

Learning By Doing  
2019 Aquatic  
Resource Monitoring  
Plan



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## Aquatic Resource Monitoring Plan Overview

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The cooperating 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 Committee, May 1, 2019) The Plan is applicable to the Cooperative Effort Area (the Colorado, Fraser and Williams Fork River basins, upstream of the Colorado River confluence with the Blue River) or CEA.

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 with focus on monitoring aquatic health over the entire CEA or can be focused in effort to track 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 2019 Plan are to:

- Compile and summarize existing monitoring activities;
- Maintain a comprehensive temperature monitoring network;
- Assess sediment and characterize bed particles size distribution;
- Assess the state of macroinvertebrate communities;
- 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;
- Assess the state of the fisheries;
- Support restoration efforts on the Colorado River by Irrigators Living in the Vicinity of Kremmling (ILVK);
- Document riparian vegetation monitoring in the CEA;
- Document assessment of aquatic life habitat surrounding Windy Gap Reservoir related to construction of the connectivity channel.

A detailed sampling plan for each objective follows.

## Summary of Existing Monitoring Efforts

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A summary of all monitoring efforts conducted within the CEA is compiled annually. The summary is based on actual sampling that occurred in the previous year by various entities. LBD's monitoring is intended to complement existing monitoring efforts in the CEA; the summary is used to inform LBDs 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 (CDPHE)
- 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 an 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 CEA boundary line, which is the confluence with the Blue River. The river miles increase at upstream sites. For example, the river mile ID for the Colorado River 10 miles upstream of the boundary of the CEA is CR-10.



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

Table 1 - River Mile Abbreviations

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

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

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

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

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

The monitoring summary includes four parts:

1. Maps – The map shows the sites in the geographic section 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. Parameter 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.

## 2018 Monitoring Summary

In 2018, monitoring was conducted at 220 entity specific sampling locations by 11 different entities. After assigning river mile IDs and grouping the sites accordingly, there were 113 sampling locations with unique river mile IDs. A complete list of the 2018 sites with river mile ID and the corresponding Entity ID is found in Appendix A – 2018 Monitoring Sites with River Mile and Entity Station Name.

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. For 2018, these assumptions include:

- Denver Water collects quarterly and bi-annual samples at several sites. The quarterly samples were put into the matrix in January, April, July and October. The biannual sampling was put into the matrix in June and September.
- CPW collects fish data bi-annually and annually. The bi-annual sampling was put into the matrix in April and September; the annual in September.
- CPW monitoring was based on input from CPW, Fish Survey Reports and the Colorado River Ecology and Water Project Mitigation Investigations annual report for 2018.
- Information on monitoring efforts was not obtained from BLM. Monitoring done at sites in previous years was assumed to be continued in 2018. This includes monitoring at RDC-0.7 and WF-13.1.

The amount of information compiled in the monitoring summary is extensive and relies on multiple sources. While putting the monitoring summary together each year, it is important to document changes, errors and issues that may occur from year to year. For the 2018 monitoring summary, the following were noted:

- Tetra Tech has collected data in support of Grand County's Stream Management Plan since 2009. In 2018, they were tasked with converting site IDs in their historic data set to the corresponding river mile ID used by LBD. While updating the Tetra Tech substrate sampling sites in the monitoring summary, it was discovered that Tetra Tech likely did their river mile conversion using different methodology than what was used by LBD and is included in the monitoring summary. This resulted in a slightly different river mile measurement for some sites included in the Tetra Tech reports compared to the sites in the LBD monitoring summary. The following sites are those known to have discrepancies in the river mile IDs:
  - Tetra Tech CR-9.6 is CR 9.3 using LBD methodology. This site was combined with site CR-9.1 which is where historic substrate monitoring has been conducted.
  - Tetra Tech CR-15.5 is CR 15 using LBD methodology. This site was combined with CR-14.9 which is where historic substrate monitoring has been conducted.
  - Tetra Tech CR-22.3 is CR 21.9 using LBD methodology. This is an existing substrate site.

- There was a mistake in the river mile ID assignment for macro and substrate monitoring near Hot Sulphur Springs in the 2017 monitoring summary. In the 2018 ARMP, the 2018 and 2019 macroinvertebrate and substrate proposals, and other documents, the site was listed as CR-22.9; it should have been CR-22.1. Flow, temperature, substrate and macroinvertebrate monitoring are all done in close proximity of one another but there is enough distance in between monitoring locations to warrant different river mile IDs. The river IDs were updated to reflect this in the 2018 monitoring summary and are listed below:
  - CR-22.1 – Location for macroinvertebrate and substrate sampling located at Hot Sulphur Springs, south of Pioneer Park.
  - CR-22.7 – Location of temperature site, just upstream of Hot Sulphur Springs at the water treatment plant intake.
  - CR-23.5 – Location of the flow gage, upstream of Hot Sulphur and the water treatment plant intake.
- An error was found in the 2017 monitoring summary and 2018 ARMP in the Fraser River basin. The macroinvertebrate and substrate sampling at Fraser River upstream of the Winter Park Sanitation District was listed using river mile ID FR-23.2. The correct river mile ID is FR-23.4. FR-23.2 is the site located just downstream of the Winter Park Sanitation District.

One of the goals of the monitoring summary is to see where monitoring overlaps and try to streamline efforts. In 2018, there were 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. The USGS is in the process of relocating their site due to beaver activity in the area.
- FR-24 – Both the EGWOB and Denver Water collect water quality samples at this location.

The complete 2018 monitoring summary is found in Appendix B – 2018 Monitoring Summary.

## 2019 Stream Temperature Monitoring Plan

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Stream temperatures 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. 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 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 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 locations in the CEA (one location is monitored by two entities). 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 2018 monitoring sites is shown in Figure 1 and details of the program are included in the 2018 Monitoring Summary in Appendix B – 2018 Monitoring Summary.



- [CR-2.3 \(Colorado River above Hwy 9 Bridge in Kremmling\)](#) - This site has been monitored by the BLM since 2006. It is of particular importance because it is the last stream temperature sensor within the CEA and shows the degree of warming on the Colorado River between the confluence of the Williams Fork and the Blue River. Thus, the BLM will download and deliver stream temperature data on a weekly basis, when conditions allow, and deliver it to the LBD Operations Subcommittee from June through September to support operations and decision making.

This site is maintained by BLM in collaboration with GCWIN and LBD. Beginning in 2019, the BLM made adjustments to the station installation in order to remain consistent with GCWIN stream temperature data collection and guidance provided by the Colorado Water Quality Control Division, [Standard Operating Procedures for the Collection of Stream Water Temperatures Utilizing the Deployment of Temperature Data Loggers](#).

#### *Review of Baseline Data Needs*

An assessment was done on data collected at two sites located very close to each other (0.4 river miles apart) downstream of the Fraser Flats River Habitat Project. One site, FR-14, is maintained by the USGS and has a long period of record. The other site, FR-14.4, is maintained by GCWIN and was installed directly downstream of Fraser Flats specifically for pre- and post-restoration project temperature data collection. The purpose of the assessment was to see if the difference in temperature regimes at the sites justified keeping both in the program.

The analysis showed that differences in the temperature regime were significant enough to maintain the two monitoring locations. Additionally, since FR-14.4 was installed specifically to look at changes from the restoration project, it is important to maintain a consistent data set that does not introduce fluctuations in temperature unrelated to the project. Therefore, the LBD Management Committee opted to maintain data collection at both FR-14 and FR-14.4.

### **2019 LBD Temperature Monitoring**

After reviewing the existing monitoring network, adjusting the frequency at select locations, and reviewing data at locations where there may be redundant data collection, the 2019 LBD temperature monitoring program consists of 9 sites (Table 2 and Figure 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 6 sites, data are download biweekly from April – October and the data are compiled and shared at the end of the monitoring season.

Table 2 – 2019 LBD Temperature Monitoring Sites

River Mile ID	Station Description	Latitude	Longitude	Download Frequency
CR-2.3	Colorado River upstream Hwy 9 Bridge in Kremmling	40.0421	-106.3714	Weekly (Jun - Sep)
STC-0	St Louis Creek above confluence with Fraser River	39.95175	-105.81471	Weekly (Jun - Sep)
STC-5.4	St Louis Creek at Fraser Experimental Forest HQ	39.907710	-105.87951	Bi-weekly
FR-15	Fraser River upstream Fraser Flats River Habitat Project	39.981338	-105.82494	Bi-weekly
FR-14.4	Fraser River downstream 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
WF-5.5	Williams Fork upstream Williams Fork Reservoir	39.999510	-106.17946	Bi-weekly



Figure 2 - Map 2019 LBD Temperature Monitoring Sites



## Station Operation, Maintenance and Data Delivery

Except for CR-2.4, GCWIN maintains all the stations in the LBD temperature monitoring program. CR-2.4 is maintained by the BLM in cooperation with GCWIN and LBD.

### *Station Operation*

Stream temperature monitoring follows guidelines set forth in the SOP, 2019 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 brief 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 must also be set to record temperature in °C as well as recording 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, QA/QC, storage, and distribution of temperature data. GCWIN's Executive Director will conduct final QA/QC on all stream temperature data. Sites with weekly downloads will have data delivered to the Learning By Doing Operations Subcommittee in an agreed upon timeframe to support timely decision making regarding environmental water releases. The final stream temperature data will be provided to Learning By Doing in an Excel spreadsheet by December 1, 2019. The data will also be stored in GCWIN's database, which is publicly accessible.

## Funding

Costs for the 2019 temperature monitoring will be shared among some LBD partners. The partners each pay a percentage of the total cost. The cost distribution for 2019 is:

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

## 2019 Sediment Monitoring Plan

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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 outcomes 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 2019 Sediment Monitoring Plan within CEA. The objectives of the 2019 LBD sediment monitoring program are to:

- Analyze riverbed substrate for aquatic habitat quality;
- Measure sediment composition including percent fines, percent algal cover, percent embeddedness, and riffle stability index;
- Assess compliance with Colorado's narrative sediment standards.

### 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 is being changed to "sediment" sampling in order to be consistent with 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*. Substrate, or sediment, sampling has historically consisted of core sampling and pebble counts associated with fish spawning habitats, pebble counts associated with macroinvertebrate habitat, and Riffle Stability Index (RSI) measurements.

Core sampling is used to measure particle size distributions, particularly percent fines. 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.

Pebble counts are a rapid method used to document the cumulative distribution of grain sizes and the degree of embeddedness. Pebble counts are also used to assess salmonid spawning bars and macroinvertebrate habitats by utilizing the Sediment Tolerance

Indicator Value (TIV<sub>SED</sub>) 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 can be estimated concurrent with pebble counts.

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.

In 2018, the Colorado River was anticipated to contain 80% of average flows, so core samples were collected on the Colorado for the first time in several years at three sites in the CR4, CR5, and CR6 reaches (Table 3). Core samples were not collected on the Fraser River and Ranch Creek since both streams were expected to exceed flushing flow recommendations during runoff. Pebble counts were conducted at the three core sample sites for assessment of spawning habitat.

Table 3 – 2018 LBD Core Sampling Reaches

Reach Designation	River Mile ID	Site Name	Site Description
CR4	CR-21.9	CR at Park	Colorado River at Pioneer Park
CR5	CR-14.9	CR blw WF	Colorado River Downstream of Williams Fork confluence and Parshall
CR6	CR-9.1	CR blw KB Ditch	Colorado River Downstream of KB Ditch

In 2018, pebble counts were also collected to accompany select macroinvertebrate sampling sites. These sites are shown in Table 4.

Table 4 – 2018 LBD Pebble Count Sites Associated with Macroinvertebrate Sites

River Mile ID	Station Description
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane Entrance
FR-23.4	Fraser River upstream of Winter Park Sanitation District
FR-20	Fraser River at Rendezvous Bridge
FR-15	Fraser River LBD Restoration Project, Upstream End
FR-14	Fraser River upstream of Tabernash below CR83 bridge
RC-1.1	Ranch Creek downstream of Meadow Creek
STC-0	Saint Louis Creek upstream of confluence with Fraser River
CR-31	Colorado River upstream from Windy Gap
CR-28.7	Colorado River downstream of Windy Gap
CR-22.9	Colorado River at Pioneer Park upstream Hot Sulphur Springs
CR-16.7	Colorado River upstream of Williams Fork
CR-9.1	Colorado River at CR39 Bridge at KB Ditch
CR-7.4	Colorado River downstream of Troublesome Creek
CR-1.7	Colorado River upstream of the Blue

## 2019 Changes to Sediment Monitoring Plan

Over the years since the Grand County Stream Management Plan was published in 2010, effective spawning and limited funding have resulted in a shift away from spawning habitats and the more labor-intensive core sampling, and toward the more rapid pebble count evaluations that can be paired with macroinvertebrate analysis. In 2019, pebble counts were only collected at macroinvertebrate sites. Because sediment sites are paired with macroinvertebrate sites, see 2019 Changes to Macroinvertebrate Monitoring Plan for the reasoning behind the following sediment site changes.

In 2019 the following changes were made:

- A new site was added on the Fraser River upstream of Union Pacific's Moffat Tunnel discharge, FR-25.1.
- Fraser River upstream of Jim Creek and Mary Jane entrance (FR-27.2) was not sampled, it is sampled on a 2-3 year basis.
- Saint Louis Creek upstream of the confluence with the Fraser River (STC-0) was not sampled, it is sampled on a 2-3 year basis.
- Fraser River upstream of Granby Sanitation District, FR-1.9, was sampled in 2019. This site is sampled on a 2-3 year basis and samples were last collected in 2017.

## 2019 LBD Sediment Monitoring

The 2019 LBD sediment monitoring program consists of 18 sites (which includes the core sampling sites on the Colorado River); 9 sites in the Colorado River, 7 sites in the Fraser River, and 2 sites in Fraser River tributaries (Ranch Creek and Saint Louis Creek). The monitoring frequency for pebble counts is paired with macroinvertebrate sampling; it 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.

After adjusting the frequency of monitoring at select locations and the addition of new sites, sediment sampling will be conducted at 14 out of the 18 LBD sites in 2019. The locations of the 2019 sampling sites are shown in Table 5 and mapped in Figure 3. The locations of the new sites are approximate; the exact location will be determined at the time of sampling and will be based on where representative samples can be collected. Sampling is conducted in the fall within 2 weeks of the macroinvertebrate bioassessments.

