser River LBD Restoration Project, Upstream end	GCWIN/LBD	Temperature	39.98134	-105.825
FR-15	Fraser River LBD Restoration Project, Upstream end	LBD	Sediment	39.98134	-105.825
FR-16.6	Fraser River downstream Fraser Sanitation	GCWIN	Temperature	39.966	-105.817
FR-16.9	Fraser River upstream Fraser Sanitation	GCWIN	Temperature	39.96195	-105.815
FR-17.7	Fraser River downstream County Rd 8 at Hammond Ditch	GCWIN	Temperature	39.95216	-105.814
FR-18.1	Fraser River downstream County Rd 804	GCWIN	Temperature	39.94689	-105.813
FR-18.1	Safeway	CPW	Fish	39.94689	-105.813
FR-20	Fraser River at Rendezvous Bridge	GCWIN	Temperature	39.93412	-105.79

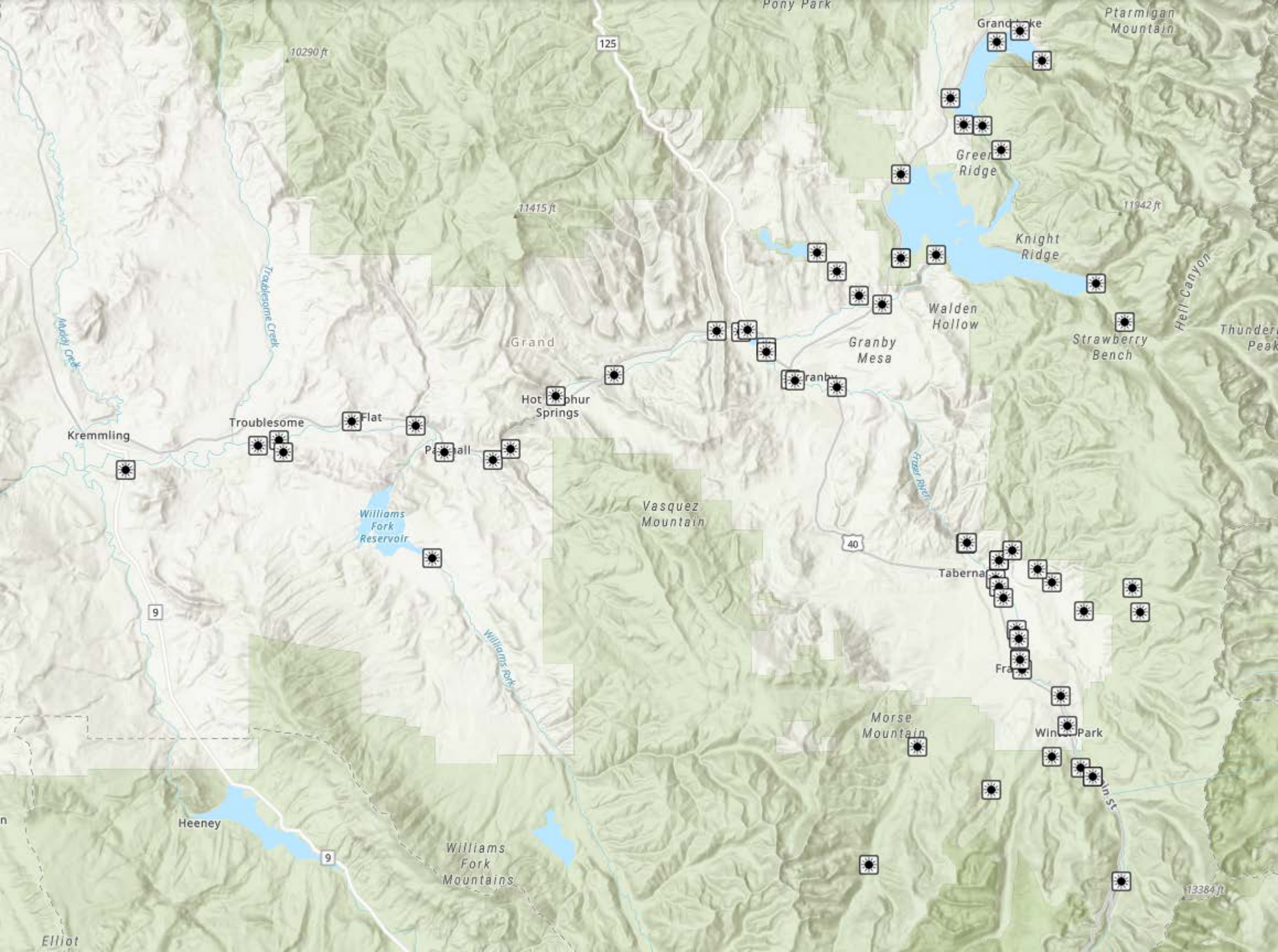
River Mile ID	Description	Entity	Type	Latitude	Longitude
FR-20	Fraser River at Rendezvous Bridge	Denver Water	Macro	39.93412	-105.79
FR-20	Fraser River at Rendezvous Bridge	LBD	Sediment	39.93412	-105.79
FR-20.6	Fraser River downstream Vasquez Creek at Winter Park Co.	EGWQB	Water Quality	39.92778	-105.786
FR-21	Confluence Park	CPW	Fish	39.92294	-105.782
FR-22.5	Fraser River downstream Winter Park Resort at Idlewild Campground	GCWIN	Temperature	39.89999	-105.777
FR-22.5	Idlewild Campground	CPW	Fish	39.89999	-105.777
FR-22.5	Fraser River at Winter Park	DW/USGS	Flow	39.89999	-105.777
FR-23.2	Fraser River downstream Winter Park Sanitation	GCWIN	Temperature	39.89596	-105.769
FR-23.4	Fraser River upstream Winter Park Sanitation District	LBD	Sediment	39.89596	-105.769
FR-23.4	Fraser River upstream Winter Park Sanitation District	EGWQB	Water Quality	39.89596	-105.769
FR-23.4	Fraser River upstream Winter Park Sanitation District	GCWIN	Temperature	39.89596	-105.769
FR-23.4	Fraser River upstream Winter Park Sanitation District	Denver Water	Macro	39.89596	-105.769
FR-TBD	Fraser River downstream of UP Railroad discharge	LBD	Macro	TBD	TBD
FR-24	Fraser River upstream Moffat Tunnel Nr Winter Park, Co	EGWQB	Water Quality	39.88656	-105.762
FR-24	Fraser/Jim Canal at Gaging Station	Denver Water	Water Quality	39.88656	-105.762
FR-25.1	Fraser River upstream of UP Railroad discharge	LBD	Macro	39.8775	-105.754
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	EGWQB	Water Quality	39.84583	-105.751
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	GCWIN	Temperature	39.84583	-105.751
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	EGWQB/USGS	Flow	39.84583	-105.751
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Macro	39.84583	105.7518
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Sediment	39.84583	-105.751
GRP-0	Granby Pump Canal above Shadow Mountain Reservoir	Northern Water	Water Quality	40.2068	-105.85
GRP-0	Granby Pump Canal above Shadow Mountain Reservoir	Northern Water	Temperature	40.2068	-105.85
GL-ATW	Grand Lake West Portal	Northern Water	Water Quality	40.2411	-105.805
GL-MID	Grand Lake Mid-Section	Northern Water	Water Quality	40.2433	-105.813
GL-WES	Grand Lake west end of lake, south of Shadow Mountain Channel	Northern Water	Water Quality	40.2419	-105.822
SM-CHL	Shadow Mountain Reservoir Channel in Grand Lake at mouth of Channel	Northern Water	Water Quality	40.24611	-105.829
SM-CHL	Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Temperature	40.24611	-105.829
SM-CHL	Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Water Quality	40.24611	-105.829
SM-CHL	Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Flow	40.24611	-105.829
HC-0.5	Herd Creek on County Road 843	Denver Water	Temperature	39.9947	-105.804
GR-DAM	Granby Reservoir Dam	Northern Water	Water Quality	40.1497	-105.865
GR-EAS	Granby Reservoir East Side	Northern Water	Water Quality	40.135	-105.796
GR-WES	Granby Reservoir West Side	Northern Water	Water Quality	40.175	-105.87
LCB-2.2	Little Cabin Creek downstream Denver Water diversion	Denver Water	Temperature	39.9743	-105.74
LVC-0.2	Little Vasquez upstream Winter Park on Arapaho Road	Denver Water	Temperature	39.90549	-105.795
MQC-0	McQueary Creek above diversion dam 1 3/4 miles north of dorm	Denver Water	Water Quality	39.78227	-105.916
MC-0.5	Meadow Creek on County Road 84/USFS 129	Denver Water	Temperature	40.0039	-105.819

River Mile ID	Description	Entity	Type	Latitude	Longitude
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern Water	Water Quality	40.219	-105.858
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern Water	Temperature	40.219	-105.858
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern Water	Flow	40.219	-105.858
NF-0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern Water	Macro	40.219	-105.858
NI-0.1	North Inlet upstream of Grand Lake	Northern Water	Water Quality	40.2511	-105.815
NI-0.1	North Inlet upstream of Grand Lake	Northern Water	Temperature	40.2511	-105.815
NI-0.1	North Inlet upstream of Grand Lake	Northern Water	Flow	40.2511	-105.815
RCC-0	Ranch Canal at Gaging Station	Denver Water	Water Quality	39.88987	-105.752
RC-1.1	Ranch Creek downstream Meadow Creek	EGWQB/CRWCD	Water Quality	39.99901	-105.828
RC-1.1	Ranch Creek downstream Meadow Creek	GC/DW	Temperature	39.99901	-105.828
RC-1.1	Ranch Creek downstream Meadow Creek	GCWIN	Temperature	39.99901	-105.828
RC-1.1	Ranch Creek downstream Meadow Creek	EGWQB/CRWCD	Flow	39.99901	-105.828
RC-1.1	Ranch Creek downstream Meadow Creek	LBD	Macro	39.99912	-105.827
RC-1.1	Ranch Creek downstream Meadow Creek	LBD	Sediment	39.99901	-105.828
RC-4.7	Ranch Creek downstream County Rd 8315	GCWIN	Temperature	39.98859	-105.795
RC-5.1	Ranch Creek downstream of willow planting project	LBD	Temperature	39.9842	-105.795
RC-5.8	Ranch Creek upstream of willow planting project	LBD	Temperature	39.97821	-105.792
RC-9	Ranch Creek Near Fraser, Co.	EGWQB	Water Quality	39.94999	-105.766
RC-9	Ranch Creek Near Fraser, Co.	EGWQB/USGS	Flow	39.94999	-105.766
RDC-0	Reeder Creek, upper	BLM	Temperature	40.05663	-106.276
RDC-0.7	Reeder Crk above footbridge, blw irrigation ditch	BLM	Temperature	40.05044	-106.273
RF-0	Roaring Fork upstream Granby Reservoir	Northern Water	Water Quality	40.1308	-105.767
RF-0	Roaring Fork upstream Granby Reservoir	Northern Water	Temperature	40.1308	-105.767
SM-DAM	Shadow Mountain Reservoir Dam	Northern Water	Water Quality	40.2101	-105.842
SM-MID	Shadow Mountain Reservoir Mid-Section	Northern Water	Water Quality	40.2252	-105.837
SM-NOR2	Shadow Mountain Reservoir North	Northern Water	Water Quality	40.24458	-105.839
SM-NW1	Shadow Mountain Reservoir northwest of the center of the Reservoir	Northern Water	Water Quality	40.237	-105.842
SWF-0	South fork at South Fork Campground at gauging station	Denver Water	Water Quality	39.79582	-106.031
SWF-0	South fork at South Fork Campground	DW/USGS	Flow	39.79582	-106.031
STC-0	St. Louis Creek upstream confluence with Fraser River	GCWIN/LBD	Temperature	39.95175	-105.815
STC-5.4	St. Louis Creek near Fraser	DW/USGS	Flow	39.90999	-105.878
STC-5.4	St. Louis Creek at Fraser Experimental Forest HQ	LBD	Temperature	39.90999	-105.878
STC-9.8	St. Louis Creek downstream Denver Water Board diversion	Denver Water	Temperature	39.85385	-105.909
STC-0	St. Louis Creek upstream confluence with Fraser River	LBD	Macro	39.95175	-105.815
STC-0	St. Louis Creek upstream confluence with Fraser River	LBD	Sediment	39.95175	-105.815
SC-0	Steelman Creek at bridge above diversion dam south of dorm	Denver Water	Water Quality	39.7571	-105.933
ST-0	Shadow Mountain Channel at Chipmunk Lane	Northern Water	Water Quality	40.1829	-105.889

River Mile ID	Description	Entity	Type	Latitude	Longitude
ST-0	Stillwater Creek upstream Granby Reservoir	Northern Water	Temperature	40.1829	-105.889
USF-0	Upper South Fork of the Williams Fork (3.5 miles above trail head)	Denver Water	Water Quality	39.70286	-105.978
VCC-0	Vasquez Canal at Vasquez #1 Gaging Station	Denver Water	Water Quality	39.88957	-105.769
VT-0	Vasquez Tunnel outlet	Denver Water	Water Quality	39.8185	-105.835
VC-0	Vasquez Creek at the town of Winter Park	DW/USGS	Flow	39.92026	-105.785
VC-0	Vasquez Creek at the town of Winter Park	Denver Water	Macro	39.92026	-105.785
VC-0	Vasquez Creek at the town of Winter Park	GCWIN	Temperature	39.92026	-105.785
VC-4.3	Vasquez Ck. upstream Vasquez Tunnel	Denver Water	Water Quality	39.8186	-105.836
VC-8	Vasquez Ck. at diversion structure	Denver Water	Water Quality	39.86379	-105.821
WF-0.5	Williams Fork downstream WF Reservoir at Kemp Breeze	LBD/Denver Water	Macro	40.0561	-106.183
WF-2	Williams Fork downstream Williams Fork Reservoir	Denver Water	Water Quality	40.03593	-106.205
WF-2	Williams Fork downstream Williams Fork Reservoir	DW/USGS	Flow	40.03593	-106.205
WF-2	Williams Fork downstream Williams Fork Reservoir	LBD/Denver Water	Macro	40.04308	-106.198
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	Denver Water	Water Quality	40.0002	-106.18
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	DW/USGS	Flow	40.0002	-106.18
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	LBD/Denver Water	Macro	39.99229	-106.171
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	LBD	Temperature	40.0002	-106.18
WF-13.1	Williams Fork downstream of Henderson Mill	BLM	Water Quality	39.9092	-106.103
WF-13.1	Williams Fork downstream of Henderson Mill	BLM	Macro	39.9092	-106.103
WF-13.1	Williams Fork downstream of Henderson Mill	BLM	Habitat	39.9092	-106.103
WF-13.1	Williams Fork downstream of Henderson Mill	LBD	Macro	39.9092	-106.103
WF-19	Williams Fork below Kinney Creek confluence at Leal gauge	Denver Water	Water Quality	39.83388	-106.056
WF-19	Williams Fork Near Leal, CO	DW/USGS	Flow	39.83388	-106.056
WF-19.6	Williams Fork upstream Darling Creek near Leal, CO	DW/USGS	Flow	39.79719	-106.026
WF-22.6	Williams Fork above bridge at Sugarloaf Campground	Denver Water	Water Quality	39.78862	-106.022
WF-28.2	Williams Fork downstream Steelman Creek, CO	DW/USGS	Flow	39.77888	-105.928
CLU-0	Surface drainage channel on C Lazy U pasture that drains to Willow Creek	Northern Water	Water Quality	40.1589	-105.986
WC-0.5	Willow Creek upstream of confluence with Colorado River	LBD	Temperature	40.12501	-105.915
CLU-0.7	Upstream end of surface water drainage channel on C Lazy U pasture	Northern Water	Water Quality	40.1677	-105.99
WC-0.9	Willow Creek upstream of confluence with Colorado River	Northern Water	Water Quality	40.1297	-105.918
WC-2.3	Willow Creek upstream of Bunte Highline Ditch	LBD	Temperature	40.13704	-105.929
WC-3.8	Willow Creek directly downstream of Willow Creek Reservoir Dam	Northern Water	Water Quality	40.1457	-105.941
WC-3.8	Willow Creek downstream of Willow Creek Reservoir	Northern Water	Flow	40.1457	-105.941
WC-3.8	Willow Creek downstream of Willow Creek Reservoir	Northern Water	Temperature	40.1457	-105.941
WC-6.3	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern Water	Water Quality	40.1558	-105.981
WC-6.3	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern Water	Flow	40.1558	-105.981
WCP-0	Willow Creek discharge chute to Lake Granby	Northern Water	Water Quality	40.143	-105.889

River Mile ID	Description	Entity	Type	Latitude	Longitude
WCP-0	Willow Creek Pump Canal Inflow to Lake Granby	Northern Water	Temperature	40.143	-105.889
WC-DAM	Willow Creek Reservoir at Dam	Northern Water	Water Quality	40.1497	-105.944
WGP-0	Windy Gap discharge chute to Granby Reservoir	Northern Water	Water Quality	40.1429	-105.889
WGP-0	Windy Gap Pump Inflow to Granby Reservoir	Northern Water	Temperature	40.1429	-105.889
WG-DAM	Windy Gap Reservoir at Dam	Northern Water	Water Quality	40.1085	-105.983