Table 5 – 2019 LBD Pebble Count Sites Associated with Macroinvertebrate Sites

Station ID	Station Description	Latitude	Longitude	New Site?
FR-25.1	Fraser River upstream of UP Moffat Tunnel discharge	39.8775	-105.7535	Yes
FR-23.4	Fraser River upstream of Winter Park Sanitation	39.8945	-105.7682	No
FR-20	Fraser River at Rendezvous Bridge	39.9341	-105.7896	No
FR-15	Fraser River upstream of Fraser Flats restoration	39.9813	-105.8249	No
FR-14	Fraser River upstream of Tabernash	39.9905	-105.8299	No
FR-1.9	Fraser River upstream of Granby Sanitation District	40.0845	-105.954	Yes
RC-1.1	Ranch Creek downstream of Meadow Creek	39.9991	-105.8275	No
CR-31	Colorado River upstream of Fraser and Windy Gap	40.1005	-105.9725	No
CR-28.7	Colorado River downstream of Windy Gap	40.1083	-106.0036	No
CR-22.9	Colorado River upstream of Hot Sulphur Springs	40.0803	-106.0986	No
CR-16.7	Colorado River upstream of Williams Fork	40.0503	-106.1725	No
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	40.0537	-106.2894	No
CR-7.4	Colorado River downstream of Troublesome Creek	40.0509	-106.3112	No
CR-1.7	Colorado River upstream of Blue River	40.0465	-106.3730	No

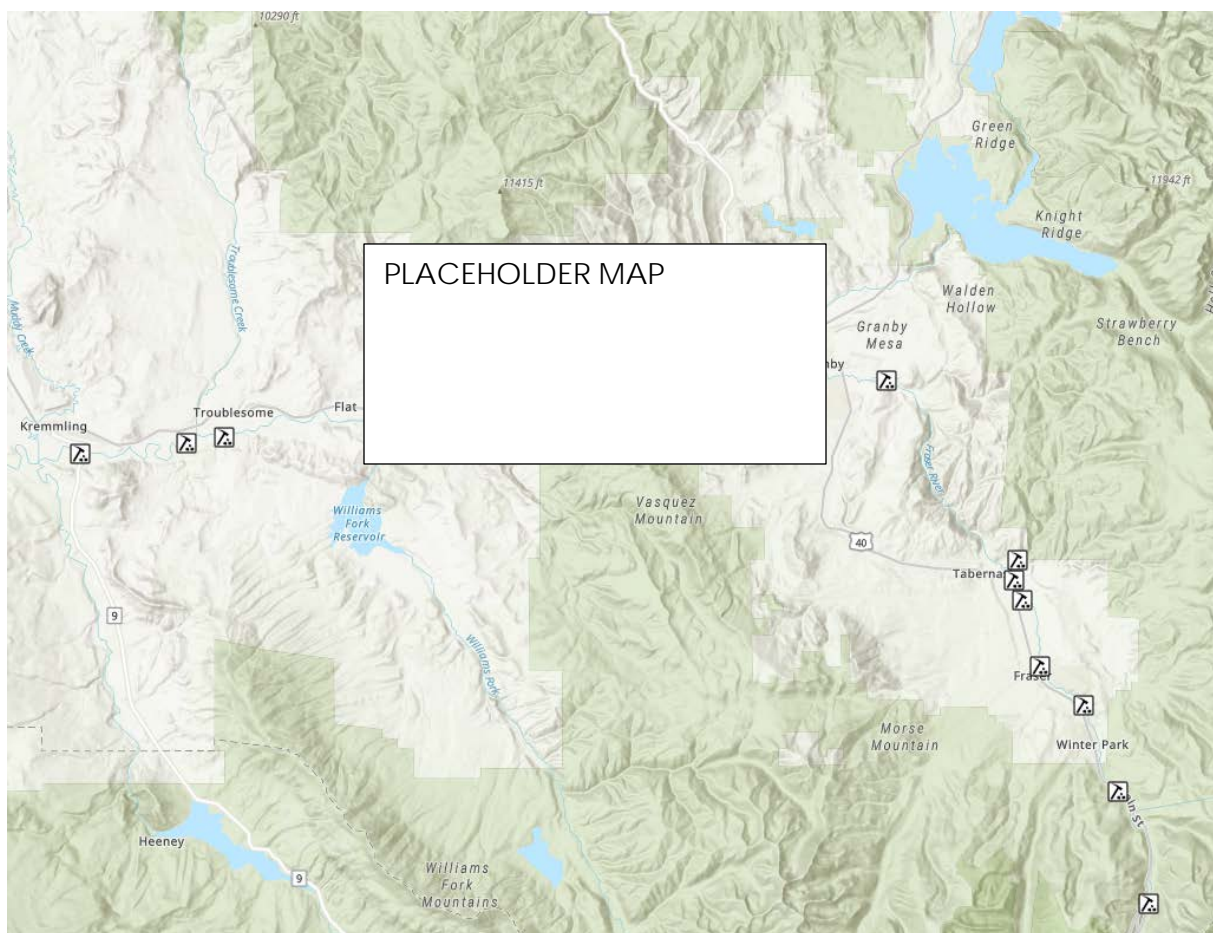


Figure 3 - Map of 2019 LBD Sediment Monitoring Sites

## Sampling Methodology

The following is reproduced from GEI Consultants 2019 Scope of Work for LBD. (GEI Consultants, 2019)

“Sediment conditions at fourteen sampling sites (Table 5) [were] determined based on pebble counts, percent fines, percent embeddedness, the riffle stability index, and percent algal cover. These are discussed individually below.”

“Pebble counts and percent fines: Bed substrate [were] measured using the sampling grid method required by Colorado WQCD Policy 98-1. The sampling grid (60 × 60 centimeter grid with at least four intersections) method required by Policy 98-1 involves sampling the entire unit within its bankfull width. However, this method requires the establishment of ten evenly spaced transects, based on bankfull width, throughout the reach and the selection of four particles (designated by a grid thrown on the substrate) at ten evenly-spaced points along the transect. Each of the 400 selected particles is measured using a gravelometer.”

“This method provides a means for measuring the cumulative distribution of grain sizes within an area of interest in a stream. Data collected with this method can also be used to address questions related to biological integrity such as the Sediment Tolerance Indicator Value (TIVSED) for macroinvertebrates or salmonid spawning habitat assessment.”

“Percent algal cover: The percent algal cover in riffles can be determined concurrent with the pebble counts. A viewing bucket, a bucket with a clear bottom and intersection markings, can be used to estimate algal cover over a small area by determining the percentage of grid intersections where algae is present. The Colorado Water Quality Control Division Standard Operating Procedures for the Collection of Stream Periphyton Samples (WQCD SOP) is similarly based on a transect approach for hard-bottom streams where algal biomass samples are collected from 25%, 50%, and 75% of the wetted transect width. Combined with the grid-based pebble count method, an appropriate number of measurements can be used to infer the amount of algal coverage throughout a site. To maintain consistency with the pebble count method and the WQCD SOP, GEI recommends measuring algal cover at three points across each of the ten transects (30 viewing bucket measurements). Concurrent with the algal cover measurements, assessments of diatom or filamentous algae presence and categorical rankings of algal thickness [were] visually estimated. This approach will provide estimates of percent algal cover (diatom or filamentous algae) and the thickness of the periphytic growth (Stevenson and Bahls 1999).”

“Percent Embeddedness: Although embeddedness has several different definitions, it is commonly accepted to be the percentage of the height of coarse particles

(such as cobbles) that is surrounded by fine substrate. There are also several different methods of estimating embeddedness, some of these methods are visual and some involve measurements. Because the grid-based pebble counts required by Policy 98-1 involve picking up 400 particles from 10 transects, a subset of these can be assessed for embeddedness. If a large gravel or cobble particle is selected during the pebble count, it will be removed from the substrate by grasping it at the surface of the fine sediment, to mark the height to which it was buried. This height will be divided by the total particle height for a measure of percent embeddedness. U.S. Geological Survey methods require a minimum of five particles selected from three transects (Fitzpatrick et al. 1998). We propose to select a minimum of five large gravel or cobble-sized particle per transect. This will allow a quantitative estimate of percent embeddedness with a minimum amount of additional effort.”

“Embeddedness measurements should be adapted from the proposed methods if embeddedness data already exist. Because of the differences in measurement techniques, estimates do not compare well if data [were] collected using different methods (Sylte and Fischenich 2003). In the case that current data exist, GEI would use the previously adopted measurement methodology in the interest of data continuity.”

“Riffle stability index (Kappesser 2002): This metric can be used to indicate excess sedimentation in riffles. It is calculated by measuring the median axis of approximately 30 of the largest, recently deposited particles on a stable bar near the riffle of interest and calculating their geometric mean. This geometric mean represents the largest particles expected to be in the riffle. The geometric mean is compared to the cumulative distribution of particle sizes from a Wolman pebble count, to determine the proportion of particles in the riffle that are smaller than the representative large particles. A higher value indicates the presence of more fine sediment, and the riffle stability index can be compared between sites to determine relative rates of sedimentation.”

### ***Data Reporting***

Data analysis will be completed by the end of 2019, and a final report will be provided to LBD in a final report in early 2020.



## Funding

Costs for the 2019 sediment monitoring were shared among some LBD partners. The partners have agreed to pay a percentage of the total monitoring cost based on the following allocation:

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

In addition, ILVK funded 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 LBD partners at their respective contribution percentage.

## 2019 Macroinvertebrate Monitoring Plan

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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 and 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 2019 Macroinvertebrate Monitoring Plan within the CEA. The objectives of the 2019 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, three locations are monitored by two entities. Denver Water, CPW, LBD, and Northern Water are the entities responsible for these monitoring efforts. A map of the 2018 monitoring sites is shown in Figure 4 and details of the program are included in the 2018 Monitoring Summary in Appendix B – 2018 Monitoring Summary.

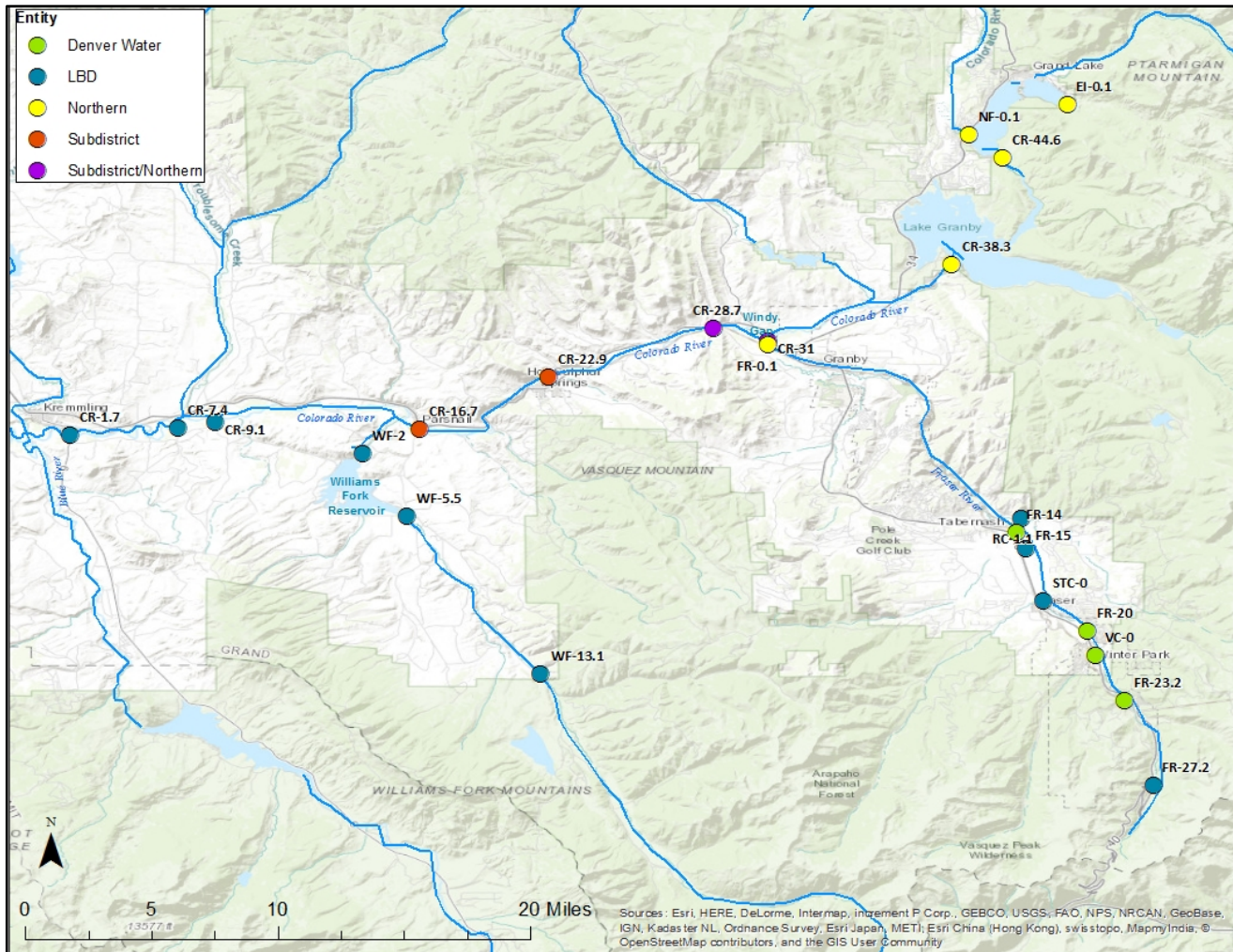


Figure 4 - 2018 Macroinvertebrate Monitoring Locations – CPW Sites not included on the map

### *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	Years Monitored		
				2017	2018	2019
FR-23.2	Fraser River upstream of Winter Park San District	Denver Water	Yes	X	X	X
FR-20	Fraser River at Rendezvous Bridge	Denver Water	Yes	X	X	X
FR-14	Fraser River upstream of Tabernash	Denver Water	Yes	X	X	X
VC-0	Vasquez Creek at the Town of Winter Park	Denver Water	Yes		X	X
CR-31	Colorado River upstream of Fraser and Windy Gap	Subdistrict	Yes	X	X	X
CR-28.7	Colorado River downstream of Windy Gap	Subdistrict	Yes	X	X	X
CR-22.9	Colorado River upstream of Hot Sulfur Springs	Subdistrict	Yes	X	X	X
CR-16.7	Colorado River upstream of Williams Fork	Subdistrict	No	X	X	X

#### *Northern Water's Baseline Macroinvertebrate Monitoring*

In addition to the annual macroinvertebrate monitoring the Subdistrict does 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 2019.

### **2019 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.

In 2019, there were several changes made to the LBD monitoring sites and sampling frequency.

#### *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 (Table 9) of macroinvertebrate health; each has a defined numeric threshold that indicates the level of health of a community.

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

Based on the criteria for determining sampling frequency, the frequency was determined to be one time every 2-3 years at three sites:

1. FR-27.2 – This site was added in 2018 to expand data collection into Segment COUCUC10a\_C, Fraser River tributaries at and above Jim Creek. This segment is on the 303(d) list of impaired waters for aquatic life use (macroinvertebrates). MMI scores for data collected in 2018 showed attainment and there are no known disturbances in the area. The monitoring frequency for this site will be every 2–3 years.
2. STC-0 – This site was added to the program in 2018 to obtain a baseline of data on Saint Louis Creek. MMI scores for data collected in 2018 showed attainment and there are no known disturbances in the area. The monitoring frequency for this site will be every 2–3 years.
3. WF-13.1 – This site was added in 2018 to collect a baseline of data downstream of the Henderson Mill. MMI scores for data collected in 2018 showed attainment and there are no known disturbances in the area. The monitoring frequency for this site will be every 2–3 years.