Appendix B – 2018 Monitoring Summary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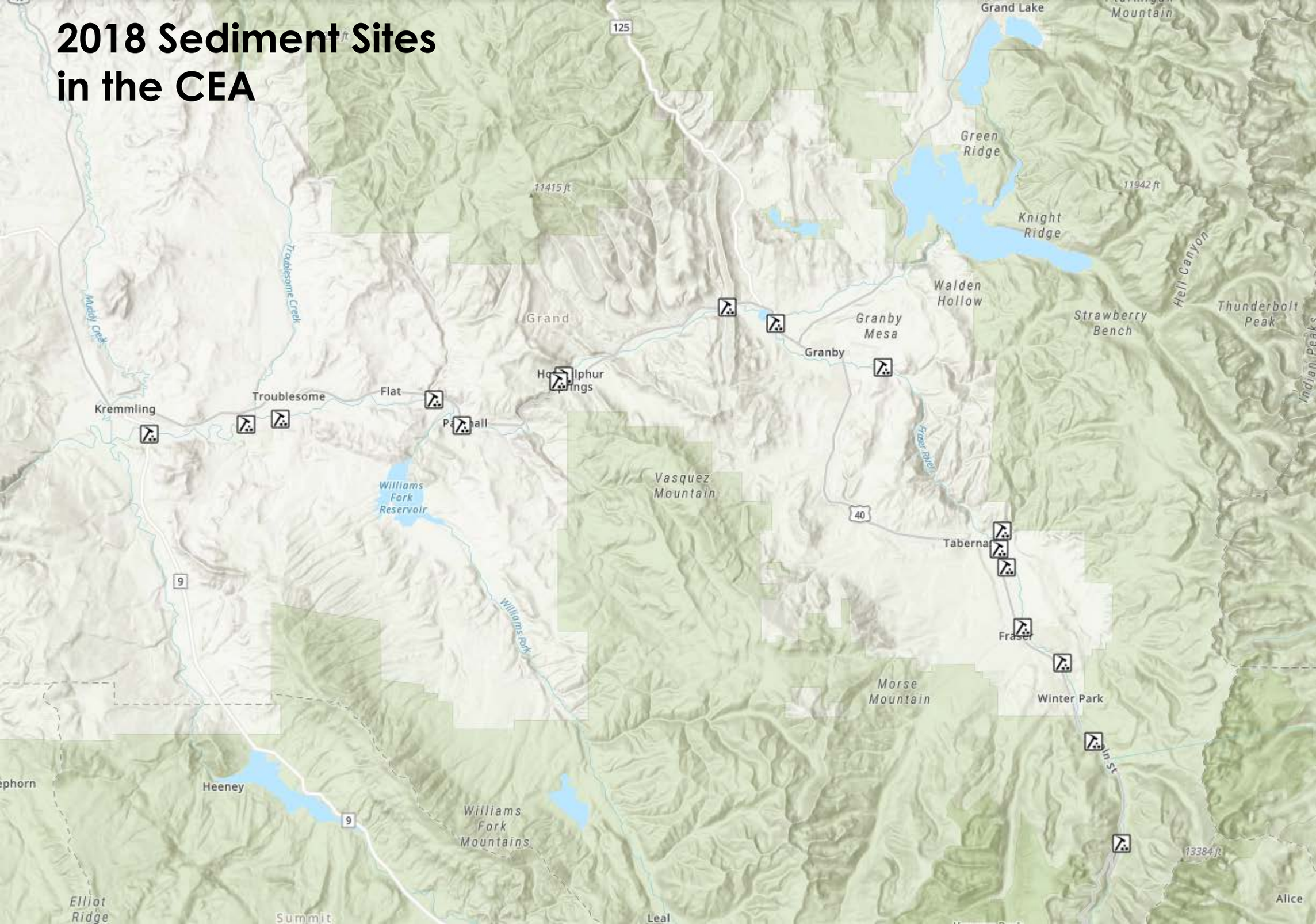
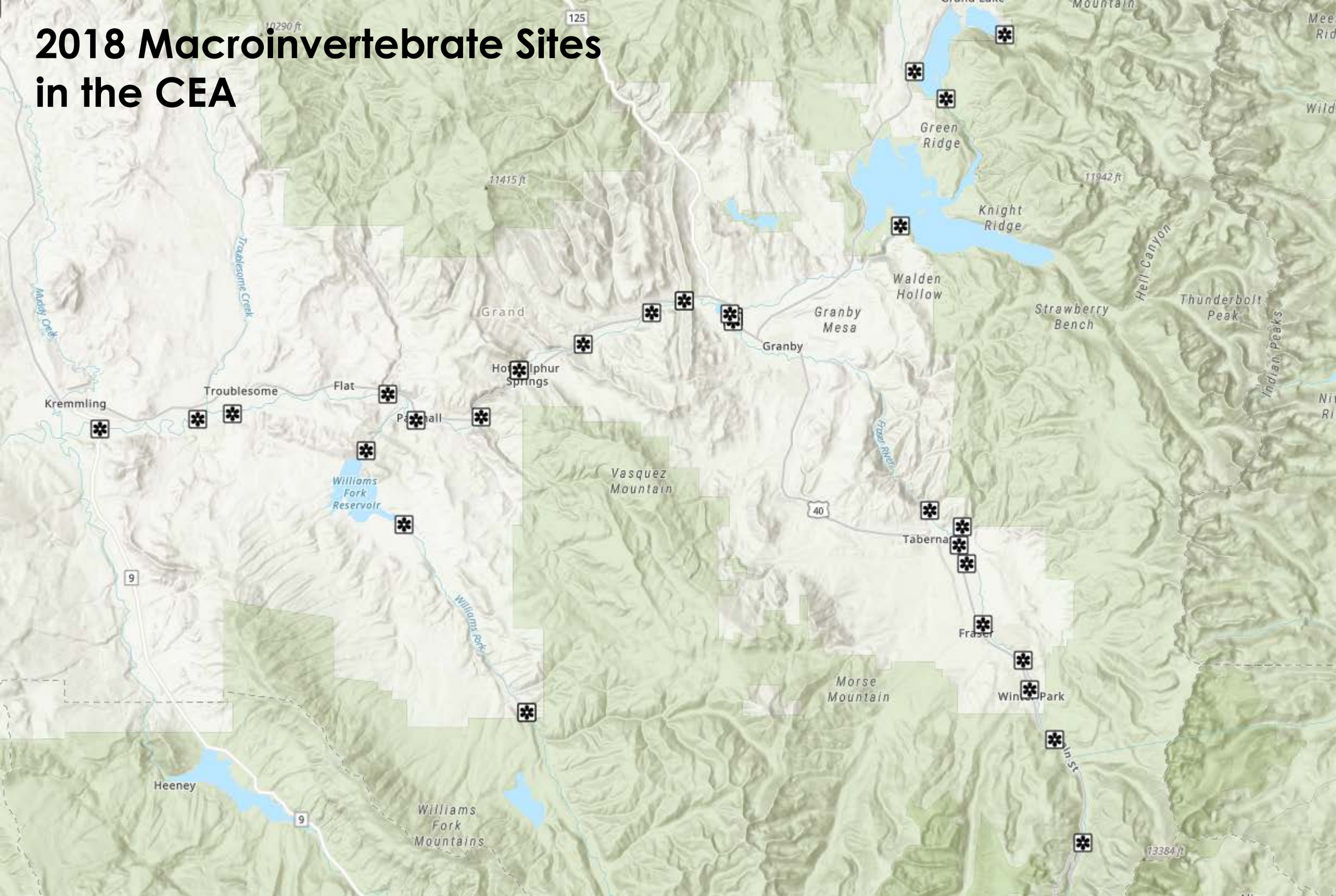
Grand Lake
Ptarmigan Mountain
10290 ft
125
Green Ridge
11415 ft
11942 ft
Knight Ridge
Hell Canyon
Walden Hollow
Granby Mesa
Strawberry Bench
Thunder Peak
Muddy Creek
Troublesome Creek
Grand
Hot Sulphur Springs
Granby
Troublesome
Flat
Kremmling
Vasquez Mountain
Williams Fork Reservoir
Fraser River
40
Tabernash
Fraser
Winter Park
Morse Mountain
Williams Fork
9
Heeney
Williams Fork Mountains
13384 ft
Elliot

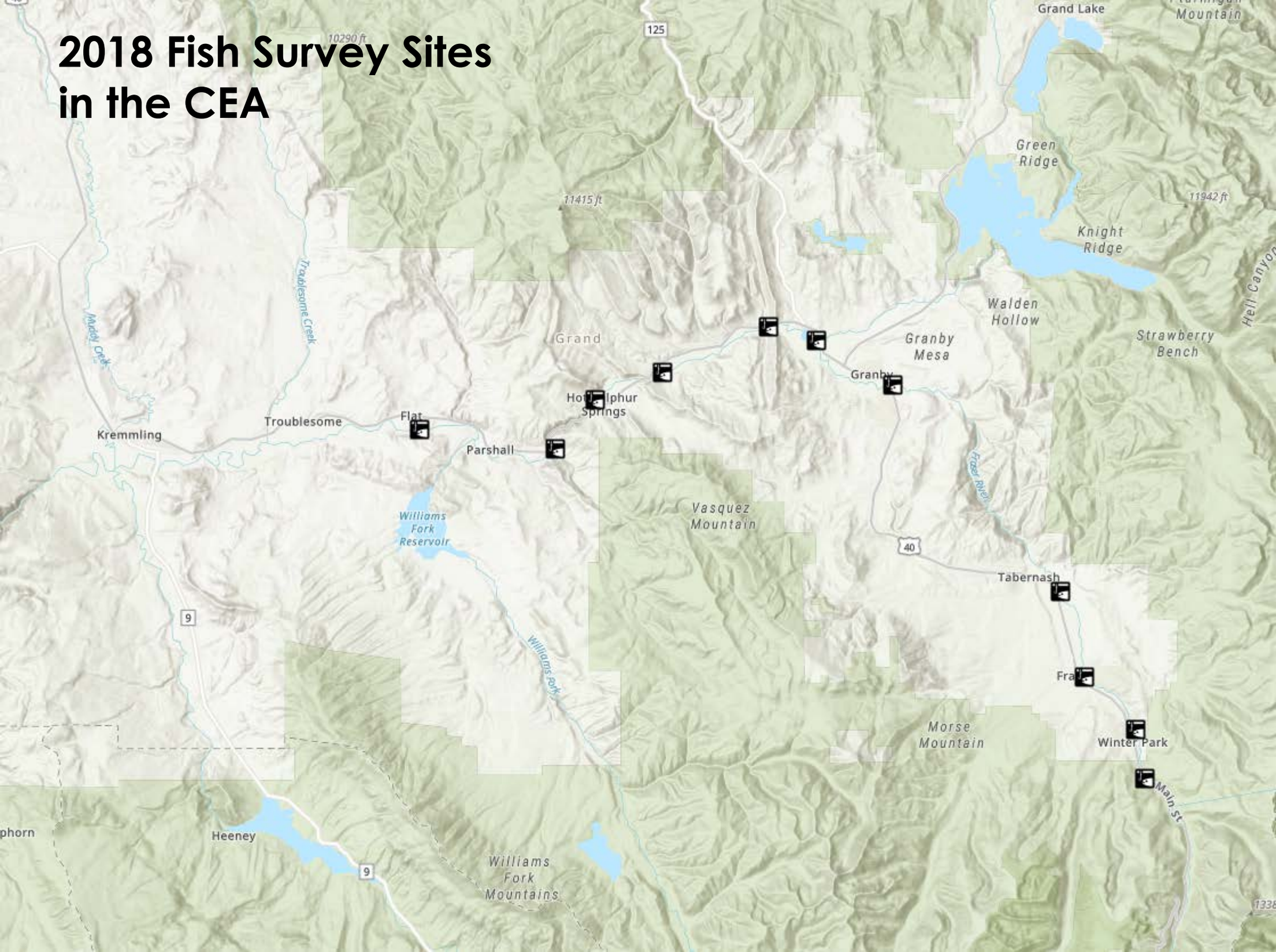
2018 Sediment Sites in the CEA



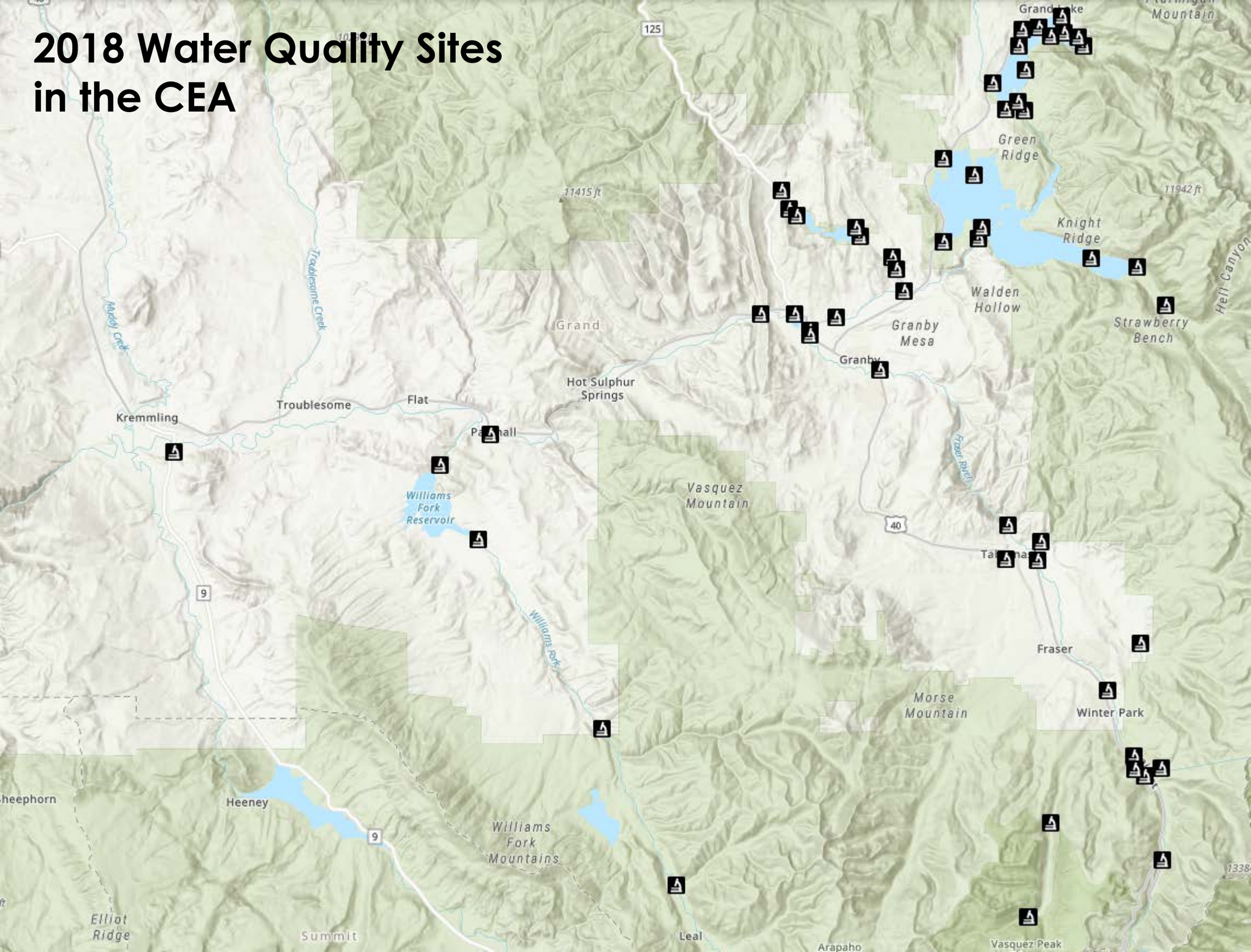
2018 Macroinvertebrate Sites in the CEA



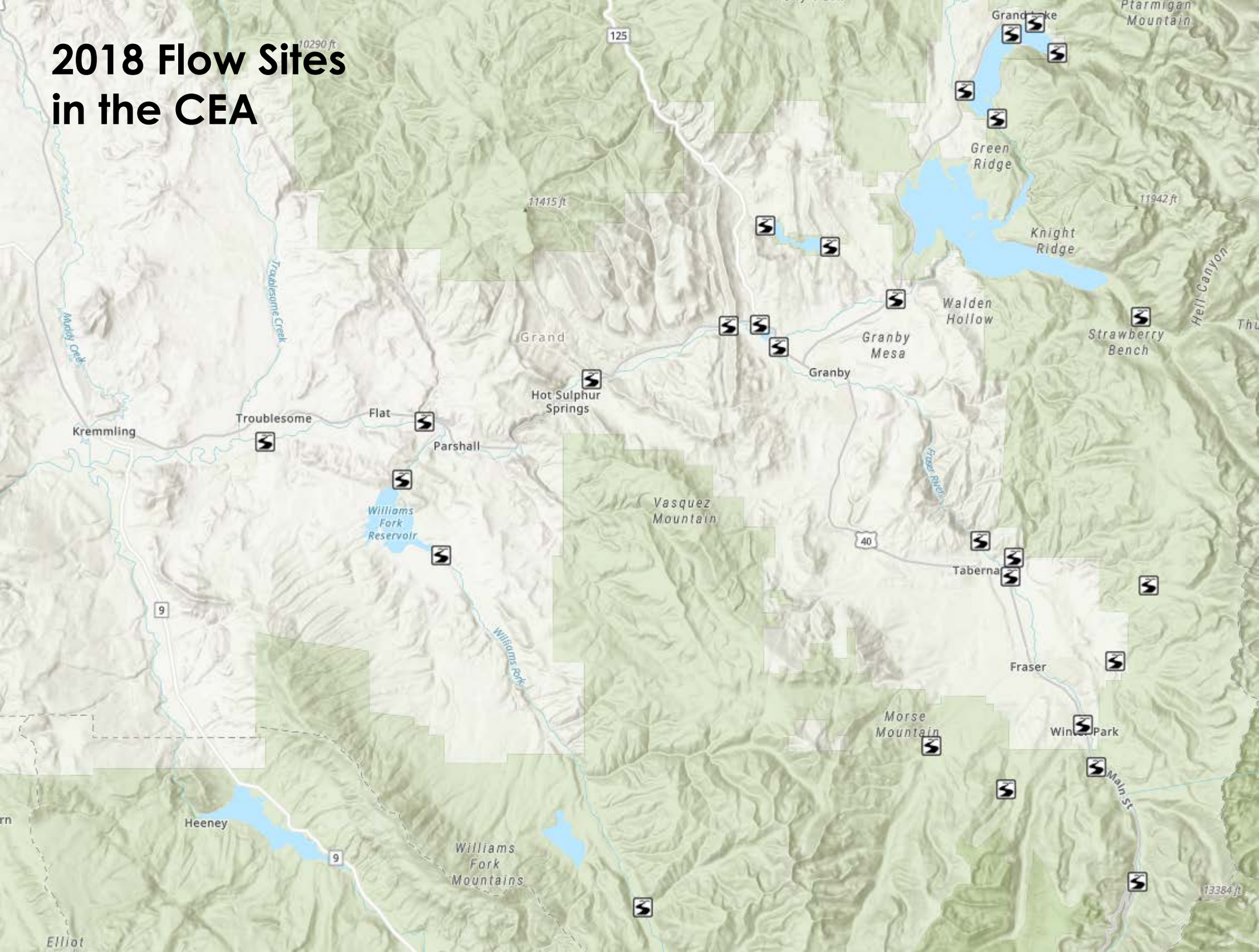
2018 Fish Survey Sites in the CEA



2018 Water Quality Sites in the CEA



2018 Flow Sites in the CEA



Colorado River - Blue River to Williams Fork

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
CR-1.7	CR-BRU	1.7	Colorado River upstream of the Blue River	LBD	Sediment	Colorado River
CR-1.7	CR-BRU	1.7	Colorado River upstream of the Blue River	LBD/ILVK	Macroinvertebrate	Colorado River
CR-2.3	COR-Hwy9	2.3	Colorado River upstream Hwy 9 Bridge at Kremmling	BLM	Temperature	Colorado River
CR-2.3	WS-CO-004	2.3	Colorado River upstream Hwy 9 Bridge at Kremmling	Denver Water	Water Quality	Colorado River
CR-7.4	CR-TCD	7.4	Colorado River downstream of Troublesome Creek	LBD	Sediment	Colorado River
CR-7.4	CR-TCD	7.4	Colorado River downstream of Troublesome Creek	LBD/ILVK	Macroinvertebrate	Colorado River
CR-9.1	COR-KBDitch	9.1	Colorado River downstream of KB Ditch	GCWIN	Temperature	Colorado River
CR-9.1	COR-KBDitch	9.1	Colorado River downstream of KB Ditch	LBD	Macroinvertebrate	Colorado River
CR-9.1	CR Blw KB Ditch	9.1	Colorado River downstream of KB Ditch	LBD	Sediment	Colorado River
CR-9.1	CR-KBD	9.1	Colorado River downstream of KB Ditch	Northern	Flow	Colorado River
CR-12.6	COR-ConRitschard	12.6	Colorado River at ConRitschard	GCWIN	Temperature	Colorado River
CR-13.7	Parshall-Sunset	13.7	Parshall-Sunset	CPW	Fish	Colorado River
CR-14.9	COR-KidPond	14.9	Colorado River downstream of Parshall near Kid Fishing Pond	GCWIN	Temperature	Colorado River
CR-14.9	CR7	14.9	Colorado River downstream of Parshall near Kid Fishing Pond	CPW	Macroinvertebrate	Colorado River
CR-14.9	CR Blw WF	14.9	Colorado River downstream of Parshall near Kid Fishing Pond	LBD	Sediment	Colorado River
CR-14.9	CR-PAR	14.9	Colorado River downstream of Parshall near Kid Fishing Pond	Northern	Flow	Colorado River
RDC-0	REE-Upper	0	Reeder Creek, upper	BLM	Temperature	Reeder Creek
RDC-0.7	REE-Lower	0.7	Reeder Crk above footbridge, blw irrigation ditch	BLM	Temperature	Reeder Creek

Colorado River - Blue River to Williams Fork

General Field Parameters	DW1	AQ1	AQ2	SED1	SED2
Temperature	X				
Dissolved Oxygen	X				
Specific Conductance	X				
pH	X				
Turbidity	X				
Flow	X				
Major Ions (plus carbon and misc)					
Calcium					
Magnesium					
Potassium					
Sodium					
Chloride					
Sulfate					
Total Organic Carbon					
Total Alkalinity	X				
Total Suspended Solids	X				
Total Dissolved Solids					
Ecoli					
Metals					
ICPMS Total/Dis Suite*	X				
Iron, total					
Aluminum, total					
Arsenic, total					
Chromium, total					
Manganese, total					
Aluminum, dis					
Copper, dis					
Iron, dis					
Manganese, dis					
Arsenic, dis					
Boron, dis					
Cadmium, dis					
Chromium, dis					
Lead, dis					
Nickel, dis					
Selenium, dis					
Silver, dis					
Uranium, dis					
Zinc, dis					
Nutrients					
TKN					
NH3 as N					
NO3					
NO3+NO2					
Ortho P					
P Total	X				
chlorophyll a					
Aquatic Habitat					
Macroinvertabrates		X			
Fish			X		
Spawning Bar Assessment				X	
Core Sample				X	
Pebble Count				X	X
Embeddedness				X	X

**ICPMS Total/Dis Suite - Be, B, Na, Mg, Al, Si, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Hg, Tl, Pb, U*

DW - Denver Water
AQ- Aquatic Life (bugs/fish)
SED - Sediment Monitoring

Colorado River - Blue River to Williams Fork

	Jan					Feb				Mar				Apr					May				Jun				Jul					Aug				Sep				Oct					Nov				Dec				
Station	**Jan 01**	**Jan 08**	**Jan 15**	**Jan 22**	**Jan 29**	**Feb 05**	**Feb 12**	**Feb 19**	**Feb 26**	**Mar 05**	**Mar 12**	**Mar 19**	**Mar 26**	**Apr 02**	**Apr 09**	**Apr 16**	**Apr 23**	**Apr 30**	**May 07**	**May 14**	**May 21**	**May 28**	**Jun 04**	**Jun 11**	**Jun 18**	**Jun 25**	**Jul 02**	**Jul 09**	**Jul 16**	**Jul 23**	**Jul 30**	**Aug 06**	**Aug 13**	**Aug 20**	**Aug 27**	**Sep 03**	**Sep 10**	**Sep 17**	**Sep 24**	**Oct 01**	**Oct 08**	**Oct 15**	**Oct 22**	**Oct 29**	**Nov 05**	**Nov 12**	**Nov 19**	**Nov 26**	**Dec 03**	**Dec 10**	**Dec 17**	**Dec 24**	**Dec 31**
CR-1.7																																		AQ1, SED2																
CR-2.3	DW1													DW1												DW1												DW1												
CR-7.4																																		AQ1, SED2																
CR-9.1																																		AQ1, SED1																
CR-12.6																																																			
CR-13.7																																		AQ2																
CR-14.9																																		AQ1,SMP2																
RDC-0																																																			
RDC-0.7																																																			

River Name	Site Abbrevation
Colorado River	CR
Reeder Creek	RDC

Approximate months when temperature data are collected

Sites where there are flow gages

Colorado River -Williams Fork to Windy Gap

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
CR-16.7	CR-WFU	16.7	Colorado River upstream of Williams Fork	Northern	Temperature	Colorado River
CR-16.7	CR-WFU	16.7	Colorado River upstream of Williams Fork	Northern	Macroinvertebrate	Colorado River
CR-16.7	WS-CO-003	16.7	Colorado River north of Parshall at Bar Lazy J Ranch bridge	Denver Water	Water Quality	Colorado River
CR-16.7	CR-WFU	16.7	Colorado River upstream of Williams Fork	LBD	Sediment	Colorado River
CR-18.4	COR-LoneBuck	18.4	Colorado River at Lone Buck	GCWIN	Temperature	Colorado River
CR-19.8	CR6	19.8	Colorado River downstream of Byers Canyon	CPW	Macroinvertebrate	Colorado River
CR-19.8	CR6	19.8	Colorado River downstream of Byers Canyon	CPW	Fish	Colorado River
CR-19.8	COR-blwByers	19.8	Colorado River downstream of Byers Canyon	GCWIN	Temperature	Colorado River
CR-21.9	CR at Ppark	21.9	Colorado River downstream of Hot Sulphur Springs.	LBD	Sediment	Colorado River
CR-22.1	CR5	22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Macroinvertebrate	Colorado River
CR-22.1	CR5	22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Fish	Colorado River
CR-22.1	CR-HSPP	22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	Northern	Macroinvertebrate	Colorado River
CR-22.1	CR-HSPP	22.1	Colorado River at Pioneer Park by Hot Sulphur Springs	LBD	Sediment	Colorado River
CR-22.7	CR-HSU	22.7	Colorado River upstream Hot Sulphur Springs at WTP	Northern	Temperature	Colorado River
CR-23.5	CR-HSU	23.5	Colorado River upstream of Hot Sulphur Springs	Northern	Flow	Colorado River
CR-24.9	CR4	24.9	Colorado River at Sheriff Ranch	CPW	Macroinvertebrate	Colorado River
CR-24.9	COR-SHRF	24.9	Colorado River at Sheriff Ranch	GCWIN	Temperature	Colorado River
CR-27.5	CR3	27.5	Colorado River downstream Chimney Rock at Upper Red Barn	CPW	Macroinvertebrate	Colorado River
CR-28.7	CR-WGD	28.7	Colorado River downstream of Windy Gap Reservoir	Northern	Water Quality	Colorado River
CR-28.7	CR-WGD	28.7	Colorado River downstream of Windy Gap Reservoir	Northern	Temperature	Colorado River
CR-28.7	CR-WGD	28.7	Colorado River downstream of Windy Gap Reservoir	Northern	Macroinvertebrate	Colorado River
CR-28.7	09034250	28.7	Colorado River downstream of Windy Gap Reservoir	NW/USGS	Flow	Colorado River
CR-28.7	CR-WGD	28.7	Colorado River downstream of Windy Gap Reservoir	LBD	Sediment	Colorado River
CR-28.7	CR2	28.7	Colorado River downstream of Windy Gap Reservoir	CPW	Macroinvertebrate	Colorado River
CR-28.7	CR2	28.7	Colorado River downstream of Windy Gap Reservoir	CPW	Fish	Colorado River
CR-29.8	CR-WGC	29.8	Colorado River at confluence of Windy Gap spillway and bypass	Northern	Temperature	Colorado River
CR-30	CR-WGB	30	Colorado River at Windy Gap Bypass	Northern	Flow	Colorado River
CR-30	CR-WGB	30	Colorado River at Windy Gap Bypass	Northern	Temperature	Colorado River
WG-DAM	WG-DAM		Windy Gap Reservoir at Dam	Northern	Water Quality	Windy Gap Reservoir

Colorado River -Williams Fork to Windy Gap

	Rivers and Streams							Windy Gap Reservoir	
General Field Parameters	**NW1**	**NW2**	**DW1**	**AQ1**	**AQ2**	**SED1**	**SED2**	**NW8**	**NW9**
Temperature	X	X	X					X	X
Dissolved Oxygen	X	X	X					X	X
Specific Conductance	X	X	X					X	X
pH	X	X	X					X	X
Turbidity	X	X	X					X	X
Flow	X	X	X						
Major Ions (plus carbon and misc)									
Calcium	X							X	
Magnesium	X							X	
Potassium	X							X	
Sodium	X							X	
Chloride	X							X	
Sulfate	X							X	
Total Organic Carbon	X	X						X	X
Total Alkalinity	X		X					X	
Total Suspended Solids	X	X	X					X	X
Total Dissolved Solids									
Metals									
ICPMS Total/Dis Suite*	X		X					X	
Iron, total	X								
Aluminum, total									
Arsenic, total	X							X	
Chromium, total	X							X	
Manganese, total									
Aluminum, Dis									
Copper, dis	X							X	X
Iron, dis	X							X	X
Manganese, dis	X							X	X
Arsenic, dis	X							X	
Boron, dis	X							X	
Cadmium, dis	X							X	
Chromium, dis	X							X	
Lead, dis	X							X	
Nickel, dis	X							X	
Selenium, dis	X							X	
Silver, dis	X							X	
Uranium, dis	X							X	
Zinc, dis	X							X	
Nutrients									
TKN	X	X						X	X
NH3 as N	X	X						X	X
NO3+NO2	X	X						X	X
Ortho P	X	X						X	X
P Total	X	X	X					X	X
chlorophyll a								X	X
Aquatic Habitat									
Macroinvertabrates				X					
Fish					X				
Spawning Bar Assessment						X			
Core Sample						X			
Pebble Count						X	X		
Embeddedness						X	X		

**ICPMS Total/Dis Suite - Be, B, Na, Mg, Al, Si, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Hg, Tl, Pb, U*

NW - Northern Water

DW - Denver Water

AQ - Aquatic Life (bugs/fish)

SED - Sediment Monitoring

Colorado River -Williams Fork to Windy Gap

	Jan					Feb				Mar				Apr					May				Jun				Jul					Aug				Sep				Oct					Nov				Dec				
Station	**Jan 01**	**Jan 08**	**Jan 15**	**Jan 22**	**Jan 29**	**Feb 05**	**Feb 12**	**Feb 19**	**Feb 26**	**Mar 05**	**Mar 12**	**Mar 19**	**Mar 26**	**Apr 02**	**Apr 09**	**Apr 16**	**Apr 23**	**Apr 30**	**May 07**	**May 14**	**May 21**	**May 28**	**Jun 04**	**Jun 11**	**Jun 18**	**Jun 25**	**Jul 02**	**Jul 09**	**Jul 16**	**Jul 23**	**Jul 30**	**Aug 06**	**Aug 13**	**Aug 20**	**Aug 27**	**Sep 03**	**Sep 10**	**Sep 17**	**Sep 24**	**Oct 01**	**Oct 08**	**Oct 15**	**Oct 22**	**Oct 29**	**Nov 05**	**Nov 12**	**Nov 19**	**Nov 26**	**Dec 03**	**Dec 10**	**Dec 17**	**Dec 24**	**Dec 31**
CR-16.7	DW1													DW1													DW1									AQ1,SED2				DW1													
CR-18.4														AQ2																																						
CR-19.8																																			AQ1,AQ2																
CR-21.9																																			SED1																
CR-22.1																																			AQ1,AQ2,SED2																
CR-22.7																																																			
CR-23.5																																																			
CR-24.9																																			AQ2																
CR-27.5																																			AQ1																
CR-28.7	NW2									NW2				NW2		NW2			NW1		NW2		NW1		NW2		NW2		NW2					NW2				NW1,AQ1,AQ2,SED2				NW2					NW1				GW1				
CR-29.8																																																			
CR-30																																																			
WG-DAM																			NW9				NW8				NW9					NW9				NW9																

River Name	Abbreviation
Colorado River	CR
Windy Gap Reservoir	WG

Approximate months when temperature data are collected

Sites where there are flow gages

Colorado River - Upstream of Windy Gap to Headwaters

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
AC-0.6	AC-GRU	0.6	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Water Quality	Arapaho Creek
AC-0.6	AC-GRU	0.6	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Temperature	Arapaho Creek
AC-0.6	AC-GRU	0.6	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Flow	Arapaho Creek
CH-0.5	CH-WCU	0.5	Church Creek upstream of Willow Creek at Flume	Northern	Water Quality	Church Creek
CLU-0	CLU1-WCU	0	Surface drainage channel on C Lazy U pasture upstream of Willow Creek	Northern	Water Quality	Willow Creek
CLU-0.7	CLU2-IRR	0.7	Upstream end of surface water drainage channel on C Lazy U pasture	Northern	Water Quality	Willow Creek
CR-30.8	CR1	30.8	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Macroinvertebrate	Colorado River
CR-30.8	CR1	30.8	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Fish	Colorado River
CR-31	CR-WGU	31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Temperature	Colorado River
CR-31	CR-WGU	31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Water Quality	Colorado River
CR-31	CR-WGU	31	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Macroinvertebrate	Colorado River
CR-31	CR-WGU	31	Colorado River upstream of Windy Gap and Fraser River confluence	CPW	Macroinvertebrate	Colorado River
CR-31	CR-WGU	31	Colorado River upstream of Windy Gap and Fraser River confluence	LBD	Sediment	Colorado River
CR-32.1	CR-WCD	32.1	Colorado River downstream of Willow Creek	Northern	Water Quality	Colorado River
CR-34.7	CR-WCU	34.7	Colorado River upstream of Willow Creek	Northern	Water Quality	Colorado River
CR-35.6	CR-YGAGE	35.6	Colorado River downstream Granby Reservoir at flow gage	Northern	Temperature	Colorado River
CR-35.6	09019500	35.6	Colorado River downstream of Granby Reservoir	USGS	Flow	Colorado River
CR-38.3	CR-GRD	38.3	Colorado River downstream of Granby Reservoir	Northern	Water Quality	Colorado River
CR-38.3	CR-GRD	38.3	Colorado River downstream of Granby Reservoir	Northern	Temperature	Colorado River
CR-38.3	CR-GRD	38.3	Colorado River downstream of Granby Reservoir	Northern	Macroinvertebrate	Colorado River
CR-43.5	CR-GRU	43.5	Colorado River upstream of Granby Reservoir	Northern	Temperature	Colorado River
CR-44.6	CR-SMD	44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern	Water Quality	Colorado River
CR-44.6	CR-SMD	44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern	Temperature	Colorado River
CR-44.6	CR-SMD	44.6	Colorado River downstream of Shadow Mountain Reservoir	Northern	Macroinvertebrate	Colorado River
CR-44.6	09015000	44.6	Colorado River downstream of Shadow Mountain Reservoir	USGS	Flow	Colorado River
EI-0.1	EI-GLU	0.1	East Inlet upstream of Grand Lake	Northern	Water Quality	East Inlet
EI-0.1	EI-GLU	0.1	East Inlet upstream of Grand Lake	Northern	Temperature	East Inlet
EI-0.1	EI-GLU	0.1	East Inlet upstream of Grand Lake	Northern	Flow	East Inlet
EI-0.1	EI-GLU	0.1	East Inlet upstream of Grand Lake	Northern	Macroinvertebrate	East Inlet
GL-ATW	GL-ATW		Grand Lake West Portal	Northern	Water Quality	Grand Lake
GL-MID	GL-MID		Grand Lake Mid-Section	Northern	Water Quality	Grand Lake
GL-WES	GL-WES		Grand Lake west end of lake, south of Shadow Mountain Channel	Northern	Water Quality	Grand Lake
GR-DAM	GR-DAM		Granby Reservoir Dam	Northern	Water Quality	Lake Granby
GR-EAS	GR-EAS		Granby Reservoir East Side	Northern	Water Quality	Lake Granby
GR-WES	GR-WES		Granby Reservoir West Side	Northern	Water Quality	Lake Granby
GRP-0	GR-PUMP	0	Granby Pump Canal above Shadow Mountain Reservoir	Northern	Water Quality	Granby Pump Canal