### *New Monitoring Sites*

After reviewing the spatial distribution of site locations and areas of known watershed disturbances, three sites were added to the 2019 LBD macroinvertebrate sampling program:

1. FR-25.1, Fraser River upstream of the UP Moffat Tunnel discharge – There are known water quality issues related to the unauthorized discharges from Union Pacific Railroad (UPRR). The effect of this on the macroinvertebrate community is unknown. This site was added to establish baseline conditions directly upstream of the UPRR discharge point. Data from this location can be compared to data downstream in cases of unauthorized discharges.
2. FR-TBD, Fraser River downstream of UP Moffat Tunnel discharge – This site was added as a placeholder for an emergency sampling event collected in case of a spill or unauthorized discharge event by UPRR. Funding is reserved for the emergency event so that sampling can be done in a timely matter if needed.
3. WF-0.5, Williams Fork at Kemp Breeze, upstream of the confluence of the Colorado River – This site is near a Denver Water restoration project. Data collected in 2019 will represent pre-project conditions. Data collection in subsequent years will represent post-project conditions.

### **2019 LBD Macroinvertebrate Monitoring**

The 2019 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. 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.

After adjusting the frequency of monitoring at select locations and the addition of new sites, macroinvertebrate sampling will be conducted at 10 out of the 15 LBD sites in 2019. The locations of the 2019 sampling sites are shown in Table 7 and mapped in Figure 4. The locations of the new sites are approximate; the exact location will be determined at the time of sampling and will be based on where representative samples can be collected. 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 - 2019 LBD Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Latitude	Longitude	New Site
FR-25.1	Fraser River upstream of UP Moffat Tunnel discharge	39.8775	-105.7535	Yes
FR-15	Fraser River upstream of Fraser Flats restoration	39.9813	-105.8249	No
FR 1.9	Fraser River upstream of Granby Sanitation District	40.0845	-105.9546	No
RC-1.1	Ranch Creek downstream of Meadow Creek	39.9991	-105.8275	No
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	40.05377	-106.28945	No
CR-7.4	Colorado River downstream of Troublesome Creek	40.0509	-106.3112	No
CR-1.7	Colorado River upstream of Blue River	40.0465	-106.3730	No
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	40.0004	-106.17975	No
WF-2	Williams Fork downstream of Williams Fork Reservoir	40.03620	-106.20489	No
WF-0.5	Williams Fork downstream WF Reservoir at Kemp Breeze	40.0561	-106.1825	Yes

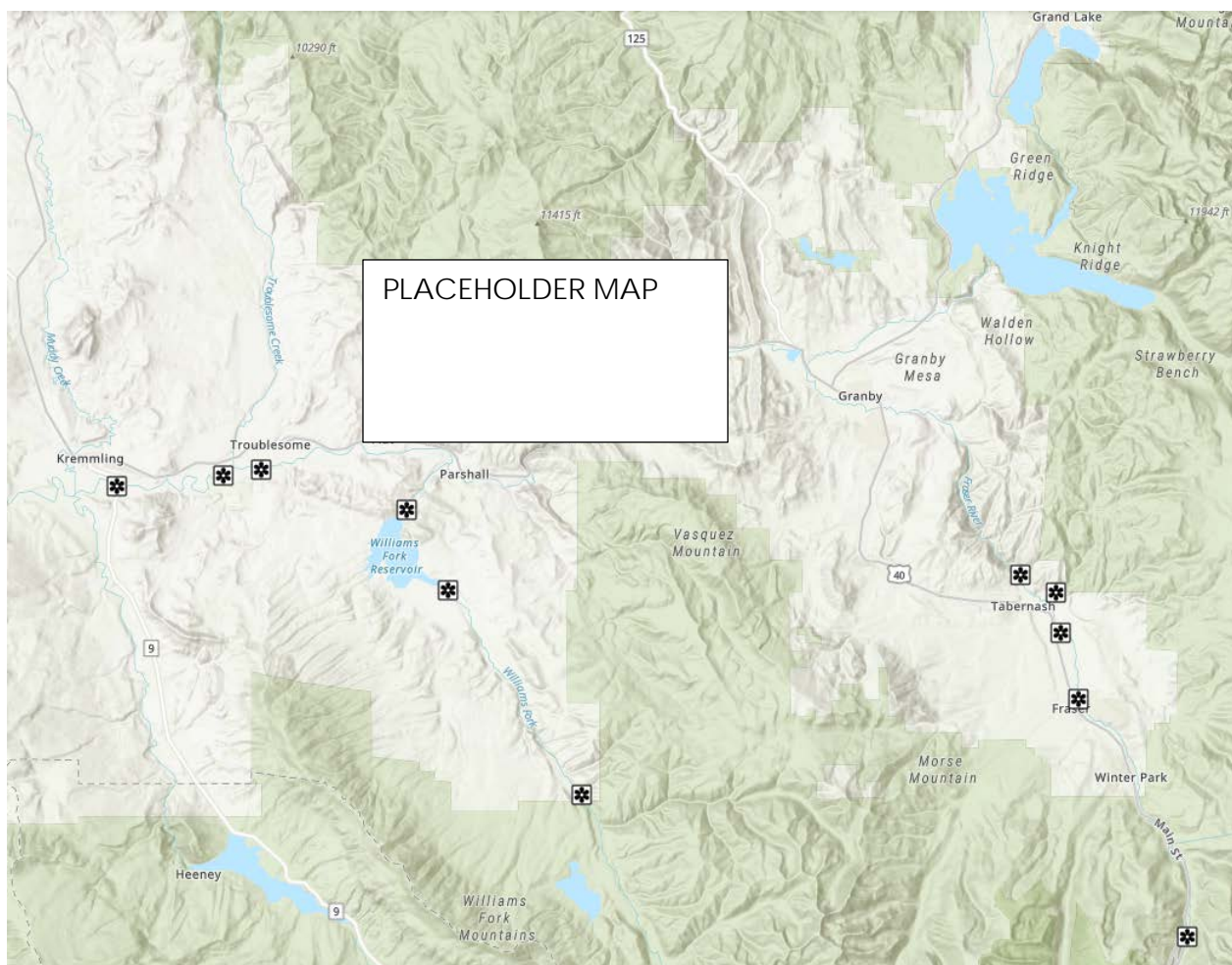


Figure 5 - Map of 2019 LBD Macroinvertebrate Monitoring Sites

Table 8 lists the all the macroinvertebrate sites monitored by LBD, indicates sampling frequency at each site, when the site was last 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.

Table 8 - LBD Macroinvertebrate Sampling Sites and Years Monitored

River Mile ID	Station Description	Monitoring Frequency	Years Monitored			Project Specific
			2017	2018	2019	
FR-27.2	Fraser River upstream of Jim Creek and Mary Jane entrance	1x per 2-3 years		X <sup>New</sup>		No
FR-25.1	Fraser River upstream of UP Moffat Tunnel discharge	Annually			X <sup>New</sup>	No
FR-TBD	Fraser River downstream of UP Moffat Tunnel discharge	As needed			TBD <sup>New</sup>	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 per 2-3 years	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 <sup>New</sup>		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 per 2-3 years*	X	X	X	No
CR-7.4	Colorado River downstream of Troublesome Creek	TBD		X <sup>New</sup>	X	Yes
CR-1.7	Colorado River upstream of the Blue River	TBD		X <sup>New</sup>	X	Yes
WF-13.1	Williams Fork downstream of Henderson Mill	1x per 2-3 years		X <sup>New</sup>		No
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	TBD		X <sup>New</sup>	X	Yes
WF-2	Williams Fork downstream of Williams Fork Reservoir	TBD		X <sup>New</sup>	X	Yes
WF-0.5	Williams Fork downstream of Williams Fork Reservoir at Kemp Breeze	TBD			X <sup>New</sup>	Yes

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

## Sample Collection 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.

In addition, 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 2019 are the same as those used in 2017 and 2018. These methods are consistent with those used by Denver Water and the Subdistrict, which allows for integration with and comparison to these datasets. Sampling and analytical methods are 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). 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 6 - Sample Collection with a Hess Sampler

- Timberline Aquatics performs the macroinvertebrate analysis for all samples.
  - 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 at Timberline Aquatics, all sorted macroinvertebrate samples and approximately 10% of identifications are checked by another qualified taxonomist.

## Reporting and Assessment Metrics

Timberline Aquatics provides sampling results to the LBD Monitoring Committee. 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 9). 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.

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 maps each metric to specific program objectives and Table 10 provides a description of the metrics.

Note, in 2019 two MMI scores will be provided; one for MMI version 3 (which was used for assessment prior to 2018) and one for the updated tool, MMI version 4.

Table 9 - 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

Table 10 – Timberline Aquatics Reported Metrics and Description

Metric	Description
<b>Multi-Metric Index (MMI)*</b>	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.
<b>Ephemeroptera Plecoptera Trichoptera (EPT)*</b>	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.
<b>Hilsenhoff Biotic Index (HBI)*</b>	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.
<b>Shannon Diversity (SDI)*</b>	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.
<b>Tolerance Indicator Value (TIV<sub>sed</sub>)*</b>	A biological indicator of impacts by excess fine sediments. The TIV <sub>sed</sub> reflects both the reduction in relative abundance of sediment-sensitive taxa and the increase in relative abundance of sediment-tolerant taxa.
<b>% Chironomidae (Midges)</b>	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.
<b>% EPT excluding Baetis</b>	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.
<b>% Intolerant Taxa</b>	% composition of intolerant taxa.
<b>% Tolerant Taxa</b>	% composition of tolerant taxa. Based on tolerance values of 7 or greater.
<b>% Hydropsychidae of Trichoptera</b>	% 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.
<b>Total Taxa Richness</b>	Total number of identifiable taxa, indicator of general community health and stability. Sensitive to metals.
<b>Pteronarcys Californica Density</b>	Pteronarcys Californica abundance, mean number per square meter.
<b>Total Density</b>	Macroinvertebrate abundance mean number per square meter. Useful when paired with other metrics.

\*Key Measurable Indicator

## Funding

Costs for the 2019 macroinvertebrate monitoring will be shared among some LBD partners. The partners each pay a percentage of the total cost. The cost distribution for 2019 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 and Northern Water's Baseline Monitoring Program.

## 2019 Fraser Flats River Habitat Project Monitoring Plan

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The following plan has been approved by the LBD Management Committee for 2019 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 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
- Trout population estimates and quality trout
- 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<sup>1</sup>.

### ***Scope of 2019 Monitoring Program Proposal***

The scope of the 2019 monitoring program is to document and compare the 2018 and 2019 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 2019. A map showing the locations of the sampling sites is provided in Figure 7.

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

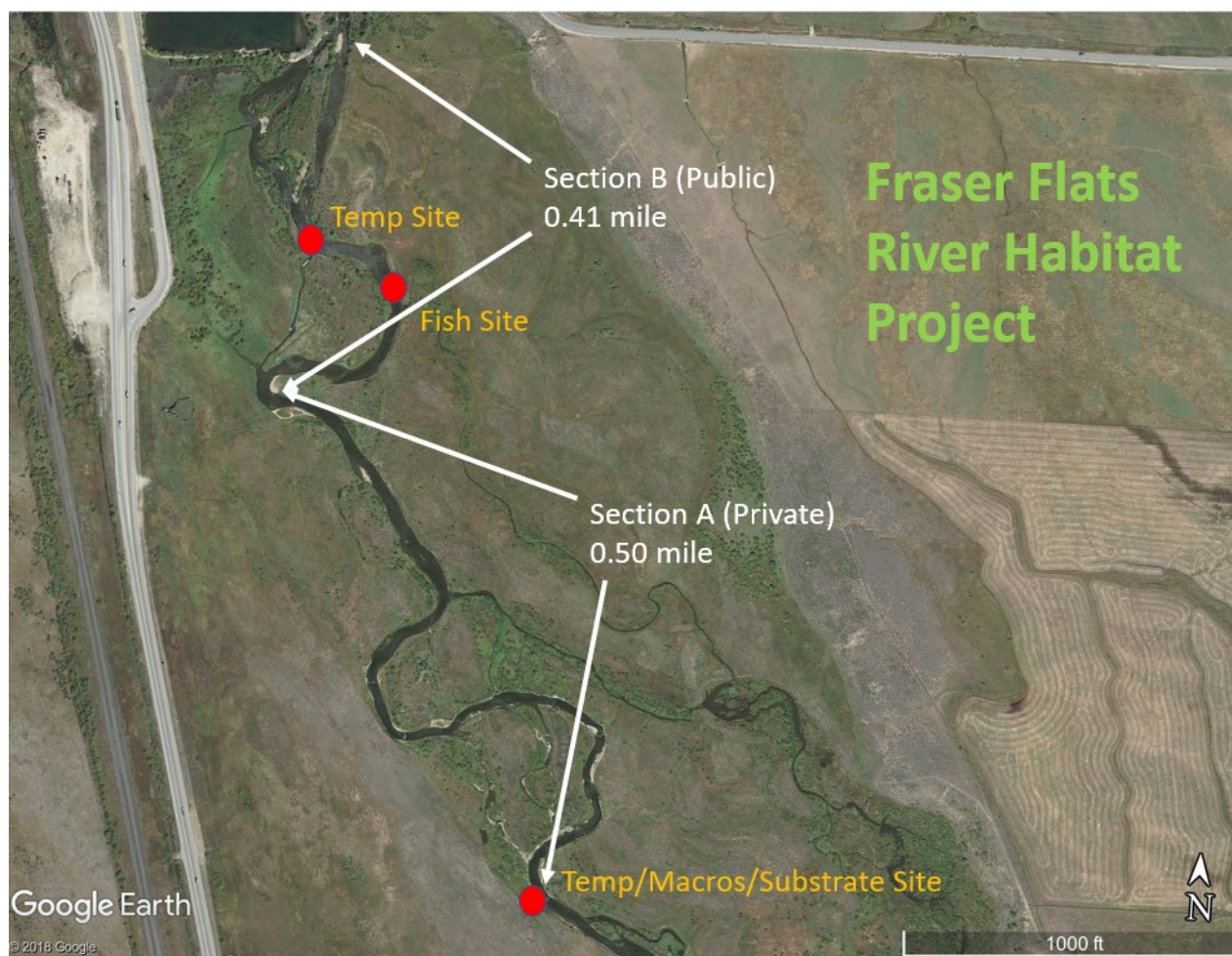


Figure 7 - Map of 2019 Fraser Flats Monitoring Sites

### ***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. This task can be approached one of two ways, either by field observations or by actual field measurements (options 1 and 2). For 2019 monitoring, a blend of both options 1 and 2 will be performed, as resources and time allow. The laser level survey equipment required in option 2 was approved for purchase by the LBD Management Committee.

Option 1 – Field Observations only. This option does not require sampling; however, a site visit will occur in late summer/early fall of 2019 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.

Prior to the field visit, the 2017 pre-project conditions documented in Freestone Aquatics' design drawings<sup>2</sup> will be used to quantify the aquatic habitat features present before the project was constructed. This pre-project inventory will include the number of riffles and pools in the project reach. Photographs, field notes, and the design drawings will be used to assess the pre-project condition of these features.

During the 2019 field visit, the as-built design drawings<sup>3</sup>, 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. An inventory of the number of riffles, runs, and pools in the project reach will be documented in the field. 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.

Option 2 – Field Measurements only. This option 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

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<sup>2</sup> Freestone Aquatics, 2017. Fraser Flats Aquatic Habitat Restoration Project. January 20, 2017.