Colorado River - Upstream of Windy Gap to Headwaters

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
GRP-0	GR-PUMP	0	Granby Pump Canal above Shadow Mountain Reservoir	Northern	Temperature	Granby Pump Canal
NF-0.1	CR-SMU	0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Water Quality	North Fork of Colorado
NF-0.1	CR-SMU	0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Temperature	North Fork of Colorado
NF-0.1	CR-SMU	0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Flow	North Fork of Colorado
NF-0.1	CR-SMU	0.1	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Macroinvertebrate	North Fork of Colorado
NI-0.1	NI-GLU	0.1	North Inlet upstream of Grand Lake	Northern	Water Quality	North Inlet
NI-0.1	NI-GLU	0.1	North Inlet upstream of Grand Lake	Northern	Temperature	North Inlet
NI-0.1	NI-GLU	0.1	North Inlet upstream of Grand Lake	Northern	Flow	North Inlet
RF-0	RF-GRU	0	Roaring Fork upstream Granby Reservoir	Northern	Water Quality	Roaring Fork
RF-0	RF-GRU	0	Roaring Fork upstream Granby Reservoir	Northern	Temperature	Roaring Fork
SM-CHL	SM-CHL		Shadow Mountain Reservoir Channel at mouth in Grand Lake	Northern	Water Quality	Grand Lake
SM-CHL	09014050		Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Temperature	Grand Lake
SM-CHL	09014050		Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Water Quality	Grand Lake
SM-CHL	09014050		Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Flow	Grand Lake
SM-DAM	SM-DAM		Shadow Mountain Reservoir Dam	Northern	Water Quality	Shadow Mountain
SM-MID	SM-MID		Shadow Mountain Reservoir Mid-Section	Northern	Water Quality	Shadow Mountain
SM-NOR2	SM-NOR		Shadow Mountain Reservoir North	Northern	Water Quality	Shadow Mountain
SM-NW1	SM-NW1		Shadow Mountain Reservoir northwest of the center of the Reservoir	Northern	Water Quality	Shadow Mountain
ST-0	ST-GRU	0	Shadow Mountain Channel at Chipmunk Lane	Northern	Water Quality	Stillwater Creek
ST-0	ST-GRU	0	Stillwater Creek upstream Granby Reservoir	Northern	Temperature	Stillwater Creek
WC-0.5	WC-abvCOR	0.5	Willow Creek upstream of confluence with Colorado River	LBD	Temperature	Willow Creek
WC-0.9	WC-CRU	1	Willow Creek upstream of confluence with Colorado River	Northern	Water Quality	Willow Creek
WC-2.3	WC-abvBHD	2.3	Willow Creek upstream of Bunte Highline Ditch	LBD	Temperature	Willow Creek
WC-3.8	WC-WCRD	3.8	Willow Creek directly downstream of Willow Creek Reservoir Dam	Northern	Water Quality	Willow Creek
WC-3.8	WC-WCRD	3.8	Willow Creek downstream of Willow Creek Reservoir	Northern	Temperature	Willow Creek
WC-3.8	WC-WCRD	3.8	Willow Creek downstream of Willow Creek Reservoir	Northern	Flow	Willow Creek
WC-6.3	WC-WCRU	6.3	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern	Water Quality	Willow Creek
WC-6.3	WC-WCRU	6.3	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern	Flow	Willow Creek
WC-DAM	WC-DAM		Willow Creek Reservoir at Dam	Northern	Water Quality	Willow Creek Reservoir
WCP-0	WC-Pump	0	Willow Creek discharge chute to Lake Granby	Northern	Water Quality	Willow Creek Pump Canal
WCP-0	WC-PUMP	0	Willow Creek Pump Canal Inflow to Lake Granby	Northern	Temperature	Willow Creek Pump Canal
WGP-0	WG-Pump	0	Windy Gap discharge chute to Granby Reservoir	Northern	Water Quality	Windy Gap Pump Canal
WGP-0	WG-PUMP	0	Windy Gap Pump Inflow to Granby Reservoir	Northern	Temperature	Windy Gap Pump Canal

Colorado River - Upstream of Windy Gap to Headwaters

	Rivers and Streams								Lakes and Reservoirs			
General Field Parameters	**NW1**	**NW2**	**NW3**	**NW4**	**NW5**	**AQ1**	**AQ2**	**SED2**	**NW6**	**NW7**	**NW8**	**NW9**
Temperature	X	X	X	X	X				X	X	X	X
Dissolved Oxygen	X	X	X	X	X				X	X	X	X
Specific Conductance	X	X	X	X	X				X	X	X	X
pH	X	X	X	X	X				X	X	X	X
Turbidity	X	X	X	X	X				X	X	X	X
Flow	X	X	X	X	X							
secchi depth									X	X	X	X
Major Ions (plus carbon and misc)												
Calcium	X								X		X	
Magnesium	X								X		X	
Potassium	X								X		X	
Sodium	X								X		X	
Chloride	X								X		X	
Sulfate	X								X		X	
Total Organic Carbon	X	X							X	X	X	X
Total Alkalinity	X								X		X	
Total Suspended Solids	X	X	X						X	X	X	X
Total Dissolved Solids												
Metals												
Iron, total	X								X		X	
Arsenic, total	X								X		X	
Chromium, total	X								X		X	
Copper, dis	X								X	X	X	X
Iron, dis	X								X	X	X	X
Manganese, dis	X				X				X	X	X	X
Arsenic, dis	X								X		X	
Boron, dis	X								X		X	
Cadmium, dis	X								X		X	
Chromium, dis	X								X		X	
Lead, dis	X								X		X	
Nickel, dis	X								X		X	
Selenium, dis	X								X		X	
Silver, dis	X								X		X	
Uranium, dis	X								X		X	
Zinc, dis	X								X		X	
Nutrients												
TKN	X	X	X	X					X	X	X	X
NH3 as N	X	X	X	X					X	X	X	X
NO3+NO2	X	X	X	X					X	X	X	X
Ortho P	X	X	X	X					X	X	X	X
P Total	X	X	X	X					X	X	X	X
chlorophyll a									X	X	X	X
Aquatic Habitat												
Phytoplankton									X	X		
Zooplankton									X	X		
Macroinvertabrates						X						
Fish							X					
Pebble Count								X				
Embeddedness								X				

NW - Northern Water

AQ- Aquatic Life (bugs/fish)

SED - Sediment Monitoring

Colorado River - Upstream of Windy Gap to Headwaters

Station	Jan 01	Jan 08	Jan 15	Jan 22	Jan 29	Feb 05	Feb 12	Feb 19	Feb 26	Mar 05	Mar 12	Mar 19	Mar 26	Apr 02	Apr 09	Apr 16	Apr 23	Apr 30	May 07	May 14	May 21	May 28	Jun 04	Jun 11	Jun 18	Jun 25	Jul 02	Jul 09	Jul 16	Jul 23	Jul 30	Aug 06	Aug 13	Aug 20	Aug 27	Sep 03	Sep 10	Sep 17	Sep 24	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31
AC-0.6	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1				NW2					NW1									
CH-0.5	NW4									NW4				NW4		NW4				NW4		NW4		NW4		NW4		NW4		NW4		NW4				NW4				NW4					NW4									
CLU-0	NW4									NW4				NW4		NW4		NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4																					
CLU-0.7																			NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4	NW4																					
CR-31	NW5		NW2							NW5		NW2		NW2,NW5			NW2		NW1		NW2,NW5		NW1		NW2,NW5		NW2,NW5			NW2		NW2,NW5			NW1	AQ1,SED2			NW2,NW5			NW5		NW1		NW5						
CR-32.1	NW5									NW5				NW5					NW5		NW5		NW5		NW5		NW5					NW5				NW5				NW5			NW5		NW5		NW5						
CR-34.7	NW5									NW5				NW5					NW5		NW5		NW5		NW5		NW5					NW5				NW5				NW5			NW5		NW5		NW5						
CR-35.6	NW5									NW5				NW5					NW5		NW5		NW5		NW5		NW5					NW5				NW5				NW5			NW5		NW5		NW5						
CR-38.3	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1	AQ1			NW2					NW1									
CR-43.5																																																					
CR-44.6	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1	AQ1			NW2					NW1									
EI-0.1	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1	AQ1			NW2					NW1									
GL-ATW	NW8									NW9									NW9				NW8				NW9					NW9				NW9				NW8														
GL-MID	NW6									NW7									NW7				NW6				NW7					NW7				NW7				NW6														
GL-WES																																																				
GR-DAM	NW6									NW7									NW7				NW6				NW7					NW7				NW7				NW6														
GR-EAS	NW8									NW9									NW9				NW8				NW9					NW9				NW9				NW8														
GR-WES	NW8									NW9									NW9				NW8				NW9					NW9				NW9				NW8														
GRP-0	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1				NW2					NW1									
NF-0.1	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1	AQ1			NW2					NW1									
NI-0.1	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1				NW2					NW1									
RF-0	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1				NW2					NW1									
SM-CHL	NW6									NW7									NW7				NW6				NW7					NW7				NW7				NW6														
SM-DAM	NW6									NW7									NW7				NW6				NW7					NW7				NW7				NW6														
SM-MID	NW6									NW7									NW7				NW6				NW7					NW7				NW7				NW6														
SM-NOR2																																																				
SM-NW1																																																				
ST-0	NW2									NW2				NW2					NW1				NW1				NW2					NW2				NW1				NW2					NW1									
WC-0.5																																																				
WC-0.9	NW5									NW5				NW5					NW5		NW5		NW5		NW5		NW5					NW5				NW5				NW5			NW5		NW5		NW5						
WC-2.3																																																				
WC-3.8	NW2									NW2				NW2		NW3				NW1		NW3		NW1		NW3		NW2		NW3		NW2				NW1				NW2					NW1									
WC-6.3	NW3									NW3				NW3		NW3				NW3		NW3		NW3		NW3		NW3		NW3		NW3				NW3				NW3					NW3									
WC-DAM	NW6									NW7									NW7				NW6				NW7					NW7				NW7				NW6														
WCP-0										NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW1	NW2	NW2	NW2	NW1	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW1	NW2	NW2	NW2	NW2		NW2			NW1		NW2							
WGP-0																NW2	NW2	NW2	NW1	NW2	NW2	NW2	NW1	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2	NW2																					

River Name	Abbreviation
Arapaho Creek	AC
Church Creek	CH
Colorado River	CR
East Inlet	EI
Granby Pump Canal	GRP
Granby Pump Canal Canal	GRP
Grand Lake	GL
Lake Granby	GR
North Fork of Colorado	NF

River Name	Abbreviation
North Inlet	NI
Roaring Fork	RF
Shadow Mountain	SM
Stillwater Creek	ST
Trail Creek	TR
Willow Creek	WC
Willow Creek Pump Canal	WCP
Willow Creek Reservoir	WC
Windy Gap Pump Canal	WGP

Approximate months when temperature data are collected

Secchi measurements collected 3x a week

Sites where there are flow gages

Fraser River - Colorado River to Winter Park

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
CB-0.6	CAB-abvChan	0.6	Cabin Creek upstream North and South Channels	Denver Water	Temperature	Cabin Creek
CB-2.7	09032100	2.7	CABIN CREEK NEAR FRASER, CO.	DW/USGS	Flow	Cabin Creek
CB-2.7	CAB-blwDWB	2.7	Cabin Creek downstream Denver Water diversion	Denver Water	Temperature	Cabin Creek
CC-1.5	395927105505700	1.5	Crooked Cr Abv Pole Creek At Tabernash	EGWQB	Water Quality	Crooked Creek
EC-5.5	09025300	5.5	Elk Creek near Fraser	DW/USGS	Flow	Elk Creek
EC-5.5	Elk-blwDWB	5.5	Elk Creek downstream Denver Water diversion	Denver Water	Temperature	Elk Creek
FR-0.1	FR-WGU	0.1	Fraser River upstream of confluence with Colorado River	Northern	Water Quality	Fraser River
FR-0.1	FR-WGU	0.1	Fraser River upstream of confluence with Colorado River	Northern	Temperature	Fraser River
FR-0.1	FR-WGU	0.1	Fraser River upstream of confluence with Colorado River	Northern	Macroinvertebrate	Fraser River
FR-0.1	FR-WGU	0.1	Fraser River upstream of confluence with Colorado River	Northern	Flow	Fraser River
FR-1.6	FR-blwGSD	1.6	Fraser River downstream of Granby Sanitation District	GCWIN	Temperature	Fraser River
FR-1.9	FR-abvGSD	1.9	Fraser River upstream of Granby Sanitation District	GCWIN	Temperature	Fraser River
FR-3.5	400453105554200	3.5	Fraser River At Hwy. 40 At Granby, Co	EGWQB	Water Quality	Fraser River
FR-3.5	FR-Hwy40Gr	3.5	Fraser River blw Highway 40 in Granby	GCWIN/LBD	Temperature	Fraser River
FR-4.5	FR-blwFRCan	4.5	Fraser River downstream Fraser Canyon	GCWIN	Temperature	Fraser River
FR-5.5	F9	5.5	Fraser River at Granby Ranch downstream of golf course	LBD	Sediment	Fraser River
FR-12.4	09033300	12.4	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Water Quality	Fraser River
FR-12.4	FR-abvFrCan	12.4	Fraser River downstream of Crooked Creek and Tabernash	GCWIN	Temperature	Fraser River
FR-12.4	09033300	12.4	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Flow	Fraser River
FR-14	9027100	14	Fraser River upstream of Tabernash	EGWQB	Water Quality	Fraser River
FR-14	09027100	14	Fraser River upstream of Tabernash	EGWQB/TU	Temperature	Fraser River
FR-14	FR-CR83	14	Fraser River upstream of Tabernash	Denver Water	Macroinvertebrate	Fraser River
FR-14	FR-CR83	14	Fraser River upstream of Tabernash	LBD	Sediment	Fraser River
FR-14	09027100	14	Fraser River upstream of Tabernash	EGWQB/USGS	Flow	Fraser River
FR-14.4	FR-SpProjD	14.4	Fraser River LBD Restoration Project, Downstream end	GCWIN	Temperature	Fraser River
FR-14.4		14.4	Winter Park W & S	CPW	Fish	Fraser River
FR-15	FR-SpProjU	15	Fraser River LBD Restoration Project, Upstream end	GCWIN	Temperature	Fraser River
FR-15	FR-SpProjU	15	Fraser River LBD Restoration Project, Upstream end	LBD	Macroinvertebrate	Fraser River
FR-15	FR-SpProjU	15	Fraser River LBD Restoration Project, Upstream end	LBD	Sediment	Fraser River
FR-16.6	FR-blwFSD	16.6	Fraser River downstream Fraser Sanitation	GCWIN	Temperature	Fraser River
FR-16.9	FR-abvFSD	16.9	Fraser River upstream Fraser Sanitation	GCWIN	Temperature	Fraser River
FR-17.7	FR-blwCR8HD	17.7	Fraser River downstream County Rd 8 at Hammond Ditch	GCWIN	Temperature	Fraser River
FR-18.1	FR-CR804	18.1	Fraser River downstream County Rd 804	GCWIN	Temperature	Fraser River
FR-18.1		18.1	Safeway	CPW	Fish	Fraser River
FR-20	FR-Rendezvous	20	Fraser River at Rendezous bridge	GCWIN	Temperature	Fraser River
FR-20	FR-Rendezvous	20	Fraser River at Rendezous bridge	Denver Water	Macroinvertebrate	Fraser River
FR-20	FR-Rendezvous	20	Fraser River at Rendezous bridge	LBD	Sediment	Fraser River

Fraser River - Colorado River to Winter Park

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
FR-20.6	09025010	20.6	Fraser River Blw Vasquez Creek At Winter Park Co.	EGWQB	Water Quality	Fraser River
FR-21		21	Confluence Park	CPW	Fish	Fraser River
FR-22.5	FR-blwWP	22.5	Fraser River downstream Winter Park Resort at Idlewild Campground	GCWIN	Temperature	Fraser River
FR-22.5		22.5	Idlewild Campground	CPW	Fish	Fraser River
FR-22.5	09024000	22.5	Fraser River at Winter Park	DW/USGS	Flow	Fraser River
FR-23.2	FR-blwWPSD	23.2	Fraser River downstream Winter Park Sanitation	GCWIN	Temperature	Fraser River
FR-23.4	09023750	23.4	Fraser River Blw Buck Creek At Winter Park Co.	EGWQB	Water Quality	Fraser River
FR-23.4	FR-abvWPSD	23.4	Fraser River upstream Winter Park Sanitation District	GCWIN	Temperature	Fraser River
FR-23.4	FR-abvWPSD	23.4	Fraser River upstream Winter Park Sanitation District	Denver Water	Macroinvertebrate	Fraser River
FR-23.4	FR-abvWPSD	23.4	Fraser River upstream Winter Park Sanitation District	LBD	Sediment	Fraser River
FR-24	09023560	24	Fraser River upstream Moffat Tunnel Nr Winter Park, Co	EGWQB	Water Quality	Fraser River
FR-24	WS-FR-010	24	Fraser/Jim Canal at Gaging Station	Denver Water	Water Quality	Fraser River
FR-27.2	09022000	27.2	Fraser River At Upper Sta, Near Winter Park, Co.	EGWQB	Water Quality	Fraser River
FR-27.2	FR-Upper	27.2	Fraser R upstream Mary Jane entrance to Winter Park	GCWIN	Temperature	Fraser River
FR-27.2	09022000	27.2	Fraser River At Upper Sta, Near Winter Park, Co.	EGWQB/USGS	Flow	Fraser River
FR-27.2	FR US JimCk	27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Sediment	Fraser River
FR-27.2	FR US JimCk	27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Macroinvertebrate	Fraser River
HC-0.5	HRD-atCR843	0.5	Herd Creek on County Road 843	Denver Water	Temperature	Herd Creek
LCB-2.2	LCAB-blwDWB	2.2	Little Cabin Creek downstream Denver Water diversion	Denver Water	Temperature	Little Cabin Creek
LVC-0.2	LVC- abvWP	0.2	Little Vasquez upstream Winter Park on Arapaho Road	Denver Water	Temperature	Little Vasquez Creek
MC-0.5	MEA-atCR84	0.5	Meadow Creek on County Road 84/USFS 129	Denver Water	Temperature	Meadow Creek
RC-1.1	09033100	1.1	Ranch Creek Blw Meadow Cr Nr Tabernash Co	EGWQB/CRWCD	Water Quality	Ranch Creek
RC-1.1	09033100	1.1	Ranch Creek Blw Meadow Cr Nr Tabernash Co	GC/DW	Temperature	Ranch Creek
RC-1.1	RC-blwMC	1.1	Ranch Creek downstream Meadow Creek	GCWIN	Temperature	Ranch Creek
RC-1.1	RC-blwMC	1.1	Ranch Creek downstream Meadow Creek	LBD	Macroinvertebrate	Ranch Creek
RC-1.1	F-RC2	1.1	Ranch Creek downstream of County Road 84	LBD	Sediment	Ranch Creek
RC-1.1	09033100	1.1	Ranch Creek Blw Meadow Cr Nr Tabernash Co	EGWQB/CRWCD	Flow	Ranch Creek
RC-4.7	RC-blwCR8315	4.7	Ranch Creek downstream County Rd 8315	GCWIN	Temperature	Ranch Creek
RC-9	09032000	9	Ranch Creek Near Fraser, Co.	EGWQB	Water Quality	Ranch Creek
RC-9	09032000	9	Ranch Creek Near Fraser, Co.	EGWQB/USGS	Flow	Ranch Creek
RCC-0	WS-FR-011	0	Ranch Canal at Gaging Station	Denver Water	Water Quality	Ranch Canal
STC-0	ST-LC	0	St. Louis Creek upstream confluence with Fraser River	GCWIN/LBD	Temperature	St Louis Creek
STC-0	STC FR	0	St. Louis Creek upstream confluence with Fraser River	LBD	Sediment	St. Louis Creek
STC-0	STC FR	0	St. Louis Creek upstream confluence with Fraser River	LBD	Macroinvertebrate	St. Louis Creek
STC-5.4	09026500	5.4	St. Louis Creek near Fraser	DW/USGS	Flow	St Louis Creek
STC-5.4	STC-Mid	5.4	St. Louis Creek at Fraser Experimental Forest HQ	LBD	Temperature	St Louis Creek
STC-9.8	STC-blwDWB	9.8	St. Louis Creek downstream Denver Water Board diversion	Denver Water	Temperature	St Louis Creek

Fraser River - Colorado River to Winter Park

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
VC-0	VC-WP	0	Vasquez Creek at the town of Winter Park	GCWIN	Temperature	Vasquez Creek
VC-0	09025000	0	Vasquez Creek at the town of Winter Park	DW/USGS	Flow	Vasquez Creek
VC-0	VC-WP	0	Vasquez Creek at the town of Winter Park	Denver Water	Macroinvertebrate	Vasquez Creek
VC-4.3	WS-FR-001	4.3	Vasquez Ck. upstream Vasquez Tunnel	Denver Water	Water Quality	Vasquez Creek
VC-8	WS-FR-002	8	Vasquez Ck. at diversion structure	Denver Water	Water Quality	Vasquez Creek
VCC-0	WS-FR-009	0	Vasquez Canal at Vasquez #1 Gaging Station	Denver Water	Water Quality	Vasquez Canal
VT-0	WS-WF-019	0	Vasquez Tunnel outlet	Denver Water	Water Quality	Vasquez Canal

Fraser River - Colorado River to Winter Park

General Field Parameters	NW1	NW2	DW1	EG1	EG2	EG3	EG4	EG5	EG6	AQ1	AQ2	SED2
Temperature	X	X	X	X	X	X	X	X	X			
Dissolved Oxygen	X	X	X	X	X	X	X	X	X			
Specific Conductance	X	X	X	X	X	X	X	X	X			
pH	X	X	X	X	X	X	X	X	X			
Turbidity	X	X	X	X	X	X	X	X	X			
Flow	X	X	X	X	X	X	X	X	X			
Major Ions (plus carbon and misc)												
Calcium	X					X	X	X	X			
Magnesium	X					X	X	X	X			
Potassium	X											
Sodium	X											
Chloride	X			X	X	X	X	X	X			
Sulfate	X											
Total Organic Carbon	X	X										
Total Alkalinity	X		X									
Total Suspended Solids	X	X	X					X	X			
Total Dissolved Solids								X	X			
Cyanide								X	X			
Ecoli												
Metals												
ICPMS Total/Dis Suite*			X									
Iron, total	X							X	X			
Aluminum, total												
Arsenic, total	X							X	X			
Boron, total								X	X			
Chromium, total	X							X	X			
Manganese, total												
Aluminum, dis												
Copper, dis	X					X	X	X	X			
Iron, dis	X					X	X	X	X			
Manganese, dis	X							X	X			
Arsenic, dis	X											
Boron, dis	X											
Cadmium, dis	X							X	X			
Chromium, dis	X											
Lead, dis	X					X	X	X	X			
Nickel, dis	X							X	X			
Selenium, dis	X							X	X			
Silver, dis	X							X	X			
Uranium, dis	X							X	X			
Zinc, dis	X					X	X	X	X			
Mercury, dis					X		X	X	X			
Nutrients												
TKN	X	X		X	X	X	X	X				
NH3 as N	X	X		X	X	X	X	X				
NO3												
NO3+NO2	X	X		X	X	X	X	X				
Ortho P	X	X		X	X	X	X	X				
P Total	X	X	X	X	X	X	X	X				
Aquatic Habitat												
Macroinvertabrates										X		
Fish											X	
Riffle Stability Index												
Pebble Count												X
Embeddedness												X

**ICPMS Total/Dis Suite - Be, B, Na, Mg, Al, Si, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Hg, Tl, Pb, U*

DW - Denver Water
NW - Northern Water
AQ- Aquatic Life (bugs/fish)
EG - East Grand Water Quality Board
SED - Sediment Monitoring

Fraser River - Colorado River to Winter Park

Station	Jan 01	Jan 08	Jan 15	Jan 22	Jan 29	Feb 05	Feb 12	Feb 19	Feb 26	Mar 05	Mar 12	Mar 19	Mar 26	Apr 02	Apr 09	Apr 16	Apr 23	Apr 30	May 07	May 14	May 21	May 28	Jun 04	Jun 11	Jun 18	Jun 25	Jul 02	Jul 09	Jul 16	Jul 23	Jul 30	Aug 06	Aug 13	Aug 20	Aug 27	Sep 03	Sep 10	Sep 17	Sep 24	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31
CB-0.6																																																				
CB-2.7																																																					
CC-1.5	EG1									EG1									EG2								EG1									EG2									EG1								
EC-5.5																																																				
FR-0.1	NW2									NW2				NW2		NW2			NW1		NW2		NW1		NW2		NW2		NW2			NW2				NW1		AQ1		NW2				NW1								
FR-1.6																																																				
FR-1.9																																																				
FR-3.5	EG1									EG1						AQ2			EG1								EG1									EG1									EG1								
FR-4.5																																																				
FR-5.5																																						SMP1															
FR-12.4	EG1																		EG1				EG1				EG1					EG1				EG1									EG1								
FR-14	EG1					EG1				EG3				EG1					EG4				EG1				EG3					EG1				EG4		AQ1,SED2		EG1				EG1				EG1				
FR-14.4																																						AQ2															
FR-15																																						AQ1,SED2															
FR-16.6																																																				
FR-16.9																																																				
FR-17.7																																																				
FR-18.1																																						AQ2															
FR-20																																						AQ1,SED2															
FR-20.6	EG1					EG1				EG3				EG1					EG4				EG1				EG3					EG1				EG4				EG1				EG1				EG1				
FR-21																AQ2																					AQ2															
FR-22.5																AQ2																					AQ2															
FR-23.2																																																				
FR-23.4	EG5					EG1				EG3				EG1					EG4				EG1				EG3					EG1				EG4		AQ1,SED2		EG1				EG5				EG1				
FR-24	EG6		DW1							EG6						DW1			EG6								EG6		DW1							EG6						DW1				EG6								
FR-27.2																			EG4								EG1									EG4		AQ1,SED2		EG1				EG1				EG1				
HC-0.5																																																				
LCB-2.2																																																				
LVC-0.2																																																				
MC-0.5																																																				
RC-1.1	EG1					EG1				EG1				EG1					EG2								EG1					EG1				EG2		AQ1,SED1						EG1								
RC-4.7																																																				
RC-9	EG1																		EG4								EG3					EG1				EG4				EG1				EG1								
RCC-0	DW1													DW1													DW1													DW1												
STC-0																																						AQ1,SED2															
STC-5.4																																																				
STC-9.8																																																				
VC-0																																						AQ1															
VC-4.3																							DW1													DW1																	
VC-8																							DW1													DW1																	
VCC-0	DW1													DW1													DW1													DW1												
VT-0																							DW1													DW1																	

River Name	Abbrevation
Cabin Creek	CB
Cabin Creek North Channel	CBN
Cabin Creek South Channel	CBS
Little Cabin Creek	LCB
Crooked Creek	CC
Elk Creek	EC
Fraser River	FR
Herd Creek	HC

River Name	Abbrevation
Meadow Creek	MC
Ranch Creek	RC
Ranch Creek Canal	RCC
Saint Louis Creek	STC
Vasquez Creek	VC
Vasquez Creek Canal	VCC
Little Vasquez Creek	LVC

Approximate months when temperature data are collected

Sites where there are flow gages

Williams Fork

River Mile ID	Entity Station ID	River Mile	Description	Entity	Type	Location
BC-0	WS-WF-008	0	Bobtail Creek above diversion dam downstream of gauging station	Denver Water	Water Quality	Bobtail Creek
BC-0	09034900	0	Bobtail Creek above diversion dam	Denver Water	Flow	Bobtail Creek
MQC-0	WS-WF-006	0	McQueary Creek above diversion dam 1 3/4 miles north of dorm	Denver Water	Water Quality	McQuery Creek
SC-0	WS-WF-005	0	Steelman Creek at bridge above diversion dam (south of dorm)	Denver Water	Water Quality	Steelman Creek
SWF-0	WS-WF-003	0	South fork at South Fork Campground at gauging station	Denver Water	Water Quality	South Fork WF
SWF-0	09035900	0	South fork at South Fork Campground	DW/USGS	Flow	South Fork WF
USF-0	WS-WF-007	0	Upper South Fork of the Williams Fork (3.5 miles above trail head)	Denver Water	Water Quality	Upper South Fork WF
WF-2	WS-WF-009	2	WIlliams Fork R. below Williams Fork Reservoir	Denver Water	Water Quality	Williams Fork
WF-2	09038500	2	WIlliams Fork R. below Williams Fork Reservoir	DW/USGS	Flow	Williams Fork
WF-2	WF-WFRD	2	WIlliams Fork R. below Williams Fork Reservoir	LBD	Macroinvertebrate	Williams Fork
WF-5.5	WS-WF-001	5.5	Williams Fork River upstream of Williams Fork Reservoir	Denver Water	Water Quality	Williams Fork
WF-5.5	09037500	5.5	WILLIAMS FORK NEAR PARSHALL, CO	DW/USGS	Flow	Williams Fork
WF-5.5	WF-abvWFR	5.5	Williams Fork upstream of Williams Fork Reservoir	LBD	Temperature	Williams Fork
WF-5.5	WF-WFRU	5.5	Williams Fork upstream of Williams Fork Reservoir	LBD	Macroinvertebrate	Williams Fork
WF-13.1	KR-LS-11081	13.1	Williams Fork	BLM	Water Quality	Williams Fork
WF-13.1	KR-LS-11081	13.1	Williams Fork	BLM	Macroinvertebrate	Williams Fork
WF-13.1	KR-LS-11081	13.1	Williams Fork	BLM	Habitat	Williams Fork
WF-13.1	WF-HMD	13.1	Williams Fork downstream of Henderson Mill	LBD	Macroinvertebrate	Williams Fork
WF-19	WS-WF-002	19	WilliamsForkRiver below Kinney Creek confluence at Leal gauge	Denver Water	Water Quality	Williams Fork
WF-19	09036000	19	WILLIAMS FORK NEAR LEAL, CO.	DW/USGS	Flow	Williams Fork
WF-19.6	09035700	19.6	WILLIAMS FORK ABOVE DARLING CREEK, NEAR LEAL, CO	DW/USGS	Flow	Williams Fork
WF-22.6	WS-WF-004	22.6	Williams Fork above bridge at Sugarloaf Campground	Denver Water	Water Quality	Williams Fork
WF-28.2	09035500	28.2	WILLIAMS FORK BELOW STEELMAN CREEK, CO.	DW/USGS	Flow	Williams Fork

Williams Fork

General Field Parameters	DW1	BLM1	AQ1	AQ2
Temperature	X	X		
Dissolved Oxygen	X	X		
Specific Conductance	X	X		
pH	X	X		
Turbidity	X			
Flow	X			
Major Ions (plus carbon and misc)				
Calcium				
Magnesium				
Potassium				
Sodium				
Chloride				
Sulfate				
Total Organic Carbon				
Total Alkalinity	X			
Total Suspended Solids	X			
Total Dissolved Solids				
Ecoli				
Metals				
ICPMS Total/Dis Suite*	X			
Nutrients				
TKN		X		
NH3 as N		X		
NO3				
NO3+NO2		X		
Ortho P				
P Total	X	X		
Aquatic Habitat				
Macroinvertabrates		X	X	
Fish				
Habitat (% fines,% pools, etc)		X		X

**ICPMS Total/Dis Suite - Be, B, Na, Mg, Al, Si, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Hg, Tl, Pb, U*

DW - Denver Water

BLM -Bureau of Land Management

AQ- Aquatic Life (bugs/fish)

Williams Fork

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BC-0					DW1				DW1			
MQC-0					DW1				DW1			
SC-0					DW1				DW1			
SWF-0					DW1				DW1			
USF-0					DW1				DW1			
WF-2	DW1		DW1	DW1	DW1	DW1	DW1		DW1,AQ1		DW1	
WF-5.5	DW1		DW1	DW1	DW1	DW1	DW1		DW1,AQ1		DW1	
WF-13.1				BLM1					AQ1			
WF-19					DW1				DW1			
WF-19.6												
WF-22.6					DW1				DW1			
WF-28.2												

River Name	Abbreviation
Bobtail Creek	BC
McQuery Creek	MQC
South Fork	SF
Steelman Creek	SC
Williams Fork	WF

Sites where there are flow gages

Approximate months when temperature data are collected

GRAND COUNTY
LEARNING BY DOING

Appendix C – 2020 Monitoring Proposals and Data Gaps Assessments

2020 Stream Temperature Data Gaps Assessment and Program Proposal

This document describes the results of the Learning By Doing (LBD) Monitoring Subcommittee's (Subcommittee) data gaps analysis and subsequent 2020 Stream Temperature Monitoring Program recommendations in the LBD cooperative effort area (CEA). LBD's stream temperature monitoring program is intended to supplement the existing stream temperature monitoring network within the CEA.

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 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.

Existing Temperature Monitoring Network

The existing temperature monitoring network consists of 65 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 2019 monitoring sites is shown in **Figure 1** below.

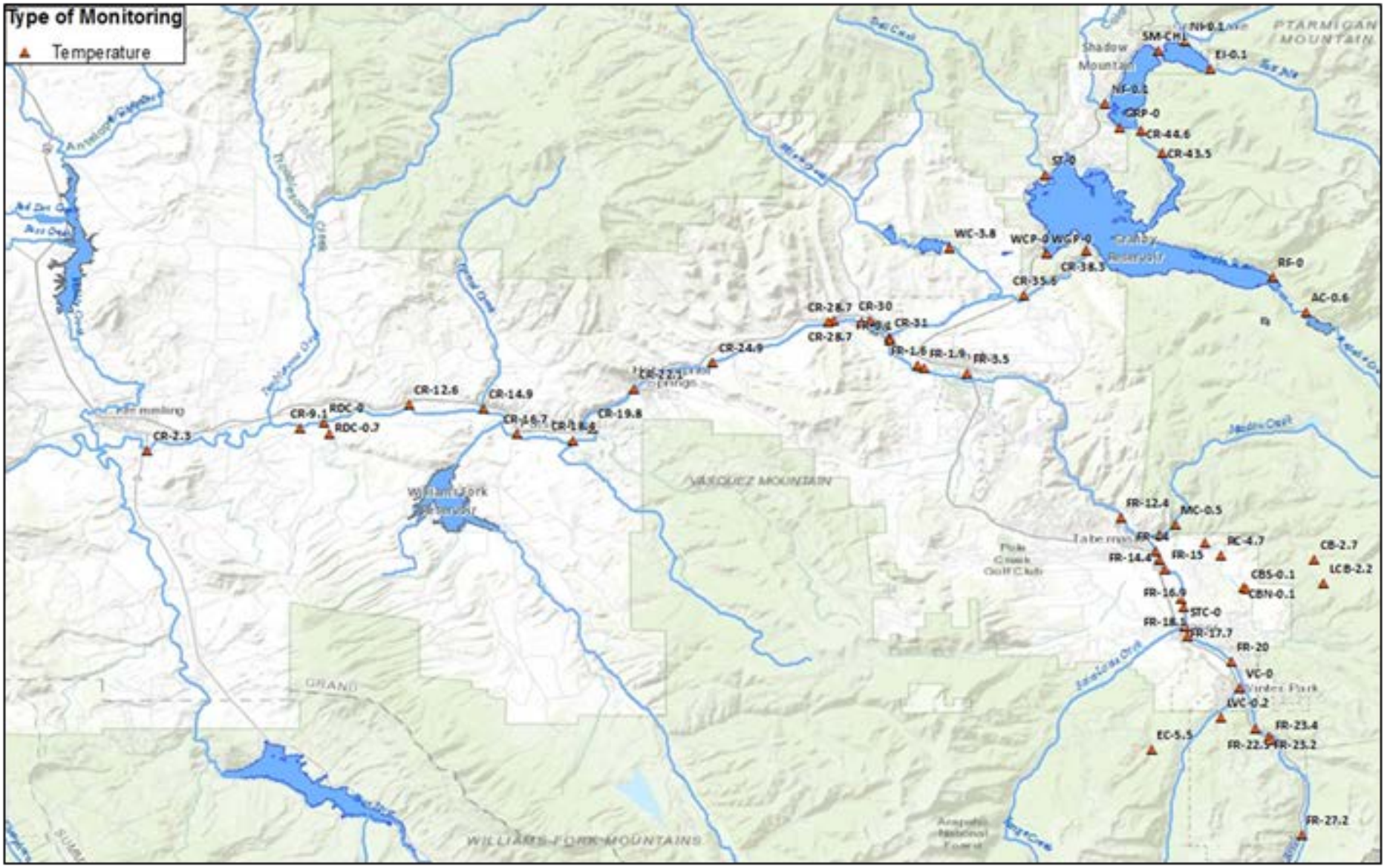


Figure 1 - 2019 Temperature Monitoring Sites in the CEA

LBD Stream Temperature Monitoring: In 2019, there were 9 sites that were monitored in the Stream Temperature Program for Learning By Doing. The data that were collected helped support the LBD stream temperature monitoring program objectives, therefore, the Subcommittee recommends monitoring at these same sites in 2020. Additionally, at 3 sites data was downloaded on a weekly basis from June - September. The weekly data downloads were used to support operational recommendations made during the weekly Operations Subcommittee calls. The Subcommittee recommends weekly downloads are maintained in 2020.

The existing LBD sites (including the recommended monitoring frequency) that the Subcommittee proposed to retain in the 2020 LBD Temperature Monitoring Plan are shown in Table 1.