<sup>3</sup> Freestone Aquatics, 2017. Fraser Flats Aquatic Habitat Restoration Project As-Built Set. September 29, 2017.

sizes, presence of fine sediment, and embeddedness) will be performed by GEI in late summer/early fall of 2019 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 and 2019 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 and 2019 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.*

## **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 2019.

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 and 2019 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 and 2019 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 2019. Members of the Monitoring Subcommittee may participate in the fish survey.



CPW will monitor the project reach with the goal of documenting changes in<sup>4</sup>:

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

The 2019 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. Accurate estimates of sculpin are difficult to measure owing to several factors, such as: the skills and experience of the volunteer field crew, and the fact that sculpin lack an air bladder so they don't float after being stunned by the arc of the electrofishing probe, which causes them to fall beneath rocks where they are often unable to be netted. For these reasons, a review of the number of sculpins captured in the fish survey each year will be evaluated according to the density of sculpin expected to be seen based on the conditions of the stream and trout population present.

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 and 2019 fish survey results.

Comparisons of fish species composition and age class 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 and 2019 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

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<sup>4</sup> LBD Monitoring Subcommittee, 2017. Fraser Flats River Habitat Project Monitoring Program Guidelines. Revised October 20, 2017 based on the August 16, 2016 monitoring plan.

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 in the summer of 2019. Members of the Monitoring Subcommittee may participate in the survey. Prior to the field visit, the riparian revegetation design plan prepared by Anna Drexler-Dreis<sup>5</sup> 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 2019 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.

### *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 and 2019 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 2019.

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<sup>5</sup> 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.

The pre-project stream temperature results from GCWIN's 2015-2017 data will be used to compare with the 2018 and 2019 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 and 2019 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<sup>6</sup>**

	<b>Method</b>	<b>Agency</b>	<b>Frequency &amp; duration</b>	<b>Sample Season</b>	<b>Site Location</b>	<b>Notes</b>
<b>Benthic macro-invertebrates</b>	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.
<b>Fish count surveys</b>	electro-fishing	CPW	annual for 3 years post construction	September 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.
<b>Riparian survey</b>	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.
<b>Substrate conditions</b>	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.
<b>Aquatic habitat features</b>	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.
<b>Stream Temperature</b>	temperature 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

<sup>6</sup> 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.

## 2019 303(d) and Monitoring and Evaluation List Monitoring Plan

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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., 2018) 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) Monitoring Program 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.

## 2019 Review of Impaired Segments

The most current 303(d) and M&E list showed that 10 stream segments are currently listed as impaired within Grand County; only 4 of these segments are located within the LBD CEA and are shown in Figure 8. Of the 4 listed segments within the LBD CEA, the impaired uses are for Water Supply and Aquatic Life Use. The primary analytes of concern are arsenic (total), iron (dissolved), manganese (dissolved), copper (dissolved), stream temperature, and macroinvertebrates.

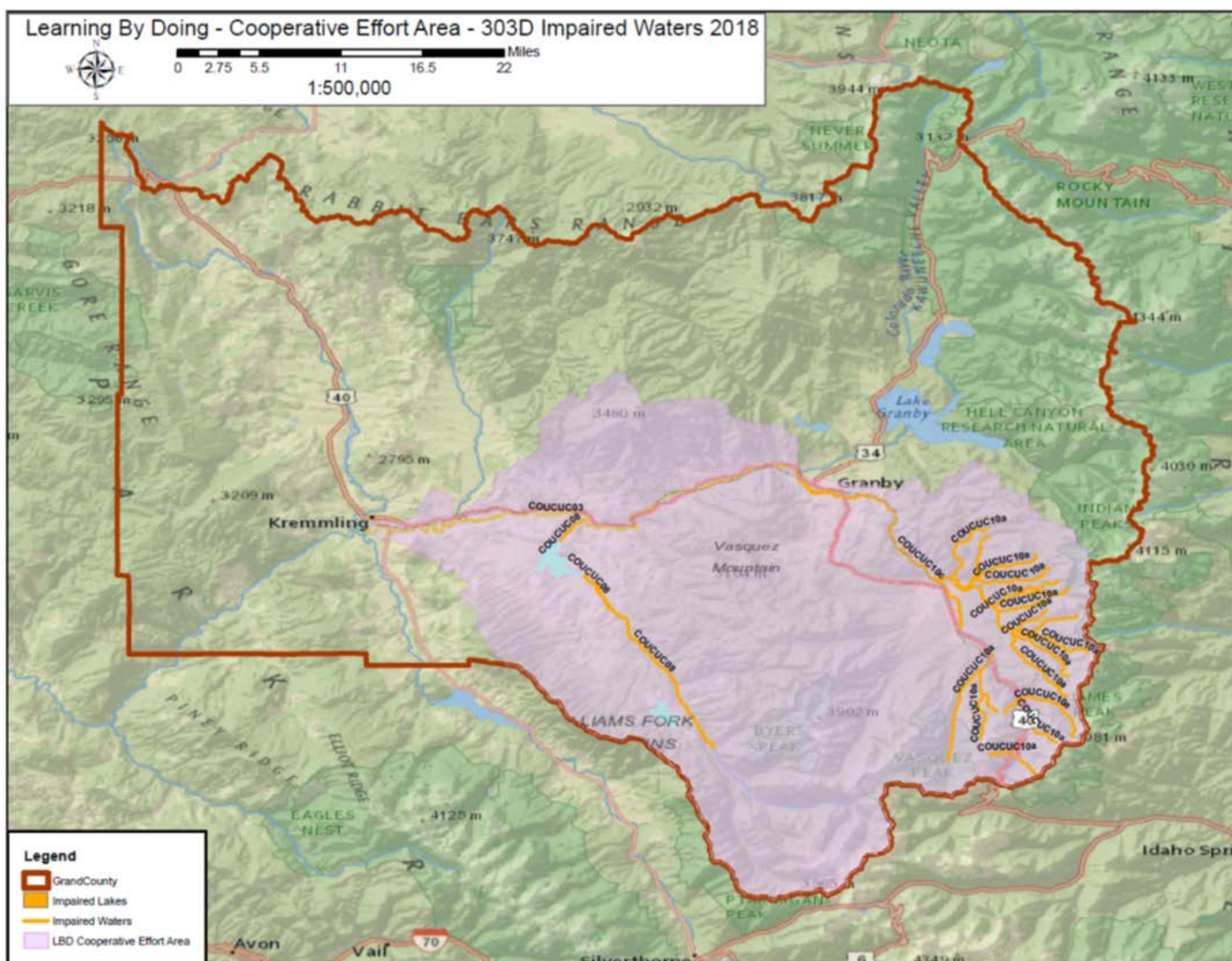


Figure 8 - Map of Segments on the 2018 303(d) List

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

1. **COUCUC03 - Mainstem of the Colorado River from the outlet of Lake Granby to the confluence with Roaring Fork River.**
  - COUCUC03\_B Colorado River from Windy Gap Reservoir to 578 Road Bridge.  
Water Supply use – Arsenic – M&E List  
Aquatic Life Use – Macroinvertebrates – M&E List
  - COUCUC03\_C Colorado River from 578 Road Bridge to Gore Canyon.  
Water Supply use – Arsenic – M&E List  
Aquatic Life Use – Macroinvertebrates – M&E List  
Aquatic Life Use – Temperature – 303(d)
2. **COUCUC08 - Mainstem of the Williams Fork River, including all tributaries and wetlands from the source to the confluence with the Colorado River, except for those tributaries listed in Segment 9.**
  - COUCUC08\_B Mainstem of Williams Fork River below Kinney Creek.  
Aquatic Life Use – Copper – M&E List
3. **COUCUC10a - Mainstem of the Fraser River from the source to a point immediately below the Rendezvous Bridge. All tributaries to the Fraser River, including wetlands, from the source to the confluence with the Colorado River, except for those tributaries included in Segment 9.**
  - COUCUC10a\_B - Ranch Creek and its tributaries.  
Aquatic Life Use – Temperature – 303(d)
  - COUCUC10a\_C - Fraser River tributaries at and above Jim Creek  
Aquatic Life Use – Macroinvertebrates (provisional) – 303(d)
  - COUCUC10a\_D - Vasquez Creek and its tributaries.  
Aquatic Life Use – Macroinvertebrates (provisional) – 303(d)  
Aquatic Life Use – Copper – 303(d)
4. **COUCUC10c - Mainstem of the Fraser River from a point immediately below the Hammond Ditch to the confluence with the Colorado River.**
  - COUCUC10c\_A - Fraser River from below the Hammond Ditch in Town of Fraser to Fraser Canyon near Tabernash.  
Water Supply Use – Iron (dissolved) – M&E List  
Water Supply Use – Arsenic (total) – 303(d)
  - COUCUC10c\_B - Fraser River from Fraser Canyon near Tabernash to the Town of Granby.  
Water Supply Use – Arsenic (total) – 303(d)  
Water Supply Use – Iron (dissolved) – 303(d)
  - COUCUC10c\_C - From the Town of Granby to confluence with the Colorado River.

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

### **2019 LBD Monitoring to Support 303(d) Listings**

The impairments listed in these segments were evaluated against the 2018 Monitoring Summary (Appendix B). This evaluation showed that there is sufficient monitoring being conducted by various entities throughout the CEA.



## 2019 CPW Fish Monitoring Plan

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In cooperation with LBD monitoring efforts, CPW plans to survey fish populations at the following locations in 2019. All fish survey activities are dependent upon flow and temperature conditions, as well as staff and volunteer availability.

### Fraser River

Robbers' Roost – a new site 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 September 2<sup>nd</sup>.

Safeway – this site is surveyed annually and is the longest continuous data set on the Fraser River. Sampling will be conducted the week of September 2<sup>nd</sup>.

Grand County Water and Sanitation #1 property – see Fraser Flats monitoring plan. Sampling will be conducted on October 4<sup>th</sup>.

BLM near Granby Ranch – a new site located on BLM property immediately upstream of the Granby Ranch property line, at the mouth of the Fraser River canyon. Sampling will be conducted the week of September 2<sup>nd</sup>.

Kaibab Park – on Town of Granby property, the farthest downstream established fish monitoring site on the Fraser River. Sampling will be conducted the week of September 2<sup>nd</sup>.

### Colorado River

Parshall-Sunset – raft electrofishing reach. Surveyed annually. Sampling will be conducted the week of September 24<sup>th</sup>.

Gilbert-Lone Buck – raft electrofishing reach on State Wildlife Area near Hot Sulphur Springs. Sampling will be conducted in Spring 2019.

## 2019 Riparian Areas and Wetlands Monitoring Plans

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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 plan to revisit the restoration site to count and assess the condition of the willows planted last year. Any observed sections of standing dead or poor condition plantings will be noted so that replacement willow stakes plantings may be supplemented in these areas. The Headwaters Chapter plans to organize volunteer harvest and planting days in May 2019 to supplement the plantings performed last year. 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.

## Study Area

The study area includes 5 reaches that were established based on similarity of vegetation complex composition and watershed characteristics (Figure 9):

Reach 1 – Extends downstream from the Windy Gap Reservoir to Drowsey Water Creek. The rough length of this reach is 2.73 river miles.

Reach 2 – Extends downstream from Reach 1, Drowsey Water Creek, to Sheriff Creek. The rough length of this reach is 2.42 river miles.

Reach 3 – Extends downstream from Reach 2, Sheriff Creek, to an unnamed drainage along Parshall Divide Road. The rough length of this reach is 2.90 river miles.

Reach 4 – Extends downstream from the unnamed drainage to Kemp-Breeze Wildlife Area. The rough length of this reach is 5.35 river miles.

Reach 5 – Extends from the downstream end of the Willow Creek Reservoir to the confluence with the Colorado River. The rough length of this reach is 3.20 river miles.

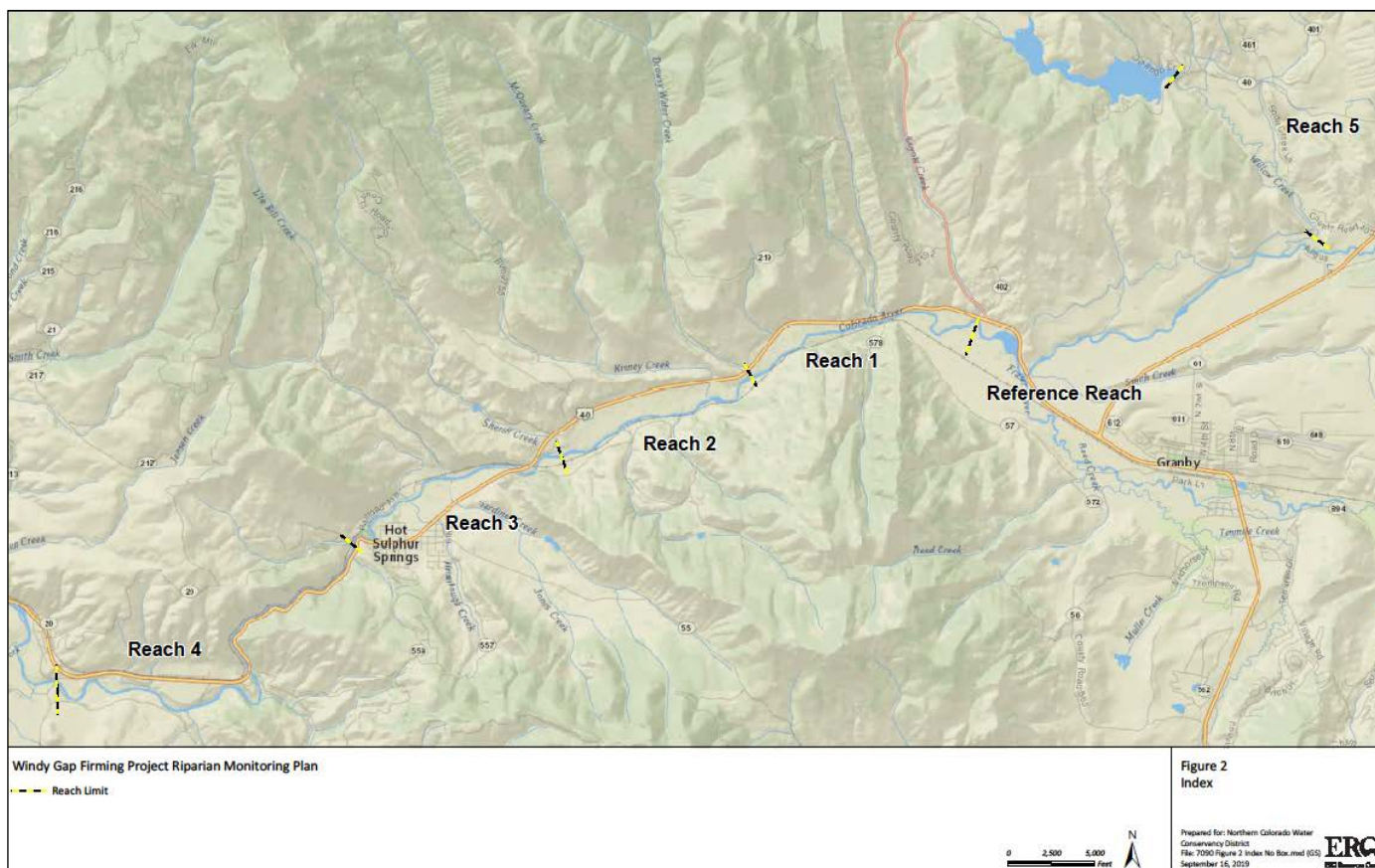


Figure 9 - Map of Riparian Monitoring Reaches in the Colorado River and Willow Creek

### ***Monitoring Schedule***

Baseline monitoring was completed during the growing season in 2018, which represented a dry year. Monitoring will also take place in 2019, which is representative of wet year conditions. Another monitoring event will occur one year prior to WGFP Project implementation. The baseline monitoring events occur between June through August.