Table 1 – Sites monitored in 2019 and recommended for 2020

River Mile ID	Station Description	2019 Site	Weekly Downloads?
STC-0	Saint Louis Creek at confluence of Fraser River	Yes	Yes
FR-3.5	Fraser River at Hwy 40 Granby	Yes	Yes
CR-2.3	Colorado River upstream of Hwy 9 Bridge in Kremmling	Yes	Yes
FR-15	Fraser Flats River Habitat Project Upstream	Yes	No
FR-14.4	Fraser Flats River Habitat Project Downstream	Yes	No
STC-5.4	Saint Louis Creek near Fraser Experimental Forest	Yes	No
WC-0.5	Willow Creek near confluence of Colorado River	Yes	No
WC-2.3	Willow Creek above Bunte Highline Ditch	Yes	No
WF-5.5	Williams Fork upstream of the reservoir	Yes	No

Stream Temperature Data Gaps Assessment: 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, the Subcommittee has the following recommendation:

1. **Spatial**
    a. **RC-blwDTU :** Ranch Creek below Devil's Thumb Ranch (Upstream of willow planting project)
        - In 2018 and 2019, willow cuttings were planted along this reach of Ranch Creek as a riparian restoration project. This reach has historically been affected by overgrazing that has nearly eliminated the willows along the river. Willows provide bank stability, shade to reduce solar exposure on the water's surface, and habitat for various wildlife and insects. This new site would bracket the planting project on the upstream end, and RC-blwDTD

would bracket the downstream end. The subcommittee recommends the addition of this site to obtain baseline stream temperature data.

b. **RC-blwDTD**: Ranch Creek below Devil's Thumb Ranch (Downstream of willow planting project)
   - In 2018 and 2019, willow cuttings were planted along this reach of Ranch Creek as a riparian restoration project. This reach has historically been affected by overgrazing that has nearly eliminated the willows along the river. Willows provide bank stability, shade to reduce solar exposure on the water's surface, and habitat for various wildlife and insects. This new site would bracket the planting project on the downstream end. The subcommittee recommends the addition of this site to obtain baseline stream temperature data.

Site Station Maintenance: The Subcommittee recommends that the proposed sites be installed and maintained by GCWIN, except for CR 2.3 which will be maintained by the BLM. GCWIN and BLM will adhere to GCWIN's SOP for temperate stations which includes the following protocols:

- 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.

Cost Estimate: The estimated cost for GCWIN to maintain the 2020 proposed sites and the increased download frequency at certain sites is shown in Table 2. Table 3 shows the 2019 cost estimate pricing breakdown. Table 4 and 5 show the cost breakdown for the proposed new site options the subcommittee recommends.

Table 2 - Estimated cost for LBD Temperature Monitoring Program

River Mile ID	Station Description	New Site?	Weekly Downloads?	2018 Site?	Cost
STC-0	Saint Louis Creek at confluence of Fraser River	No	Yes	Yes	$471
FR-3.5	Fraser River at Hwy 40 Granby	No	Yes	Yes	$471
CR-2.3	Colorado River above Hwy 9 Bridge in Kremmling	No	Yes	No	$0
FR-15	Fraser Flats River Habitat Project Upstream	No	No	Yes	$471
FR-14.4	Fraser Flats River Habitat Project Downstream	No	No	Yes	$471
STC-5.4	Saint Louis Creek near Fraser Experimental Forest	No	No	Yes	$471
WC-0.5	Willow Creek near confluence of Colorado River	No	No	Yes	$471
WC-2.3	Willow Creek above Bunte Highline Ditch	No	No	Yes	$471
WF-5.5	Williams Fork upstream of the reservoir	No	No	Yes	$471
	TOTAL				**$ 3,770**
RC-?	Ranch Creek below Devils Thumb – one site				$518
	TOTAL – 2020 Proposal				**$4,288**
RC-?	Ranch Creek below Devils Thumb – Upstream				$546
RC-?	Ranch Creek below Devils Thumb – Downstream	Yes	No	No	$546
	TOTAL – 2020 Proposal – with both sites				**$4,862**

Note: the cost per site is an estimate and the price can change for 2020 depending on the sampling plan.

Table 3 – Pricing breakdown for temperature monitoring for 2019

Program Element	Unit Costs	Total Costs
1. Labor: GCWIN Field Technician	92 hours x $25/hr x 7.63% payroll taxes	$ 2,376
2. Labor: GCWIN E.D. Data QA/QC for weekly delivery to LBD	11 hours x $35/hr x 7.63% payroll taxes	$ 414
3. Mileage	1000 miles x $0.58/mile	$ 580
4. Miscellaneous Equipment	Assume some equipment must be replaced due to wear and tear	$ 400
TOTAL		**$3,770**

Table 4 – Cost breakdown if 1 new site on Ranch Creek is added. This table includes monitoring expenses for the existing 9 sites.

Program Element- Add 1 site	Unit Costs	Total Costs
1. Labor: GCWIN Field Technician	100 hours x $25/hr x 7.63% payroll taxes	$ 2,690
2. Labor: GCWIN E.D. Data QA/QC for weekly delivery to LBD	15 hours x $35/hr x 7.63% payroll taxes	$ 565
3. Mileage	1050 miles x $0.575/mile	$ 604
4. Miscellaneous Equipment	Assume some equipment must be replaced due to wear and tear. Wear and tear contingency $200 total for existing sites. (One new temperature sensor at $129 and one new sensors housing at $100)	$ 429
TOTAL		**$4,288**

Note: the cost per site is an estimate and the price can change for 2020 depending on the sampling plan.

Table 5 – Cost breakdown if 2 new sites on Ranch Creek is added. This table includes monitoring expenses for the existing 9 sites.

Program Element – Add 2 sites	Unit Costs	Total Costs
1. Labor: GCWIN Field Technician	110 hours x $25/hr x 7.63% payroll taxes	$ 2,960
2. Labor: GCWIN E.D. Data QA/QC for weekly delivery to LBD	17 hours x $35/hr x 7.63% payroll taxes	$ 640
3. Mileage	1050 miles x $0.575/mile	$ 604
4. Miscellaneous Equipment	Assume some equipment must be replaced due to wear and tear. Wear and tear contingency $200 total for existing sites. (Two new temperature sensors at $129x2 and two new sensors housing at $100x2)	$658
TOTAL		**$4,862**

Note: the cost per site is an estimate and the price can change for 2020 depending on the sampling plan.

Additional Maps for RC-blwDTU and RC-blwDTD: Figure 2 below shows the two existing sites on Ranch Creek with the proposed addition of RC-blwDTU and RC-blwDTD. Figure 3 and Figure 4 are maps to show visual evidence of riparian vegetation degradation on this reach of Ranch Creek. This is the location of the 2018-2019 willow planting restoration project.

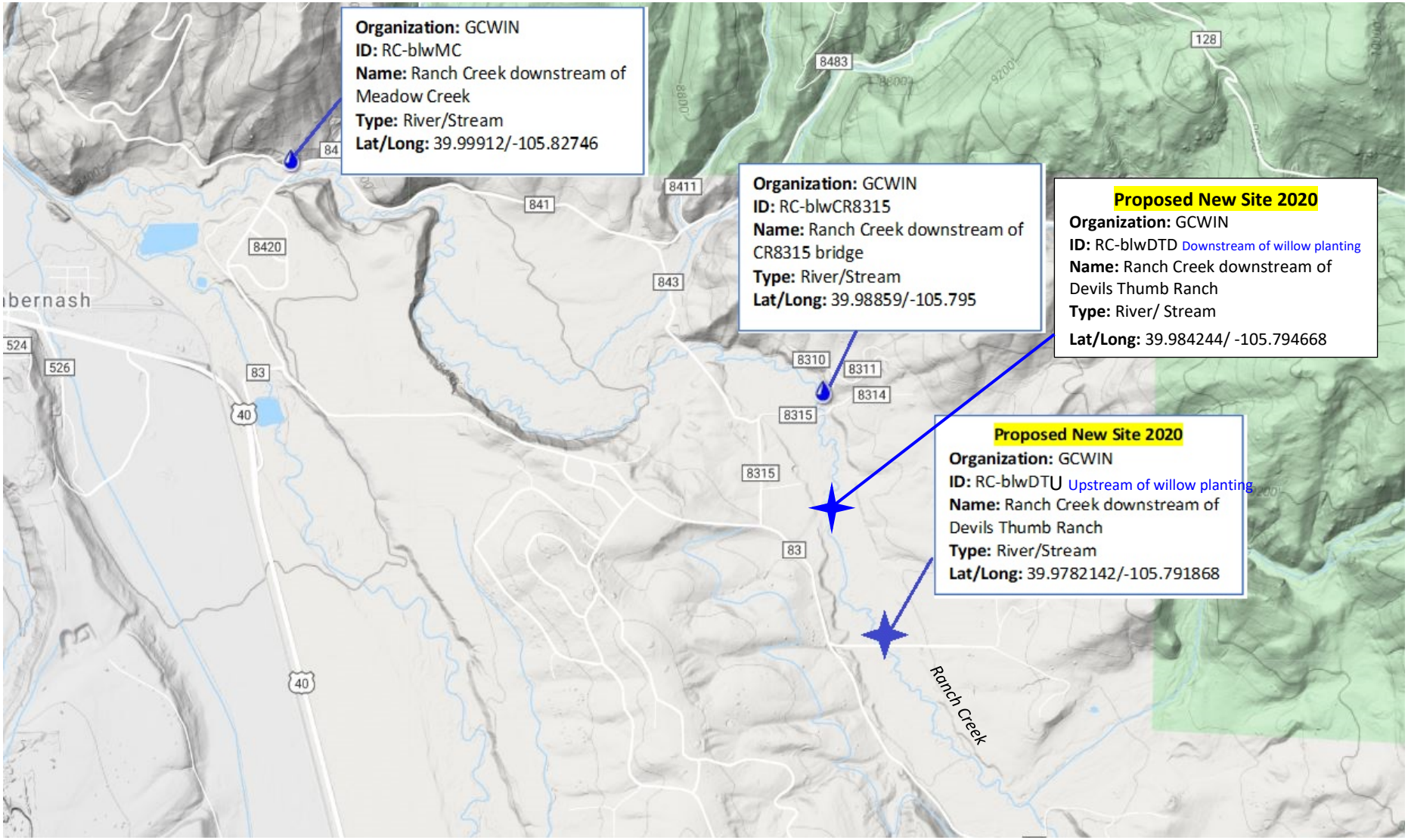


Figure 2 – Proposed new sites on Ranch Creek for 2020 . Map snipped from AWQMS database.

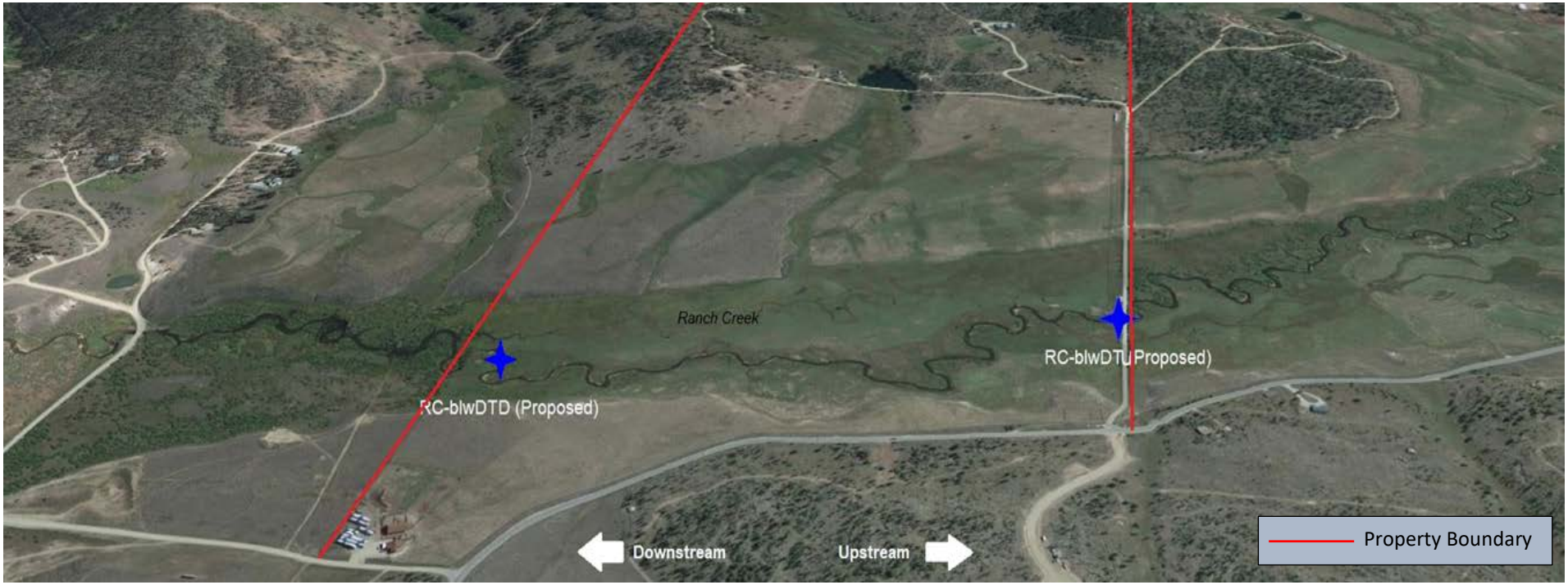


Figure 3 – In this map, there is visual evidence of riparian vegetation upstream and downstream of property boundary. 2018-2019 willow planting project occurred along this reach between the two red property boundary lines. Map: Google Earth 2020.

Figure 4. Location of 2020 proposed sites in proximity to existing Ranch Creek site RC-blwCR8315.

GRAND COUNTY
LEARNING BY DOING

2020 Grand County Substrate Sampling Plan Proposal

Introduction

This document presents the Learning By Doing (LBD) Monitoring Subcommittee's proposal for 2020 substrate monitoring within the LBD Cooperative Effort Area (CEA). Monitoring of river substrate began in 2010 "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." The primary goal was to evaluate the draft flushing flow recommendations contained in the Stream Management Plan. These recommendations were based on maintenance of the structure and function of these important spawning habitats.[1] This plan still monitors recommendations contained in the Stream Management Plan, and expands LBD's objectives to a broader evaluation of substrate as described below.

Objectives

In 2020, the objectives of the monitoring include:

- 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*; [2]
- 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.

Samples Collected

When conditions permit, substrate monitoring has historically consisted of three components: 1) sediment core sampling in trout spawning habitat, 2) 100-count Wolman pebble counts using a zig-zag cross-section pattern (in 2019 the method was switched to 400 count, using transects and a grid sampler), and 3) Riffle Stability Index (RSI) measurements at macroinvertebrate monitoring locations. A table comparing each method and detailed descriptions of methods are included at the end of this document (Appendix 1).

[1] Tetra Tech and HabiTech, *Final Draft Report 2017 Monitoring Report, Grand County Colorado*, May 10, 2018.
[2] Colorado Water Quality Control Commission, *Guidance for Implementation of Colorado's Narrative Sediment Standard Regulation #31, Section 31.11(1)(a)(i), Policy 98-1*, November 10, 2014

Sediment 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-Ahnell[3] 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. It may not be possible to use the core sampler in areas such as in riffles where the dominant substrate is larger. 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. The fine particle sizes from the suspended sediment sample are included in the overall particle size distribution in each sample. Core sampling should occur during low flow. Data collected will be compared to past data from the CEA.

Wolman Pebble Counts[4,5]:
This widely used method samples coarse riverbed material in streams as a way of estimating riverbed texture. It is a geomorphic measure, which is a good method for identifying median bed particle size. This method tends to be biased toward larger particles.

Rather than using the original Wolman method, a modified Wolman Pebble Count method which aligns with CDPHE guidelines[6] and uses a sampling frame in which sampling point locations are identified by cross points in the sampling frame grid is recommended for LBD purposes. The investigator walks along 10 evenly spaced transects over a length of 30 times the bankfull width within the river segment to make a minimum of 400 measurements of pebble size in a segment. The sampling frame is a sturdy 60 by 60 cm aluminum frame that is placed in the river. The frame is placed down ten times across each river transect. After the frame is placed, the grid points within the frame are used to identify where particles in the riverbed are to be

[3] 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
[4] Wolman, M.G. (1954) A method of sampling coarse river-bed material. Transactions American Geophysical Union 35(6) p. 951-956
[5] Bevenger, G.S. and R.M. King (1995) A Pebble Count Procedure for Assessing Watershed Cumulative Effects. USDA Forest Research Paper, RM-RP-319
[6] Colorado Water Quality Control Commission, *Guidance for Implementation of Colorado's Narrative Sediment Standard Regulation #31, Section 31.11(1)(a)(i), Policy 98-1*, November 10, 2014

selected. Substrate under grid intersections are picked up and the longest length of the particle is measured with a Gravelometer.
The Wolman Pebble Count is more meaningful when the same river segment is repeatedly measured over time and the results are compared to past results from the same segment. Pebble counts were collected in the CEA using a modified Wolman methodology along a zig-zag pattern from 2010-2018. This method is biased toward larger particles. The change in methodology to discrete transects and a grid sampler will be consistent with CDPHE methodology and will minimize bias towards large particles. Continuing with pebble counts will help provide continuity in the dataset.

Riffle Stability Index (RSI):
This method estimates the mobile sediment fraction in a river's riffle, that is, how the river bed 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. Evaluations in the past have been conducted at core sampling sites, which are trout spawning areas. However, riffles are shallower sites with fast moving water that are not where trout spawn. The RSI is more appropriate in riffles, which are macroinvertebrate habitat. The RSI helps determine whether the year's high flows were adequate to mobilize coarse bed particles and facilitate bar dynamics. "The RSI… protocol is intended for use only following runoff events of sufficient magnitude and duration to cause scour and deposition of coarse bed material."[7] A river receiving excessive fine 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 of > 70 indicate a riffle that is somewhat loaded with sediment, and values >85 indicate excess sediment. High levels of sediment deposition are symptomatic of a depositional environment that can limit macroinvertebrate habitat and salmonid reproduction. To be able to compare to 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.

Algae Presence:
The presence of filamentous algae, the percent filamentous algae cover, and diatom thickness are estimated along each transect during pebble counts. The presence and percent cover are visually estimated through a viewing bucket with a grid to estimate percent algae cover which is then recorded. Photographs should be taken during the survey to document representative observations and to calibrate surveys over time.

Monitoring Sites and Sampling Frequency
The proposed substrate monitoring plan includes:

[7] Tetra Tech and HabiTech, *Technical Memorandum, 2018 Substrate Monitoring*, April 9, 2019

- 400 count pebble counts that are compliant with Water Quality Control Commission Policy 98-1, and algae assessment at each of the 2020 macroinvertebrate sites (Table 1 - LBD Pebble Count and Algae Assessment Sites).
- RSI at 3 of the historical core sampling sites (Table 2 – LBD Core Sampling Reaches , Figure 1 - Core sample sites F-RC2 and F-9: Ranch Creek below Meadow Creek and Fraser River at Granby Ranch (red triangles).
- Figure 2, and Figure 3).
- RSI at 6 riffle sites as indicated in Table 3.
- Sediment core sampling at All 5 of the historical core sample sites

In 2020, 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.

Table 1 - LBD Pebble Count and Algae Assessment Sites

River Mile ID	Station Description	Monitoring Frequency	Years Monitored		
			2017	2018	2019
FR-27.2	Fraser River upstream Jim Crk/Mary Jane entrance	1x/2-3 yrs		X[New]	
FR-25.1	Fraser River upstream of UP Railroad discharge	Annually			X[New]
FR-23.2	Fraser River upstream of Winter Park San District	Annually	X	X	X
FR-20	Fraser River at Rendezvous Bridge	Annually	X	X	X
FR-15	Fraser River upstream of Fraser Flats restoration	Annually	X	X	X
FR-14	Fraser River upstream of Tabernash	Annually	X	X	X
FR-12.4	Fraser River upstream of Fraser Canyon	1x/2-3 yrs	X		
FR-1.9	Fraser River upstream of Granby Sanitation District	1x/2-3 yrs	X		X
STC-0	Saint Louis Creek at Fraser River	1x/2-3 yrs		X[New]	X
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	X	X	X
CR-31	Colorado River upstream Fraser and Windy Gap	Annually	X	X	X
CR-28-7	Colorado River downstream of Windy Gap	Annually	X	X	X
CR-22.9	Colorado River upstream of Hot Sulphur Springs	Annually	X	X	X
CR-16.7	Colorado River upstream of Williams Fork	Annually	X	X	X
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	1x/2-3 yrs*	X	X	X
CR-7.4	Colorado River downstream Troublesome Creek	TBD		X[New]	X
CR-1.7	Colorado River upstream of the Blue River	TBD		X[New]	X

**Site will be sampled annually during the ILVK restoration project*

Table 2 – LBD Core Sampling Reaches and Sampling History

Reach Designation	Site Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
F9	Fraser River between the Fraser Canyon and Granby	x	x	x	x	x	x	x	x			x
F-RC2	Fraser River Tributary, Ranch Creek (lower)	x	x	x		x			x			x
CR4	Chimney Rock (X^1), Paul Gilbert (X^2), or Pioneer Park (X^3) depending on site conditions	x^1	x^1	x^2	x^2	x^3	x^3	x^3	x^3	x^3		x
CR5	Downstream of Williams Fork confluence and Parshall	x	x	x	x	x	x	x	x	x		x
CR6	Downstream of KB Ditch	x	x	x	x	x	x	x	x	x		x

**No core sampling in 2019*

Figure 1 - Core sample sites F-RC2 and F-9: Ranch Creek below Meadow Creek and Fraser River at Granby Ranch (red triangles).

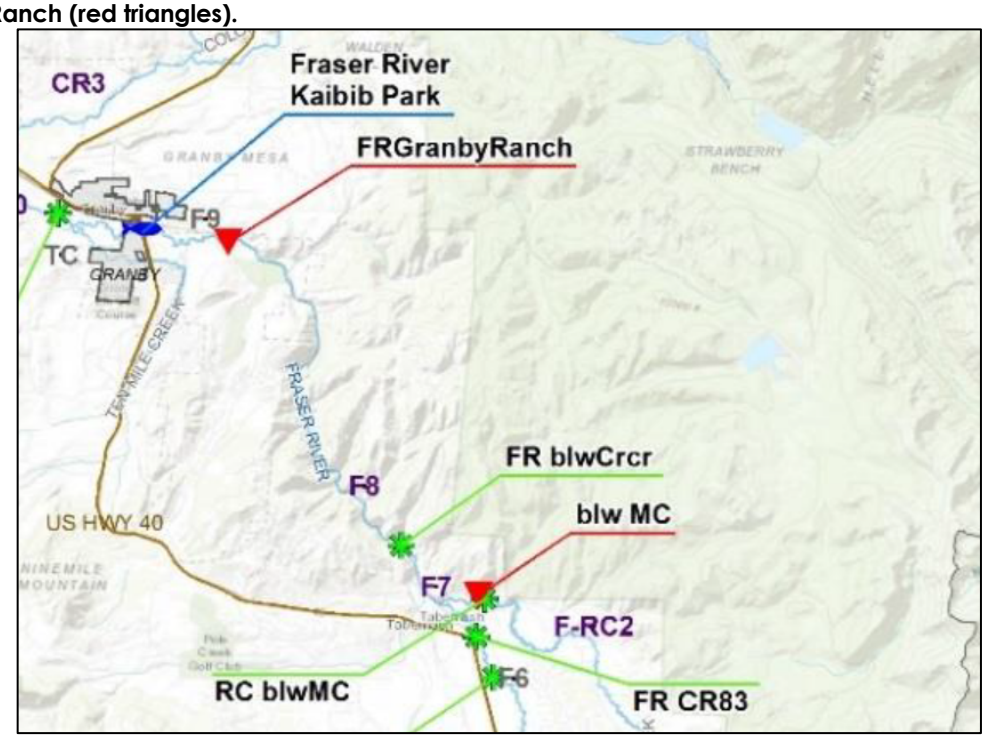


Figure 2 – CR4 Paul Gilbert Core Sample Site

Figure 3 – CR4, CR5 and CR6: Core Sample Sites at Pioneer Park, below Williams Fork, and below KB-Ditch (red triangles).

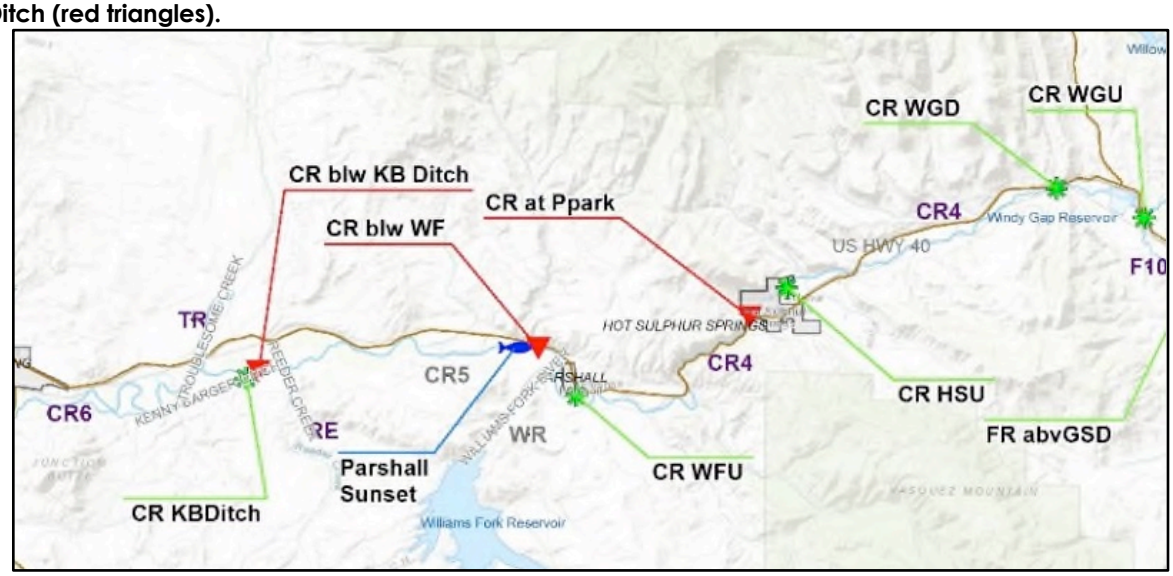


Table 3 Proposed LBD Monitoring Sites, Analysis, and Estimated Costs based on 2019

River Mile ID	Station Description	Pebble Count	RSI	Core Sample	Entity	Pebble Count Cost	RSI cost	Core Sample Cost
FR-27.2	Fraser River upstream Jim Creek/Mary Jane entrance				LBD			
FR-25.1	Fraser River upstream of UP Railroad discharge	X			LBD	$425		
FR-23.2	Fraser River upstream of Winter Park San District	X	X		LBD	$425	$171	
FR-20	Fraser River at Rendezvous Bridge	X			LBD	$425		
FR-15	Fraser River upstream of Fraser Flats restoration	X	X		LBD	$425	$171	
FR-14	Fraser River upstream of Tabernash	X			LBD	$425		
FR-12.4	Fraser River upstream of Fraser Canyon	X			LBD	$425		
FR-1.9	Fraser River upstream of Granby Sanitation District				LBD	--		
STC-0	Saint Louis Creek at Fraser River				LBD	--		
RC-1.1	Ranch Creek downstream of Meadow Creek	X	X		LBD	$425	$171	
CR-31	Colorado River upstream Fraser and Windy Gap	X			LBD	$425		
CR-28-7	Colorado River downstream of Windy Gap	X	X		LBD	$425	$171	
CR-22.9	Colorado River upstream of Hot Sulphur Springs	X			LBD	$425		
CR-16.7	Colorado River upstream of Williams Fork	X	X		LBD	$425	$171	
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	X	X		LBD	$425	$171	
CR-7.4	Colorado River downstream Troublesome Creek	X			LBD/ILVK	$425		
CR-1.7	Colorado River upstream of the Blue River	X			LBD/ILVK	$425		
F9	Fraser River between the Fraser Canyon and Granby		X	X	LBD		$171	?
F-RC2	Fraser River Tributary, Ranch Creek (lower)		X	X	LBD		$171	?
CR4	Paul Gilbert or Pioneer Park (depends on site conditions)			X	LBD			?
CR5	Downstream of Williams Fork confluence and Parshall			X	LBD			?
CR6	Downstream of KB Ditch		X	X	LBD		$171	?

LBD Total >>$ 7,489

Appendix 1

Sediment Monitoring Methodologies

Table 1. Current and potential sediment monitoring methodologies for LBD

	Method	Objective Short Description	Assess Habitat for Macroinvertebrates	Assess Habitat for Fish Spawning	Monitor Effectiveness of Flushing Flows	Monitor Changes in Particle Distribution	Monitor Impacts of Restoration Projects	Assess Intergravel Fine Sediment Concentrations	Monitor Algal Conditions
1	Wolman Pebble Count, 1954 Method and Modified Wolman	Measures median bed particle size	X			**X**		X	
2	Percent Embeddedness	Measures to what degree fine sediments have accumulated in the spaces between rocks	**X**	**X**	X			**X**	
3	Sediment Core	Measures size of sediment in spawning redds		**X**	X	X		**X**	
4	Riffle Stability Index	Measures mobile sediment fraction in a riffle	**X**		**X**	X			
5	% Algae Cover Viewing Bucket	Percent algae covering riverbed			X				X
6	TIVsed score	A macroinvertebrate index, numerates the presence of sediment tolerant/intolerant bugs	X		X		X		
7	Grid Count	Measures percent fines, can be applied in spawning beds or across transects at macroinvertebrate sites	X	**X**	X	X			
8	Tracer Rocks	A representative sample of individual rocks are marked or identified in some way and monitored for movement			X	X	X		
9	Scour Chains	Chains are anchored and buried vertically in the riverbed at points of interest; the length of chain laying horizontally post-runoff documents depth of scour			X	X	X		
10	Chlorophyll a	Measure of the areal abundance of attached algae or periphyton (CDPHE Method)		X	X		X		X
11	Photo Documentation	Photographs of algae cover at specific locations							X

Description of Sediment Monitoring Methods

1) Wolman Pebble Count

The Wolman Pebble Count (Wolman 1954; Bevenger and King 1995) samples coarse riverbed material in streams as a way of estimating riverbed texture, it is a geomorphic measurewhich is good method for identifying median bed particle size. It is a widely used method. The investigator walks in zig-zag lines* across the river segment to make a minimum of 400 measurements of pebble size in a segment. The modified Wolman Pebble Count method is an improvement on the older Wolman method where the operator picks up a particle in the river touching the end of their boot (where the operator tends to pick up larger particles and bypass fine sediment). The modified method, employed by the CDPHE (WQCC 2014) and GEI in 2019 on the LBD sites, aims to reduce errors in operator influence on particle selection by using a sampling frame in which sampling point locations are identified by cross points in the sampling frame grid. The sampling frame is a sturdy 60 by 60 cm aluminum frame that is placed in the river. The frame is placed down ten times across each river transect. After the frame is placed down, the grid points where elastic bands cris-cross within the frame are used to identify particles in the riverbed to be selected. Pebbles under grid intersections are picked up and the longest length of the particle is measured with a Gravelometer.
The Wolman Pebble Count is more meaningful when the same river segment is repeatedly measured over time and the results from one time are compared to the same segment another time.
*One improvement that could be made on the current modified Wolman method used by LBD contractors is to perform the same method along evenly spaced transects and not in a zig-zag pattern. The zig-zag approach is less randomized and allows the observer to pick and choose where they walk and where they sample.

2) Percent Embeddedness

A subset of 4-5 particles measured during the modified Wolman pebble count are used to determine percent embeddedness. Embeddedness is measured by estimating the percent of the selected particles that are buried in fine substrate. It can be used to assess fish spawning and macroinvertebrate habitat because as rocks become embedded, there are fewer living spaces available to macroinvertebrates and shelter for egg incubation. Estimates are simple and cost-effective, if backed with photographic examples used to calibrate observers between assessments. It can be estimated in any type of substrate or channel unit type (riffle, run, pool), no matter the dominant substrate type.

3) Sediment Core

A quantitative method used to assess fine sediment in trout spawning beds. Trout spawning bars identified during fish redd surveys in the previous fall are then sampled with a McNeill-Ahnell 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. It may not be possible to use the core sampler in areas where the dominant substrate is larger, like in riffles. It is a method well suited for evaluating salmonid spawning sites with the smaller substrate like pebble and gravel. Samples can be sent to a lab for dry sieve analysis with sieve sizes ranging from 75 to 0.074 mm.
A 150 ml suspended sediment sample can also be collected from the water-fine sediment mixture remaining in the core sampler, results are reported in mg/L. This provides an estimate of the fine sediments, such as silt and clay that are also within the spawning bed. The fine

particle sizes from the suspended sediment sample are included in the overall particle size distribution in each sample. This is the method that Tetra Tech had employed.

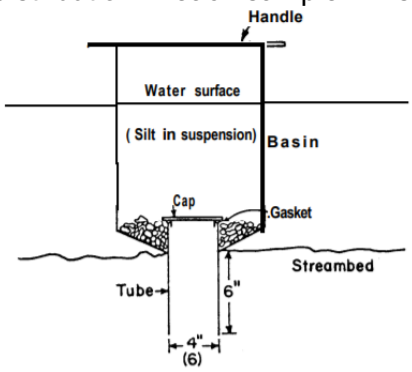


Figure 1. The original McNeil-Ahnell corer design (McNeil and Ahnell, 1964)

4) Riffle Stability Index

Estimates mobile sediment fraction in a river's riffle. It is another geomorphic measure, not a habitat measure. A river receiving excessive fine 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 of > 70 indicate a riffle that is somewhat loaded with sediment, and values >85 indicate excess sediment. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for organisms

5) Algae Presence

The presence of filamentous algae, the percent filamentous algae cover, and diatom thickness are estimated along each transect during pebble counts. The presence and percent cover are visually estimated (GEI 2019 Sediment Assessment for LBD). Algae presence will depend on the time of year that it is assessed, for instance it may be scoured and displaced in high flows and re-establish during lower flow.

6) TIVsed Score

Sediment Tolerance Indicator Value. A biological metric used by the CDPHE to estimate impacts of excess fine sediments on macroinvertebrate communities. The TIVsed illustrates a reduction in sediment sensitive taxa. It is a bioasseessment of sedimentation rate. Compares the expected condition established from reference stream sites to actual condition. The metric looks at area covered by sediment < 2mm (which is the particle size that is considered as "fines" which can clog interstitial spaces and bury habitat) LBD is already monitoring this under the macroinvertebrate monitoring program.
*In the CDPHE Policy 98-1 they note that macroinvertebrate density may be the most sensitive indicator of negative effects of sediment on insects. Density may be a better indicator than the other diversity metrics. This would support Timberline's Hess sampler-full count method and should be a metric he collects already.

7) Grid Count Method

Grid toss/ Grid counts along a transect to differentiate between fines < 2 mm and < 8 mm (Bunte et al. 2012). A plexiglass viewer with a 7 x 7 grid, with 49 intersections, is used to look at the stream bottom, the observer looks at the corners of the grid to estimate the size of the sediment at the intersections. The grids can be randomly tossed into riffles in small streams, or verified spawning beds, or along transects that are perpendicular to the shore. If using the grid along a transect, it is generally placed in 5-7 locations along the transect. The reported outcome is a percent fines or percent of the area covered in < 2 mm and < 8 mm sediment.
The CDPHE Policy 98-1 provides a narrative standard to evaluate sediment deposition in spawning beds. The standard provides a guideline of <20% of the spawning area covered in sediment < 8 mm. They employ the modified Wolman Pebble Count to do this.

8) Tracer Rocks

A representative sample of individual rocks are marked or identified in some way and monitored for movement.

9) Scour Chains

Chains are anchored and buried vertically in the riverbed at points of interest; the length of chain laying horizontally post-runoff documents depth of scour.

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Macroinvertebrate Monitoring Data Gaps Assessment and 2020 Program Proposal

The following is the Learning By Doing (LBD) Monitoring Subcommittee's (Subcommittee) data gaps assessment and proposal for 2020 macroinvertebrate monitoring within the LBD Cooperative Effort Area (CEA). The proposal includes an overview of the existing macroinvertebrate monitoring program, including Denver Water's and Northern Water Municipal Subdistrict's (Subdistrict) 2020 monitoring plans, and the Subcommittee's recommendations on 2020 monitoring needs within the CEA.

The proposed objectives of the 2020 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.

Existing Monitoring Programs

This section summarizes existing macroinvertebrates monitoring programs that will take place independently from LBD in 2020. This information is provided for context since the LBD macroinvertebrate monitoring program is intended to supplement existing monitoring efforts.

Moffat Project and Windy Gap Firming Project 401 Certification Compliance Monitoring

Denver Water and the Subdistrict are both required to conduct annual macroinvertebrate monitoring at 7 sites collectively in the LBD CEA to comply with the Moffat Project and Windy Gap Firming Project (WGFP) 401 Certifications[1,2].