Monitoring will continue post WGFP project implementation.

### ***Monitoring Methods***

The field data collection procedures are designed to evaluate the structure and composition of riparian vegetation in multi-strata communities and assess the health and vigor of dominant overstory trees in the riparian community. This monitoring plan was developed by reviewing and adapting several approaches for monitoring riparian vegetation and cottonwood-dominated woodlands, with an emphasis on repeatability and efficiency of sampling. Field data collection includes:

- Cross transect study plots
- Documenting vegetation in established greenlines (the first perennial vegetation at or near the water's edge)
- Establishing baseline conditions of woody regeneration

In addition to field data collection efforts, the following assessments are done:

- Evaluation of the study area using the Ecological Integrity Assessment protocol for baseline and post-project monitoring
- A riparian health factors qualitative assessment
- Aerial imagery assessment of the study area captured using drones and high-resolution cameras

### ***Data and Reporting***

Data will be provided for each sampling event. These include field sheets in PDF format, Excel spreadsheets of the unaltered and tabulated data, GIS files of transect and plot locations, and aerial imagery data. The data are submitted to the Subdistrict; the Subdistrict will distribute the data files to Grand County and LBD.

A report summarizing the conditions of riparian vegetation is prepared and submitted to the Subdistrict. The report includes transect figures, aerial imagery figures, photographs, summary data tables, and the collected field data in table format. The Subdistrict will distribute the report to Grand County and LBD.

## 2019 ILVK Monitoring Program

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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 in addition to more extensive vegetation monitoring.

### *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 will be the fourth year CPW will conduct 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 2019. 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.



## 2019 Connectivity Channel Monitoring

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Northern Water's Municipal Subdistrict is planning to construct a bypass channel to provide 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 Firing 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. With construction anticipated to begin in 2021, CPW will begin work in 2020 so baseline data can be obtained before construction of the connectivity channel and 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 Windy Gap Bypass.

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 – 2018 Monitoring Sites with River Mile and Entity Station Name

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River Mile ID	Entity Station ID	Description	Entity	Type
AC-0.6	AC-GRU	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Water Quality
AC-0.6	AC-GRU	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Temperature
AC-0.6	AC-GRU	Arapaho Creek at Monarch Lake upstream of Granby Reservoir	Northern	Flow
BC-0	WS-WF-008	Bobtail Creek above diversion dam downstream of gauging station	Denver Water	Water Quality
BC-0	09034900	Bobtail Creek above diversion dam	Denver Water	Flow
CB-0.6	CAB-abvChan	Cabin Creek upstream North and South Channels	Denver Water	Temperature
CB-2.7	09032100	CABIN CREEK NEAR FRASER, CO.	DW/USGS	Flow
CB-2.7	CAB-blwDWB	Cabin Creek downstream Denver Water diversion	Denver Water	Temperature
CC-1.5	395927105505700	Crooked Cr Abv Pole Creek At Tabernash	EGWQB	Water Quality
CH-0.5	CH-WCU	Church Creek upstream of Willow Creek at Flume	Northern	Water Quality
CLU-0	CLU1-WCU	Surface drainage channel on C Lazy U pasture that drains to Willow Creek	Northern	Water Quality
CLU-0.7	CLU2-IRR	Upstream end of surface water drainage channel on C Lazy U pasture	Northern	Water Quality
CR-1.7	CR-BRU	Colorado River upstream of the Blue River	LBD	Substrate
CR-1.7	CR-BRU	Colorado River upstream of the Blue River	LBD/ILVK	Macroinvertebrate
CR-12.6	COR-ConRitschard	Colorado River at ConRitschard	GCWIN	Temperature
CR-13.7	Parshall-Sunset	Parshall-Sunset	CPW	Fish
CR-14.9	COR-KidPond	Colorado River downstream of Parshall near Kid Fishing Pond	GCWIN	Temperature
CR-14.9	CR7	Colorado River downstream of Parshall near Kid Fishing Pond	CPW	Macroinvertebrate
CR-14.9	CR Blw WF	Colorado River downstream of Parshall near Kid Fishing Pond	LBD	Substrate
CR-14.9	CR-PAR	Colorado River downstream of Parshall near Kid Fishing Pond	Northern	Flow
CR-16.7	CR-WFU	Colorado River upstream of Williams Fork	Northern	Temperature
CR-16.7	CR-WFU	Colorado River upstream of Williams Fork	Northern	Macroinvertebrate
CR-16.7	CR-WFU	Colorado River upstream of Williams Fork	LBD	Substrate
CR-16.7	WS-CO-003	Colorado River north of Parshall at Bar Lazy J Ranch bridge	Denver Water	Water Quality
CR-18.4	COR-LoneBuck	Colorado River at Lone Buck	GCWIN	Temperature
CR-19.8	CR6	Colorado River downstream of Byers Canyon	CPW	Macroinvertebrate
CR-19.8	CR6	Colorado River downstream of Byers Canyon	CPW	Fish
CR-19.8	COR-blwByers	Colorado River downstream of Byers Canyon	GCWIN	Temperature
CR-2.3	COR-Hwy9	Colorado River upstream Hwy 9 Bridge at Kremmling	BLM	Temperature
CR-2.3	WS-CO-004	Colorado River upstream Hwy 9 Bridge at Kremmling	Denver Water	Water Quality
CR-21.9	CR at Ppark	Colorado River downstream of Hot Sulphur Springs.	LBD	Substrate
CR-22.1	CR5	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Macroinvertebrate
CR-22.1	CR5	Colorado River at Pioneer Park by Hot Sulphur Springs	CPW	Fish
CR-22.1	CR-HSPP	Colorado River at Pioneer Park by Hot Sulphur Springs	Northern	Macroinvertebrate
CR-22.1	CR-HSPP	Colorado River at Pioneer Park by Hot Sulphur Springs	LBD	Substrate
CR-22.7	CR-HSU	Colorado River upstream Hot Sulphur Springs at WTP	Northern	Temperature
CR-23.5	CR-HSU	Colorado River upstream of Hot Sulphur Springs	Northern	Flow
CR-24.9	CR4	Colorado River at Sheriff Ranch	CPW	Macroinvertebrate
CR-24.9	COR-SHRF	Colorado River at Sheriff Ranch	GCWIN	Temperature
CR-27.5	CR3	Colorado River downstream Chimney Rock at Upper Red Barn	CPW	Macroinvertebrate
CR-28.7	CR-WGD	Colorado River downstream of Windy Gap Reservoir	Northern	Water Quality
CR-28.7	CR-WGD	Colorado River downstream of Windy Gap Reservoir	Northern	Temperature
CR-28.7	CR-WGD	Colorado River downstream of Windy Gap Reservoir	Northern	Macroinvertebrate
CR-28.7	CR-WGD	Colorado River downstream of Windy Gap Reservoir	LBD	Substrate
CR-28.7	CR2	Colorado River downstream of Windy Gap Reservoir	CPW	Macroinvertebrate
CR-28.7	CR2	Colorado River downstream of Windy Gap Reservoir	CPW	Fish
CR-28.7	09034250	Colorado River downstream of Windy Gap Reservoir	NW/USGS	Flow
CR-29.8	CR-WGC	Colorado River at confluence of Windy Gap spillway and bypass	Northern	Temperature
CR-30	CR-WGB	Colorado River at Windy Gap Bypass	Northern	Flow
CR-30	CR-WGB	Colorado River at Windy Gap Bypass	Northern	Temperature
CR-30.8	CR1	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Macroinvertebrate
CR-30.8	CR1	Colorado River downstream of Fraser, upstream of Windy Gap	CPW	Fish
CR-31	CR-WGU	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Temperature
CR-31	CR-WGU	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Water Quality
CR-31	CR-WGU	Colorado River upstream of Windy Gap and Fraser River confluence	Northern	Macroinvertebrate
CR-31	CR1	Colorado River upstream of Windy Gap and Fraser River confluence	CPW	Macroinvertebrate
CR-31	CR-WGU	Colorado River upstream of Windy Gap and Fraser River confluence	LBD	Sediment
CR-32.1	CR-WCD	Colorado River downstream of Willow Creek	Northern	Water Quality
CR-34.7	CR-WCU	Colorado River upstream of Willow Creek	Northern	Water Quality
CR-35.6	CR-YGAGE	Colorado River downstream Granby Reservoir at flow gage	Northern	Temperature
CR-35.6	09019500	Colorado River downstream of Granby Reservoir	USGS	Flow
CR-38.3	CR-GRD	Colorado River downstream of Granby Reservoir	Northern	Water Quality
CR-38.3	CR-GRD	Colorado River downstream of Granby Reservoir	Northern	Temperature
CR-38.3	CR-GRD	Colorado River downstream of Granby Reservoir	Northern	Macroinvertebrate

CR-43.5	CR-GRU	Colorado River upstream of Granby Reservoir	Northern	Temperature
CR-44.6	CR-SMD	Colorado River downstream of Shadow Mountain Reservoir	Northern	Water Quality
CR-44.6	CR-SMD	Colorado River downstream of Shadow Mountain Reservoir	Northern	Temperature
CR-44.6	CR-SMD	Colorado River downstream of Shadow Mountain Reservoir	Northern	Macroinvertebrate
CR-44.6	09015000	Colorado River downstream of Shadow Mountain Reservoir	USGS	Flow
CR-7.4	CR-TCD	Colorado River downstream of Troublesome Creek	LBD	Substrate
CR-7.4	CR-TCD	Colorado River downstream of Troublesome Creek	LBD/ILVK	Macroinvertebrate
CR-9.1	COR-KBDitch	Colorado River downstream of KB Ditch	GCWIN	Temperature
CR-9.1	COR-KBDitch	Colorado River downstream of KB Ditch	LBD	Macroinvertebrate
CR-9.1	CR Blw KB Ditch	Colorado River downstream of KB Ditch	LBD	Substrate
CR-9.1	CR-KBD	Colorado River downstream of KB Ditch	Northern	Flow
EC-5.5	09025300	Elk Creek near Fraser	DW/USGS	Flow
EC-5.5	Elk-blwDWB	Elk Creek downstream Denver Water diversion	Denver Water	Temperature
EI-0.1	EI-GLU	East Inlet upstream of Grand Lake	Northern	Water Quality
EI-0.1	EI-GLU	East Inlet upstream of Grand Lake	Northern	Temperature
EI-0.1	EI-GLU	East Inlet upstream of Grand Lake	Northern	Flow
EI-0.1	EI-GLU	East Inlet upstream of Grand Lake	Northern	Macroinvertebrate
FR-0.1	FR-WGU	Fraser River upstream of confluence with Colorado River	Northern	Water Quality
FR-0.1	FR-WGU	Fraser River upstream of confluence with Colorado River	Northern	Temperature
FR-0.1	FR-WGU	Fraser River upstream of confluence with Colorado River	Northern	Macroinvertebrate
FR-0.1	FR-WGU	Fraser River upstream of confluence with Colorado River	Northern	Flow
FR-1.6	FR-blwGSD	Fraser River downstream of Granby Sanitation District	GCWIN	Temperature
FR-1.9	FR-abvGSD	Fraser River upstream of Granby Sanitation District	GCWIN	Temperature
FR-12.4	09033300	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Water Quality
FR-12.4	FR-abvFrCan	Fraser River downstream of Crooked Creek and Tabernash	GCWIN	Temperature
FR-12.4	09033300	Fraser River downstream of Crooked Creek and Tabernash	EGWQB/CRWCD	Flow
FR-14	9027100	Fraser River upstream of Tabernash	EGWQB	Water Quality
FR-14	09027100	Fraser River upstream of Tabernash	EGWQB/TU	Temperature
FR-14	FR-CR83	Fraser River upstream of Tabernash	Denver Water	Macroinvertebrate
FR-14	FR-CR83	Fraser River upstream of Tabernash	LBD	Substrate
FR-14	09027100	Fraser River upstream of Tabernash	EGWQB/USGS	Flow
FR-14.4	FR-SpProjD	Fraser River LBD Restoration Project, Downstream end	GCWIN	Temperature
FR-14.4		Winter Park W & S	CPW	Fish
FR-15	FR-SpProjU	Fraser River LBD Restoration Project, Upstream end	GCWIN	Temperature
FR-15	FR-SpProjU	Fraser River LBD Restoration Project, Upstream end	LBD	Macroinvertebrate
FR-15	FR-SpProjU	Fraser River LBD Restoration Project, Upstream end	LBD	Substrate
FR-16.6	FR-blwFSD	Fraser River downstream Fraser Sanitation	GCWIN	Temperature
FR-16.9	FR-abvFSD	Fraser River upstream Fraser Sanitation	GCWIN	Temperature
FR-17.7	FR-blwCR8HD	Fraser River downstream County Rd 8 at Hammond Ditch	GCWIN	Temperature
FR-18.1	FR-CR804	Fraser River downstream County Rd 804	GCWIN	Temperature
FR-18.1		Safeway	CPW	Fish
FR-20	FR-Rendezvous	Fraser River at Rendezvous bridge	GCWIN	Temperature
FR-20	FR-Rendezvous	Fraser River at Rendezvous bridge	Denver Water	Macroinvertebrate
FR-20	FR-Rendezvous	Fraser River at Rendezvous bridge	LBD	Substrate
FR-20.6	09025010	Fraser River Blw Vasquez Creek At Winter Park Co.	EGWQB	Water Quality
FR-21		Confluence Park	CPW	Fish
FR-22.5	FR-blwWP	Fraser River downstream Winter Park Resort at Idlewild Campground	GCWIN	Temperature
FR-22.5		Idlewild Campground	CPW	Fish
FR-22.5	09024000	Fraser River at Winter Park	DW/USGS	Flow
FR-23.2	FR-blwWPSD	Fraser River downstream Winter Park Sanitation	GCWIN	Temperature
FR-23.4	09023750	Fraser River Blw Buck Creek At Winter Park Co.	EGWQB	Water Quality
FR-23.4	FR-abvWPSD	Fraser River upstream Winter Park Sanitation District	GCWIN	Temperature
FR-23.4	FR-abvWPSD	Fraser River upstream Winter Park Sanitation District	Denver Water	Macroinvertebrate
FR-23.4	FR-abvWPSD	Fraser River upstream Winter Park Sanitation District	LBD	Substrate
FR-24	09023560	Fraser River upstream Moffat Tunnel Nr Winter Park, Co	EGWQB	Water Quality
FR-24	WS-FR-010	Fraser/Jim Canal at Gaging Station	Denver Water	Water Quality
FR-27.2	09022000	Fraser River At Upper Sta, Near Winter Park, Co.	EGWQB	Water Quality
FR-27.2	FR-Upper	Fraser R upstream Mary Jane entrance to Winter Park	GCWIN	Temperature
FR-27.2	09022000	Fraser River At Upper Sta, Near Winter Park, Co.	EGWQB/USGS	Flow
FR-27.2	FR US JimCk	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Substrate
FR-27.2	FR US JimCk	Fraser River upstream of Jim Creek and Mary Jane Entrance	LBD	Macroinvertebrate
FR-3.5	400453105554200	Fraser River At Hwy. 40 At Granby, Co	EGWQB	Water Quality
FR-3.5	FR-Hwy40Gr	Fraser River blw Highway 40 in Granby	GCWIN/LBD	Temperature
FR-4.5	FR-blwFRCan	Fraser River downstream Fraser Canyon	GCWIN	Temperature
FR-5.5	F9	Fraser River at Granby Ranch downstream of golf course	LBD	Substrate
GL-ATW	GL-ATW	Grand Lake West Portal	Northern	Water Quality

GL-MID	GL-MID	Grand Lake Mid-Section	Northern	Water Quality
GL-WES	GL-WES	Grand Lake west end of lake, south of Shadow Mountain Channel	Northern	Water Quality
GR-DAM	GR-DAM	Granby Reservoir Dam	Northern	Water Quality
GR-EAS	GR-EAS	Granby Reservoir East Side	Northern	Water Quality
GRP-0	GR-PUMP	Granby Pump Canal above Shadow Mountain Reservoir	Northern	Water Quality
GRP-0	GR-PUMP	Granby Pump Canal above Shadow Mountain Reservoir	Northern	Temperature
GR-WES	GR-WES	Granby Reservoir West Side	Northern	Water Quality
HC-0.5	HRD-atCR843	Herd Creek on County Road 843	Denver Water	Temperature
LCB-2.2	LCAB-blwDWB	Little Cabin Creek downstream Denver Water diversion	Denver Water	Temperature
LVC-0.2	LVC- abvWP	Little Vasquez upstream Winter Park on Arapaho Road	Denver Water	Temperature
MC-0.5	MEA-atCR84	Meadow Creek on County Road 84/USFS 129	Denver Water	Temperature
MQC-0	WS-WF-006	McQueary Creek above diversion dam 1 3/4 miles north of dorm	Denver Water	Water Quality
NF-0.1	CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Water Quality
NF-0.1	CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Temperature
NF-0.1	CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Flow
NF-0.1	CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir	Northern	Macroinvertebrate
NI-0.1	NI-GLU	North Inlet upstream of Grand Lake	Northern	Water Quality
NI-0.1	NI-GLU	North Inlet upstream of Grand Lake	Northern	Temperature
NI-0.1	NI-GLU	North Inlet upstream of Grand Lake	Northern	Flow
RC-1.1	09033100	Ranch Creek Blw Meadow Cr Nr Tabernash Co	EGWQB/CRWCD	Water Quality
RC-1.1	09033100	Ranch Creek Blw Meadow Cr Nr Tabernash Co	GC/DW	Temperature
RC-1.1	RC-blwMC	Ranch Creek downstream Meadow Creek	GCVIN	Temperature
RC-1.1	RC-blwMC	Ranch Creek downstream Meadow Creek	LBD	Macroinvertebrate
RC-1.1	F-RC2	Ranch Creek downstream of County Road 84	LBD	Substrate
RC-1.1	09033100	Ranch Creek Blw Meadow Cr Nr Tabernash Co	EGWQB/CRWCD	Flow
RC-4.7	RC-blwCR8315	Ranch Creek downstream County Rd 8315	GCVIN	Temperature
RC-9	09032000	Ranch Creek Near Fraser, Co.	EGWQB	Water Quality
RC-9	09032000	Ranch Creek Near Fraser, Co.	EGWQB/USGS	Flow
RCC-0	WS-FR-011	Ranch Canal at Gaging Station	Denver Water	Water Quality
RDC-0	REE-Upper	Reeder Creek, upper	BLM	Temperature
RDC-0.7	REE-Lower	Reeder Crk above footbridge, blw irrigation ditch	BLM	Temperature
RF-0	RF-GRU	Roaring Fork upstream Granby Reservoir	Northern	Water Quality
RF-0	RF-GRU	Roaring Fork upstream Granby Reservoir	Northern	Temperature
SC-0	WS-WF-005	Steelman Creek at bridge above diversion dam (south of dorm)	Denver Water	Water Quality
SM-CHL	SM-CHL	Shadow Mountain Reservoir Channel in Grand Lake at mouth of Channel	Northern	Water Quality
SM-CHL	09014050	Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Temperature
SM-CHL	09014050	Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Water Quality
SM-CHL	09014050	Shadow Mountain Channel at Chipmunk Lane	GC/USGS	Flow
SM-DAM	SM-DAM	Shadow Mountain Reservoir Dam	Northern	Water Quality
SM-MID	SM-MID	Shadow Mountain Reservoir Mid-Section	Northern	Water Quality
SM-NOR2	SM-NOR2	Shadow Mountain Reservoir North	Northern	Water Quality
SM-NW1	SM-NW1	Shadow Mountain Reservoir northwest of the center of the Reservoir	Northern	Water Quality
ST-0	ST-GRU	Shadow Mountain Channel at Chipmunk Lane	Northern	Water Quality
ST-0	ST-GRU	Stillwater Creek upstream Granby Reservoir	Northern	Temperature
STC-0	ST-LC	St. Louis Creek upstream confluence with Fraser River	GCVIN/LBD	Temperature
STC-0	STC FR	St. Louis Creek upstream confluence with Fraser River	LBD	Substrate
STC-0	STC FR	St. Louis Creek upstream confluence with Fraser River	LBD	Macroinvertebrate
STC-5.4	09026500	St. Louis Creek near Fraser	DW/USGS	Flow
STC-5.4	STC-Mid	St. Louis Creek at Fraser Experimental Forest HQ	LBD	Temperature
STC-9.8	STC-blwDWB	St. Louis Creek downstream Denver Water Board diversion	Denver Water	Temperature
SWF-0	WS-WF-003	South fork at South Fork Campground at gauging station	Denver Water	Water Quality
SWF-0	09035900	South fork at South Fork Campground	DW/USGS	Flow
USF-0	WS-WF-007	Upper South Fork of the Williams Fork (3.5 miles above trail head)	Denver Water	Water Quality
VC-0	VC-WP	Vasquez Creek at the town of Winter Park	GCVIN	Temperature
VC-0	09025000	Vasquez Creek at the town of Winter Park	DW/USGS	Flow
VC-0	VC-WP	Vasquez Creek at the town of Winter Park	Denver Water	Macroinvertebrate
VC-4.3	WS-FR-001	Vasquez Ck. upstream Vasquez Tunnel	Denver Water	Water Quality
VC-8	WS-FR-002	Vasquez Ck. at diversion structure	Denver Water	Water Quality
VCC-0	WS-FR-009	Vasquez Canal at Vasquez #1 Gaging Station	Denver Water	Water Quality
VT-0	WS-WF-019	Vasquez Tunnel outlet	Denver Water	Water Quality
WC-0.5	WC-abvCOR	Willow Creek upstream of confluence with Colorado River	LBD	Temperature
WC-0.9	WC-CRU	Willow Creek upstream of confluence with Colorado River	Northern	Water Quality
WC-2.3	WC-abvBHD	Willow Creek upstream of Bunte Highline Ditch	LBD	Temperature
WC-3.8	WC-WCRD	Willow Creek directly downstream of Willow Creek Reservoir Dam	Northern	Water Quality
WC-3.8	WC-WCRD	Willow Creek downstream of Willow Creek Reservoir	Northern	Temperature
WC-3.8	WC-WCRD	Willow Creek downstream of Willow Creek Reservoir	Northern	Flow

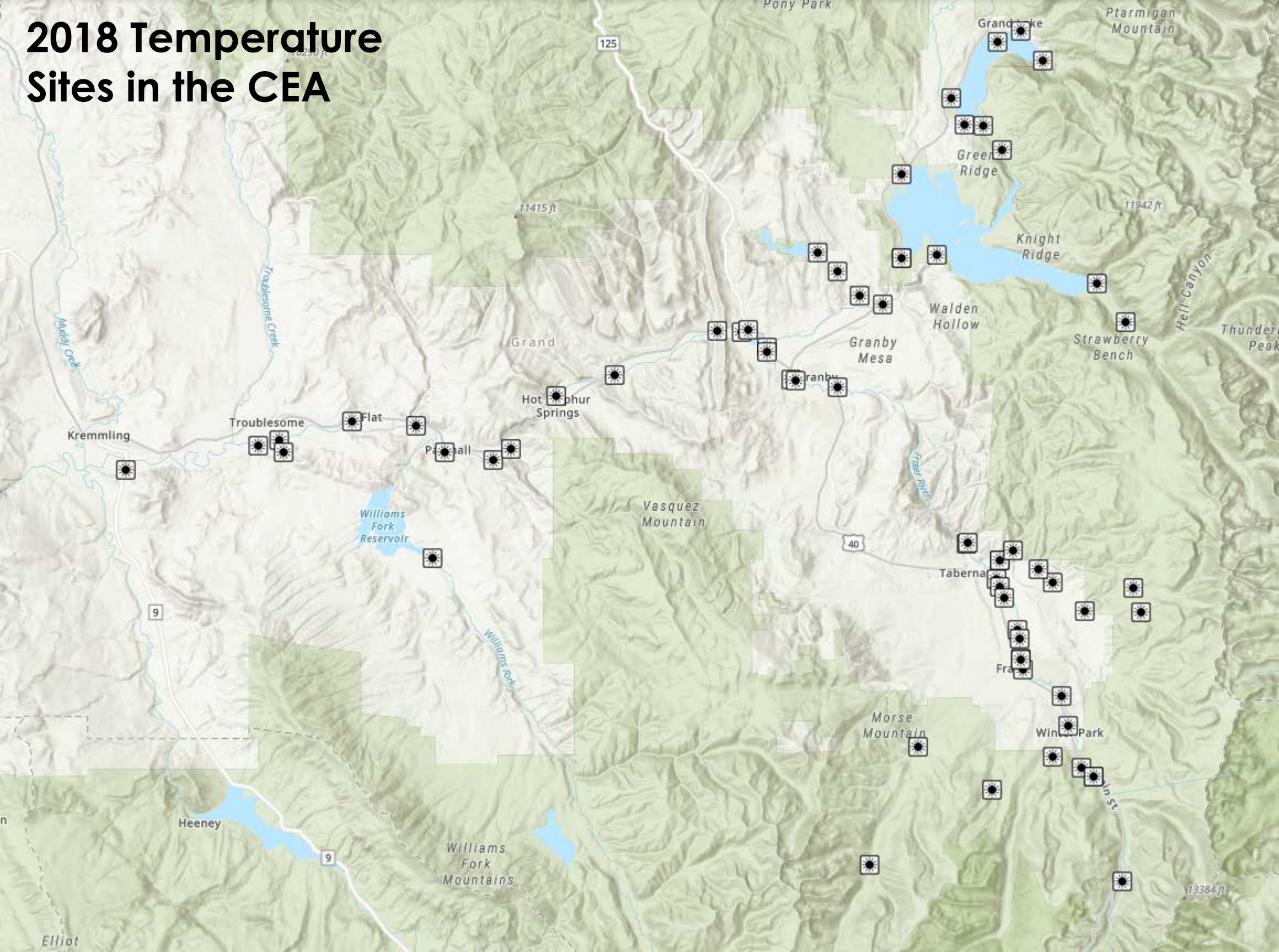
WC-6.3	WC-WCRU	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern	Water Quality
WC-6.3	WC-WCRU	Willow Creek at USGS Gage upstream C-Lazy-U Ranch	Northern	Flow
WC-DAM	WC-DAM	Willow Creek Reservoir at Dam	Northern	Water Quality
WCP-0	WC-Pump	Willow Creek discharge chute to Lake Granby	Northern	Water Quality
WCP-0	WC-PUMP	Willow Creek Pump Canal Inflow to Lake Granby	Northern	Temperature
WF-13.1	KR-LS-11081	Williams Fork	BLM	Water Quality
WF-13.1	KR-LS-11081	Williams Fork	BLM	Macroinvertebrate
WF-13.1	KR-LS-11081	Williams Fork	BLM	Habitat
WF-13.1	WF-HMD	Williams Fork downstream of Henderson Mill	LBD	Macroinvertebrate
WF-19	WS-WF-002	WilliamsForkRiver below Kinney Creek confluence at Leal gauge	Denver Water	Water Quality
WF-19	09036000	WILLIAMS FORK NEAR LEAL, CO.	DW/USGS	Flow
WF-19.6	09035700	WILLIAMS FORK ABOVE DARLING CREEK, NEAR LEAL, CO	DW/USGS	Flow
WF-2	WS-WF-009	Williams Fork R. below Williams Fork Reservoir	Denver Water	Water Quality
WF-2	09038500	Williams Fork R. below Williams Fork Reservoir	DW/USGS	Flow
WF-2	WF-WFRD	Williams Fork R. below Williams Fork Reservoir	LBD	Macroinvertebrate
WF-22.6	WS-WF-004	Williams Fork above bridge at Sugarloaf Campground	Denver Water	Water Quality
WF-28.2	09035500	WILLIAMS FORK BELOW STEELMAN CREEK, CO.	DW/USGS	Flow
WF-5.5	WS-WF-001	Williams Fork River upstream of Williams Fork Reservoir	Denver Water	Water Quality
WF-5.5	09037500	WILLIAMS FORK NEAR PARSHALL, CO	DW/USGS	Flow
WF-5.5	WF-abvWFR	Williams Fork upstream of Williams Fork Reservoir	LBD	Temperature
WF-5.5	WF-WFRU	Williams Fork upstream of Williams Fork Reservoir	LBD	Macroinvertebrate
WG-DAM	WG-DAM	Windy Gap Reservoir at Dam	Northern	Water Quality
WGP-0	WG-Pump	Windy Gap discharge chute to Granby Reservoir	Northern	Water Quality
WGP-0	WG-PUMP	Windy Gap Pump Inflow to Granby Reservoir	Northern	Temperature