Denver Water's requirements include 3 sites in the Fraser River and one site on Vasquez Creek, upstream of Winter Park.

The WGFP 401 Certification requires sampling at 3 sites on the Colorado River. In addition, the Subdistrict annually monitors a site that is not part of the 401 Certification requirements, but that was deemed important to provide contextual information for the other 3 sites. Therefore, 8 sites (Table 1) are included in the combined 2020 monitoring programs for Denver Water and the Subdistrict.

[1] Colorado Department of Public Health and Environment, Water Quality Control Division, Moffat. (2016, June). Rationale for Conditional 401 Certification of the Moffat Collection System Project. Denver, CO.

[2] Colorado Department of Public Health and Environment, Water Quality Control Division, WGFP. (2016, March). Rationale for Conditional 401 Certification of the Windy Gap Firming Project. Denver, Colorado, USA.

Table 1 - 2019 Denver Water and Northern Water Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Entity	2017 Site	Permit Required
FR-23.2	Fraser River upstream of Winter Park San District	Denver	Yes	Yes
FR-20	Fraser River at Rendezvous Bridge	Denver	Yes	Yes
FR-14	Fraser River upstream of Tabernash	Denver	Yes	Yes
VC-0	Vasquez Creek at the Town of Winter Park	Denver	No	Yes
CR-31	Colorado River upstream of Fraser and Windy Gap	Northern	Yes	Yes
CR-28.7	Colorado River downstream of Windy Gap	Northern	Yes	Yes
CR-22.9	Colorado River upstream of Hot Sulphur Springs	Northern	Yes	Yes
CR-16.7	Colorado River upstream of Williams Fork	Northern	Yes	No

Timberline Aquatics will collect samples and conduct the analyses at these 8 sites in 2020. Samples will be collected with a Hess sampler, utilizing protocols approved by the Colorado Water Quality Control Division's (Division) Section 303(d) Listing Methodology 2018 Listing Cycle. Identification and enumeration will be done for the entire sample (i.e. all macroinvertebrates in the sample are counted).

Denver Water's and Northern Water's program will include LBD's agreed upon set of metrics for macroinvertebrate monitoring, and these metrics will be calculated for each sample.

LBD Macroinvertebrate Monitoring Program

Monitoring Summary

The 2019 LBD macroinvertebrate program consisted of 15 sites; 3 sites in the Colorado River, 6 sites in the Fraser River, 2 sites in Fraser River tributaries (Ranch Creek and Saint Louis Creek) and 4 sites in Williams Fork. Monitoring was conducted at 10 of these sites in 2019. (Table 2). All the sites in the LBD program are in addition and complementary to the annual macroinvertebrate monitoring conducted by Denver Water and Northern Water (Table 1). They were selected based on one or a combination of the following criteria:

- Provide adequate spatial coverage in the CEA
- Support restoration efforts (Generally, this requires data collection pre- and post-project)
- Establish a baseline of data in areas where there are known stressors
- Maintain a baseline of data at established sites

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 as a result of varying hydrology, even at sites subject to stable watershed influences. In addition, the

LBD program includes several metrics that are considered key measurable indicators (Table 3) of macroinvertebrate health; each has a defined numeric threshold that indicates how healthy a community is.

Based on knowledge of activities in the watershed and scores of the key measurable indicators, LBD monitoring frequency is site specific based on the following guidelines:

- Sites that have good scores for the key measurable indicators and that 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 or restoration, are expected, samples should be collected annually.

Following these guidelines, six sites in the LBD program are sampled on a rotating basis every 2 - 3 years (Table 2). There are five sites in the LBD program where long-term sampling frequency has not yet been determined due to insufficient data sets and/or ongoing restoration efforts (TBD in Table 2). These sites are recommended for sampling again in 2020 in order to establish baseline conditions.

Table 2 – 2019 LBD Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Monitoring Frequency	Years Monitored			Project Specific
			2017	2018	2019	
FR-27.2	Fraser River upstream Jim Crk/Mary Jane entrance	1x/2-3 yrs		X New		No
FR-25.1	Fraser River upstream of UP Railroad discharge	Annually			X New	No
FR-TBD	Fraser River downstream of UP Railroad discharge	As needed			New	No
FR-15	Fraser River upstream of Fraser Flats restoration	Annually	X	X	X	Yes
FR-12.4	Fraser River upstream of Fraser Canyon	1x/2-3 yrs	X			No
FR-1.9	Fraser River upstream of Granby Sanitation District	1x/2-3 yrs	X		X	No
STC-0	Saint Louis Creek at Fraser River	1x/2-3 yrs		X New		No
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	X	X	X	No
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	1x/2-3 yrs*	X	X	X	No
CR-7.4	Colorado River downstream Troublesome Creek	TBD		X New	X	Yes
CR-1.7	Colorado River upstream of the Blue River	TBD		X New	X	Yes
WF-13.1	Williams Fork downstream of Henderson Mill	1x/2-3 yrs		X New		No
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	TBD		X New	X	Yes
WF-2	Williams Fork downstream of Williams Fork Reservoir	TBD		X New	X	Yes
WF-0.5	Williams Fork downstream of Williams Fork Reservoir at Kemp Breeze	TBD			X New	Yes

**Site will be sampled annually during the ILVK restoration project*

Metrics and Results

The LBD macroinvertebrate data is assessed by looking at a set of 13 metrics or biological indicators (Table 3). Together, these metrics provide the information needed to best meet the objectives of the program. Five of the 13 metrics are considered key measurable indicators; these have vetted thresholds that demonstrate whether the community is healthy or stressed.

Table 3 - 2019 Macroinvertebrate Metrics

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**

The metrics include Colorado's Multi-Metrix Index (MMI) which is a Colorado specific tool developed by the Colorado Water Quality Control Division for quantitative bioassessments. The MMI is computed based on macroinvertebrate data and then used to characterize the aquatic health of stream. The MMI assessment relies on numeric thresholds to provide "predictable, transparent, and understandable techniques" to assess attainment of aquatic life uses in streams. The attainment

thresholds for MMI scores are shown in (Table 4). Thresholds are noted for MMI v3, applicable prior to 2018, and MMI v4, currently applicable. MMI v4 relies on an updated model to conduct the assessment. Since a different assessment tool is used and different thresholds apply, the MMI scores from v3 and v4 are ***not*** comparable. MMI v4 scores are used for assessment purposes; MMI v3 scores are provided for reference and comparability to historic MMI scores.

Table 4 - MMI v3 and MMI v4 Thresholds

	MMI v3 Biotype 1	MMI v4 Biotype 1
Attainment	52.0 - 100.0	45.3 - 100.0
Grey Zone	42.0 - 52.0	33.7 - 45.2
Impaired	0.0 - 41.9	0.0 - 33.6

All sites except FR-27.2 are classified as Biotype 1, Transition Streams, with MMI impairment thresholds shown in Table 4. FR-27.2 is classified as Biotype 2, Mountains Streams, with an attainment threshold in v4 of 48 and an impairment threshold of 40. MMI scores that fall between attainment and impairment are in the 'grey zone', warranting further investigation, and typically result in the site being place on the Monitoring & Evaluation List. Table 5 summarizes MMI scores for all sites in the CEA (LBD, Denver Water and Northern Water).

Table 5 – Macroinvertebrate MMI Scores at all sites in CEA

River Mile ID	Station Description	Entity	2017 MMI v3	2018 MMI v3	2018 MMI v4	2019 MMI v4
FR-27.2	Fraser River upstream Jim Crk/Mary Jane entrance	LBD	--	54.1	74.5	--
FR-25.1	Fraser River upstream of UP Railroad discharge	LBD	--	--	--	64.5
FR-23.2	Fraser River upstream of Winter Park San District	DW	32.9	40.5	49.8	51.7
FR-20	Fraser River at Rendezvous Bridge	DW	35.2	38.6	42	54.9
FR-15	Fraser River upstream of Fraser Flats restoration	LBD	48	54.8	67.8	70.1
FR-14	Fraser River upstream of Tabernash	DW	65.4	68.1	79.7	70.2
FR-12.4	Fraser River upstream of Fraser Canyon	LBD	69.1	--	--	--
FR-1.9	Fraser River upstream of Granby Sanitation District	LBD	86.9	--	--	85.4
VC-0	Vasquez Creek at the town of Winter Park	DW	--	59.6	55.1	59.1
STC-0	Saint Louis Creek at Fraser River	LBD	--	67.4	66.5	--
RC-1.1	Ranch Creek downstream of Meadow Creek	LBD	58.9	70.3	76.8	79.9
CR-31	Colorado River upstream of Fraser and Windy Gap	NW	66.6	70.2	73.9	62.3
CR-28.7	Colorado River downstream of Windy Gap	NW	74.6	72.3	80.4	65.4
CR-22.9	Colorado River upstream of Hot Sulphur Springs	NW	77.7	64.6	75.4	70.6
CR-16.7	Colorado River upstream of Williams Fork	NW	78.8	72.7	78.6	76.6
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	LBD	73.2	72.3	79.5	73.2
CR-7.4	Colorado River downstream of Troublesome Creek	LBD/ILVK	--	75.2	86.2	78.1
CR-1.7	Colorado River upstream of the Blue River	LBD/ILVK	--	50.2	43.2	66.7
WF-13.1	Williams Fork downstream of Henderson Mill	LBD	--	54.1	75.4	--
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	LBD	--	51.4	63.5	80.0
WF-2	Williams Fork downstream of Williams Fork Reservoir	LBD	--	13.7	44.2	47.9
WF-0.5	Williams Fork downstream WF Res at Kemp Breeze	LBD	--	--	--	46.0

MMI Score legend: Green = attainment, Grey = M&E Listing, Red = non-attainment/303-d listing

Monitoring Subcommittee Recommendations for 2020 Monitoring

2020 Monitoring Recommendations for Existing Sites

The Subcommittee's recommendations for monitoring at the LBD sites are:

- FR-27.2 – No monitoring in 2020. Maintain frequency to every 2 – 3 years. This segment was previously on the 303d list of impaired waters for aquatic life use (macroinvertebrates) but was proposed to be removed in 2020.

- FR-25.1 – Continue annual monitoring. There are known water quality issues related to the unauthorized discharges from Union Pacific Railroad (UPRR); the effect this has on the macroinvertebrate community is unknown. Annual sampling at this site will establish a baseline of data which can be used to compare to conditions downstream or in cases of unauthorized discharges.

- FR-TBD – Maintain as a placeholder for an emergency sampling event to be collected in case of a spill or unauthorized discharge event by UPRR. Funding should be set aside so that sampling can be done in a timely matter if needed.

- FR-15 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the Fraser Flats Restoration Project.

- FR-12.4 – Maintain frequency to every 2 – 3 years. Monitoring to occur in 2020 since 2017 was the last time data were collected.

- FR-1.9 – No monitoring in 2020. Maintain monitoring frequency every 2 – 3 years.

- RC-1.1 – Continue annual monitoring. Although the MMI scores have shown attainment from 2011-2018, this site is subject to thermal stressors and annual monitoring is recommended.

- STC-0 – No monitoring in 2020. Maintain monitoring frequency every 2 – 3 years.

- CR-9.1 – Since this site is upstream of the ILVK restoration project, annual monitoring is recommended until the project and post-project assessment period is complete. Recommended monitoring frequency at this site is every 2 – 3 years after restoration is completed.

- CR-7.4 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the ILVK restoration efforts.

- CR-1.7 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the ILVK restoration efforts. In addition, MMI scores from 2018 were in the grey zone.

- WF-13.1 – No monitoring in 2020. Maintain monitoring frequency every 2 – 3 years.

- WF-5.5 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the Denver Water restoration efforts. Frequency to be determined after restoration is completed and there are more data to establish a baseline.

- WF-2 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the Denver Water restoration efforts. Frequency to be determined after restoration is completed and there are more data to establish a baseline.

- WF-0.5 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the Denver Water restoration efforts. Frequency to be determined after restoration is completed and there are more data to establish a baseline.

2020 Proposed New Sampling Sites

Colorado River downstream of Lone Buck – This recommendation is to address concerns raised specifically regarding macroinvertebrate populations in a section of the river adjacent to private property directly downstream of the Lone Buck campground. It is recommended that sampling occur within the property boundaries if access is permitted. If not, it is recommended that sampling occur directly upstream of the property boundary by Lone Buck. It is also recommended that LBD ask the property owner to share the cost of this effort since they raised the concern and the area is not publicly accessible, which is out of scope for LBD priority reaches. Note: Northern Water has collected macroinvertebrate samples at a location just downstream of property boundaries. Data collected at this site indicate a healthy bug community.

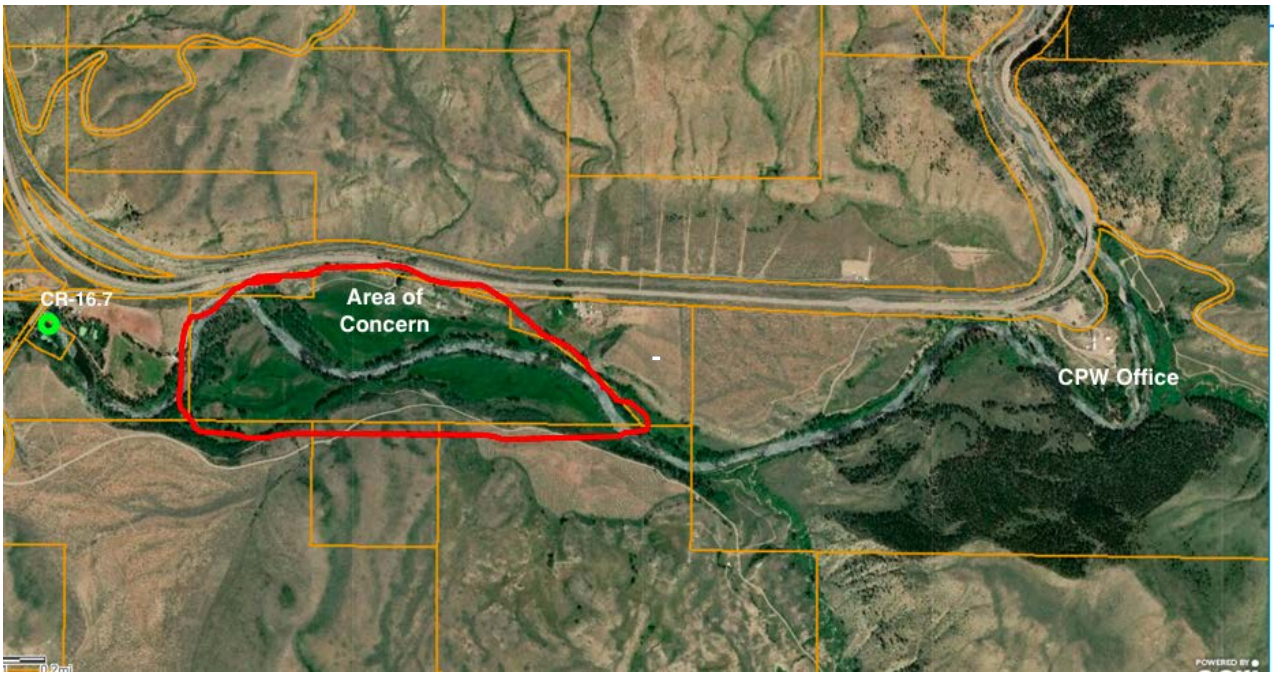

Figure 1 - Map of proposed macroinvertebrate monitoring site downstream of Lone Buck

Summary of 2020 Proposed Sampling Sites

The Monitoring Subcommittee recommends macroinvertebrate monitoring at 11 sites in 2020, including 1 new monitoring location (Table 6). In addition, an allocation of emergency funds is recommended in the event of an unauthorized discharge event at the UPRR Moffat Tunnel discharge. Monitoring in 2020 is not recommended at four sites in the monitoring program as the monitoring frequency at these sites is every 2-3 years. A cost share with various partners is requested at 6 sites.

Table 6 - Proposed 2020 macroinvertebrate monitoring sites

River Mile ID	Station Description	Proposed for 2020	New Site	Entity	LBD Cost**
FR-27.2	Fraser River upstream Jim Creek/Mary Jane entrance			LBD	--
FR-25.1	Fraser River upstream of UP Railroad discharge	X		LBD	$1,900
FR-TBD	Fraser River downstream of UP Railroad discharge	X*		LBD	NA
FR-15	Fraser River upstream of Fraser Flats restoration	X		LBD	$1,900
FR-12.4	Fraser River upstream of Fraser Canyon	X		LBD	$1,900
FR-1.9	Fraser River upstream of Granby Sanitation District			LBD	--
STC-0	Saint Louis Creek at Fraser River			LBD	--
RC-1.1	Ranch Creek downstream of Meadow Creek	X		LBD	$1,900
CR-TBD	Colorado River downstream of Lone Buck	X	X	LBD/Stark?	$950
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	X		LBD	$1,900
CR-7.4	Colorado River downstream Troublesome Creek	X		LBD/ILVK	$950
CR-1.7	Colorado River upstream of the Blue River	X		LBD/ILVK	$950
WF-13.1	Williams Fork downstream of Henderson Mill			LBD	$1,900
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	X		LBD/DW	$950
WF-2	Williams Fork downstream of Williams Fork Reservoir	X		LBD/DW	$950
WF-0.5	Williams Fork downstream of Williams Fork Reservoir at Kemp Breeze	X		LBD/DW	$950
				LBD TOTAL	**$17,100**

**Sample collected only in the event of an unauthorized discharge from UPRR. This site was added to the program in 2019 but monitoring was not needed. Therefore, 2019 funding can be used if monitoring is needed in 2020. The cost of this event may be less than $1,900 if a different entity (such as GCWIN) collects the sample.*
***Costs are estimated based on 2019*

Sample Collection, Analysis and Metrics

The monitoring subcommittee recommends that sample collection, analysis and metrics remain the same as 2019. The following established guidelines will be adhered to:

- Sampling will occur 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[3].

[3] Colorado Department of Public Health and Environment. (2010). Aquatic life use attainment: Methodology to determine use attainment for rivers and streams. Policy Statement 10-1.

- Timberline Aquatics will collect the samples utilizing protocols approved by the Division's Section *303(d) Listing Methodology 2018 Listing Cycle*. Three quantifiable Hess samples will be taken from riffle habitat at each of the sites.

- Timberline Aquatics will perform the macroinvertebrate analysis for all samples. Identification and enumeration will be done for the entire sample (i.e. all macroinvertebrates in the sample are counted). Macroinvertebrates are identified to the lowest practical taxonomic level.