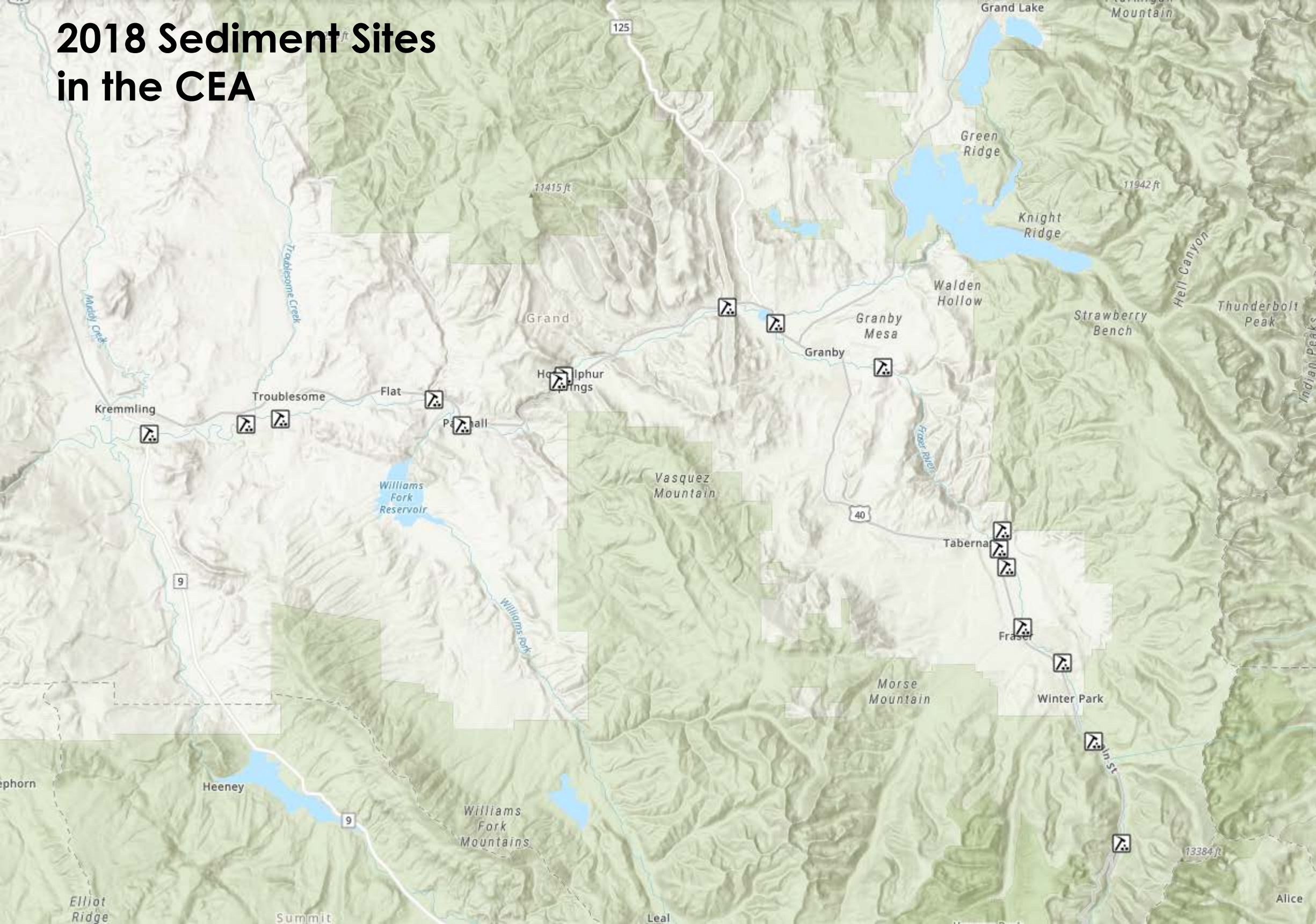
## Appendix B – 2018 Monitoring Summary

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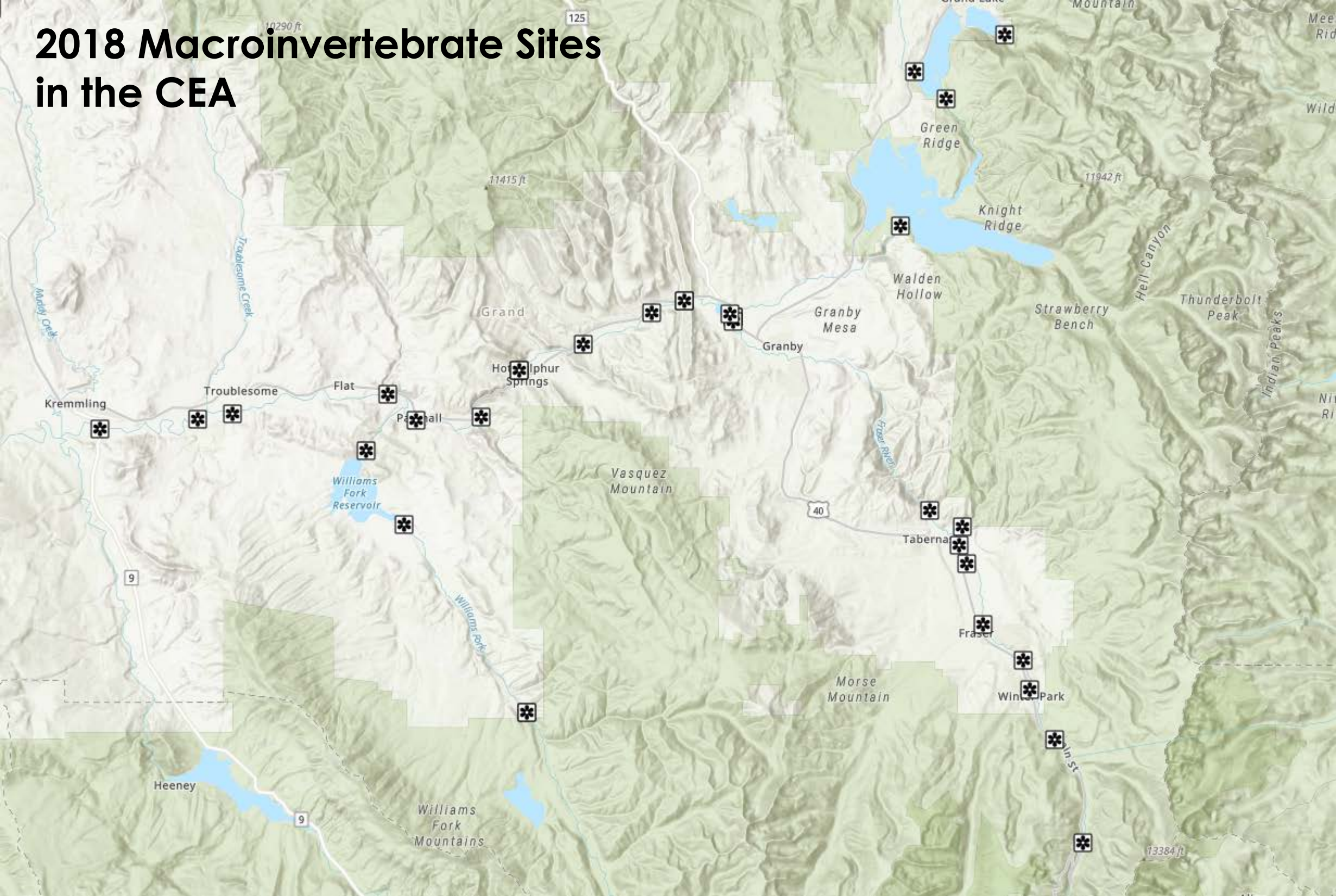
# 2018 Temperature Sites in the CEA



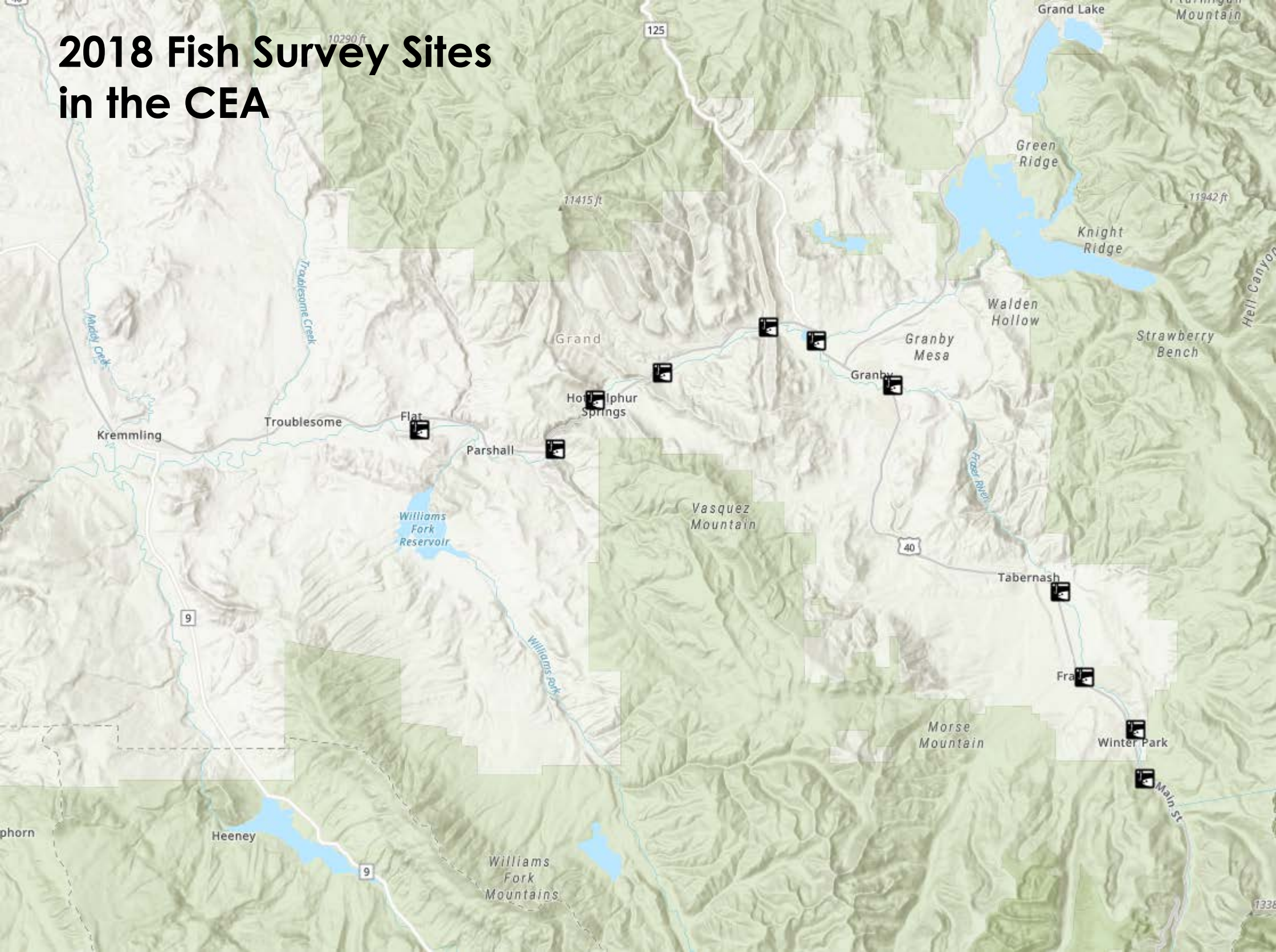
# 2018 Sediment Sites in the CEA



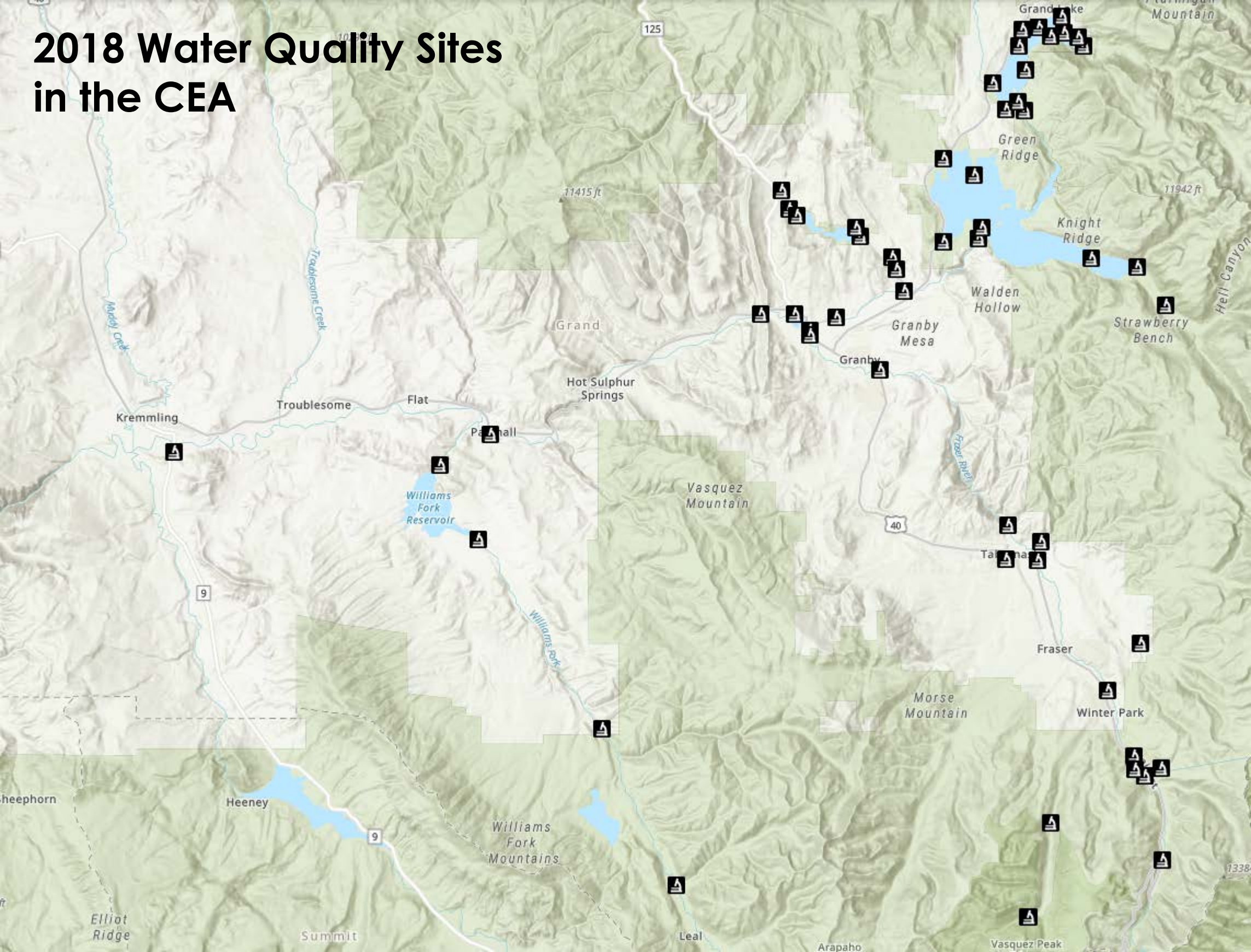
# 2018 Macroinvertebrate Sites in the CEA



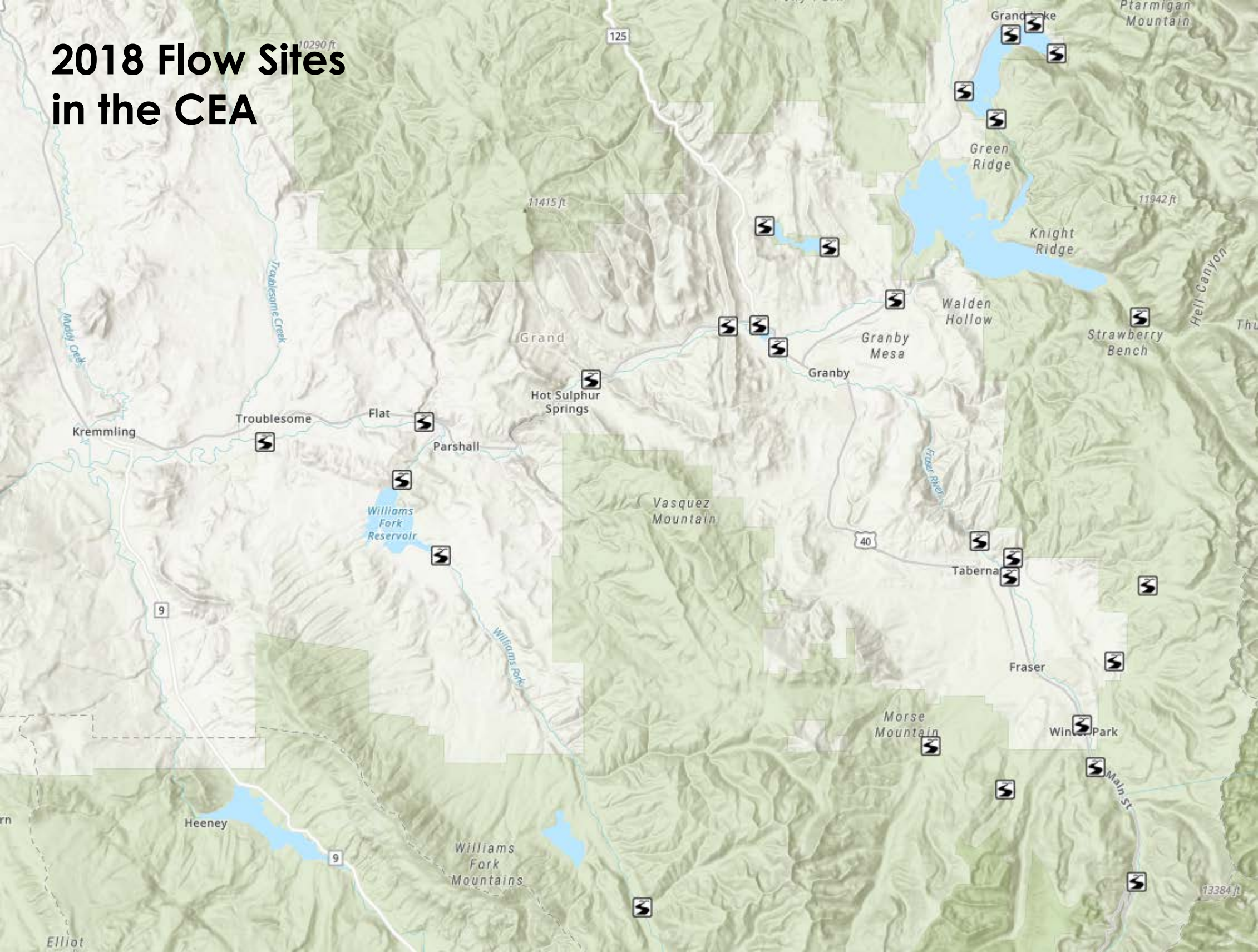
# 2018 Fish Survey Sites in the CEA



# 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**

<b>General Field Parameters</b>	<b>DW1</b>	<b>AQ1</b>	<b>AQ2</b>	<b>SED1</b>	<b>SED2</b>
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**

Macroinvertebrates		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 -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**

General Field Parameters	Rivers and Streams						Windy Gap Reservoir		
	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**

Macroinvertebrates				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 - 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

General Field Parameters	Rivers and Streams							Lakes and Reservoirs				
	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		
Macroinvertebrates						X						
Fish							X					
Pebble Count								X				
Embeddedness								X				

NW - Northern Water

AQ- Aquatic Life (bugs/fish)

SED - Sediment Monitoring





## 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 Rendezvous bridge	GCWIN	Temperature	Fraser River
FR-20	FR-Rendezvous	20	Fraser River at Rendezvous bridge	Denver Water	Macroinvertebrate	Fraser River
FR-20	FR-Rendezvous	20	Fraser River at Rendezvous 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**

<b>General Field Parameters</b>	<b>NW1</b>	<b>NW2</b>	<b>DW1</b>	<b>EG1</b>	<b>EG2</b>	<b>EG3</b>	<b>EG4</b>	<b>EG5</b>	<b>EG6</b>	<b>AQ1</b>	<b>AQ2</b>	<b>SED2</b>
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**

Macroinvertebrates										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



## 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

<u>General Field Parameters</u>	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			
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### Nutrients

TKN		X		
NH3 as N		X		
NO3				
NO3+NO2		X		
Ortho P				
P Total	X	X		

### Aquatic Habitat

Macroinvertebrates		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

## Appendix C – Temperature 2019 Monitoring Proposal and Data Gaps Assessment

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# 2019 Stream Temperature Data Gaps Assessment and Program Proposal

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This document describes the results of the Learning By Doing (LBD) Monitoring Subcommittee's (Subcommittee) data gaps analysis and subsequent 2019 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

In 2018, there were 63 temperature monitoring sites in the CEA. Several entities maintain these sites: The Bureau of Land Management, Grand County Water Information Network (GCWIN), Northern Water and the U.S. Geological Survey. Stakeholders that support the existing program include LBD members as well as non-LBD members. A map of the 2018 monitoring sites is shown in Figure 1 below.

## Temperature Monitoring Sites in Cooperative Effort Area

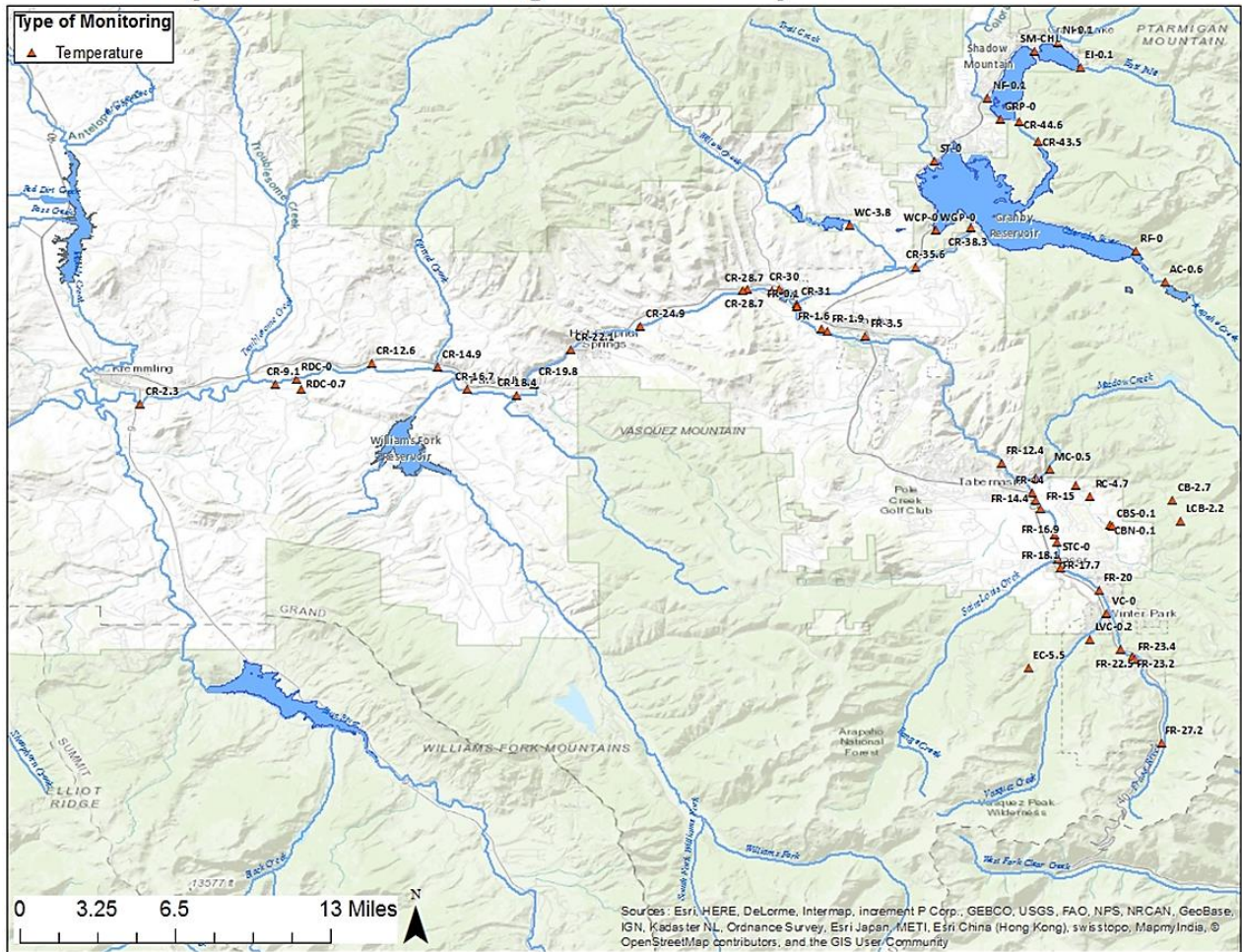


Figure 1 - 2018 Temperature Monitoring Sites in the CEA

**LBD Stream Temperature Monitoring:** In 2018, there were 10 sites that were monitored in the Stream Temperature Program for Learning By Doing, with 4 sites being monitored on a weekly basis from July 2 - September 15. The data that was collected helped support the LBD stream temperature monitoring program objectives, therefore, the Subcommittee recommends monitoring at these same sites in 2019. The existing sites are shown in Table 1 below.

Table 1 – Sites monitored in 2018 and recommended for 2019

River Mile ID	Station Description	2018 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-22.1	Colorado River upstream of Hot Sulphur by Water Treatment Plant	Yes	Yes
CR-16.7	Colorado River upstream of confluence with Williams Fork	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. Temporal

- a. **CR-2.3:** Colorado River above Hwy 9 Bridge at Kremmling
  - This site has been monitored by the BLM since 2006 and has particular importance because it is the last stream temperature sensor within the CEA. Additionally, this site provides the necessary baseline data to demonstrate that stream temperature warming exists on the Colorado River between the confluence of the Williams Fork and the Blue River. It's understood that the Williams Fork has a cooling effect on the Colorado River, but its impacts are short lived which necessitates more research. Thus, the Subcommittee recommends the BLM to download and deliver stream temperature data on a weekly basis, when conditions allow, and deliver it to the LBD operations subcommittee from July through September to support LBD operations and decision making.

**Proposed New 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. In order to remain consistent with historical GCWIN stream temperature data, it is recommended that the following protocols are followed:

- GCWIN 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 1<sup>st</sup>.
- 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 2019 proposed sites and the increased download frequency at certain sites is shown in Table 2.

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	Yes	Yes	No	\$0
CR-22.1	Colorado River upstream of Hot Sulphur by Water Treatment Plant	No	Yes	Yes	\$0
CR-16.7	Colorado River upstream of confluence with Williams Fork	No	Yes	Yes	\$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
<b>TOTAL</b>					<b>\$ 3,770</b>

Note: the cost per site is an estimate and the price can change for 2019 depending on the sampling plan.

## Appendix D – Sediment 2019 Monitoring Proposal and Data Gaps Assessment

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## 2019 Grand County Substrate Sampling Plan

### **Introduction**

This document is a preliminary draft of the Learning By Doing (LBD) Monitoring Subcommittee's proposal for 2019 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 SMP. These recommendations were based on maintenance of the structure and function of these important spawning habitats."<sup>1</sup>

### **Objectives**

In 2019, the objectives of the monitoring include:

- Evaluate flushing flows in key reaches within the SMP project area;
- Report on physical conditions in the riffles at macroinvertebrate monitoring locations;
- Assess sediment deposition impacts to aquatic life in a manner that is compliant with the Colorado Water Quality Control Commission *Narrative Sediment Policy 98-1*.<sup>2</sup>

### **Samples Collected**

When conditions permit, substrate monitoring has historically consisted of three components: core sampling, 100-count pebble counts, and Riffle Stability Index (RSI) measurements.

*Core sampling* is used to measure particle size distributions, and particularly percent fines. Data from core sampling can be compared to applicable state standards for trout spawning bar habitat quality. Several years of core samples in higher flow years with similar results have resulted in a recent focus on core sampling only during low flow years. Current stream-flow projections indicate core sampling is not recommended in 2019.

*Pebble counts* document surficial substrate particle size, degree of embeddedness, and the presence/absence of aquatic vegetation. Pebble counts are conducted using a modified 100-count Wolman Pebble Count method. Pebble counts have been collected using this methodology since 2010, providing continuity in the dataset. Pebble counts are used to assess spawning bars and macroinvertebrate habitats, and can be made regardless of hydrologic year conditions.

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<sup>1</sup> Tetra Tech and HabiTech, *Final Draft Report 2017 Monitoring Report, Grand County Colorado*, May 10, 2018.

<sup>2</sup> 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

## LEARNING BY DOING

Riffle Stability Index (RSI) evaluations are made at core sampling sites to help 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."<sup>3</sup> As 2019 promises to be a high flow year, RSI measurements are recommended at each of the historical core sample sites.

### **Monitoring Sites and Sampling Frequency**

As of April 30, 2019, above average flows are anticipated in rivers in the CEA for 2019. The proposed substrate monitoring plan includes:

- Pebble counts at each of the 2019 macroinvertebrate sites (Table 1),
- RSI at each of the historical core sampling sites (Table 2, Figure 1, Figure 2, and Figure 3).

Core samples are not proposed for inclusion in the 2019 substrate monitoring plan.

In 2018, 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. For maps and details on new sites see the 2019 Macroinvertebrate Program Proposal.

All sampling will be conducted once in the early fall.

**Table 1 - LBD Pebble Count Sites Associated with Macroinvertebrate Sites**

River Mile ID	Station Description	Monitoring Frequency
<b>FR-26</b>	Fraser River upstream of UP Moffat Tunnel discharge	TBD
<b>FR-23.2</b>	Fraser River upstream of Winter Park San District	Annually
<b>FR-20</b>	Fraser River at Rendezvous Bridge	Annually
<b>FR-15</b>	Fraser River upstream of Fraser Flats Restoration	Annually
<b>FR-14</b>	Fraser River below bridge on CR83	Annually
<b>FR-1.9</b>	Fraser River upstream of Granby Sanitation	1x per 2-3 years
<b>RC-1.1</b>	Ranch Creek below Meadow Creek	Annually
<b>CR-31</b>	Colorado River upstream from Windy Gap	Annually
<b>CR-28.7</b>	Colorado River downstream of Windy Gap	Annually
<b>CR-22.9</b>	Colorado River at Pioneer Park upstream of Hot Sulphur Springs	Annually
<b>CR-16.7</b>	Colorado River upstream of Williams Fork	Annually
<b>CR-9.1</b>	Colorado River at CR39 Bridge at KB Ditch	1x per 2-3 years
<b>CR-7.4</b>	Colorado River downstream of Troublesome Creek	TBD
<b>CR-1.7</b>	Colorado River upstream of the Blue	TBD

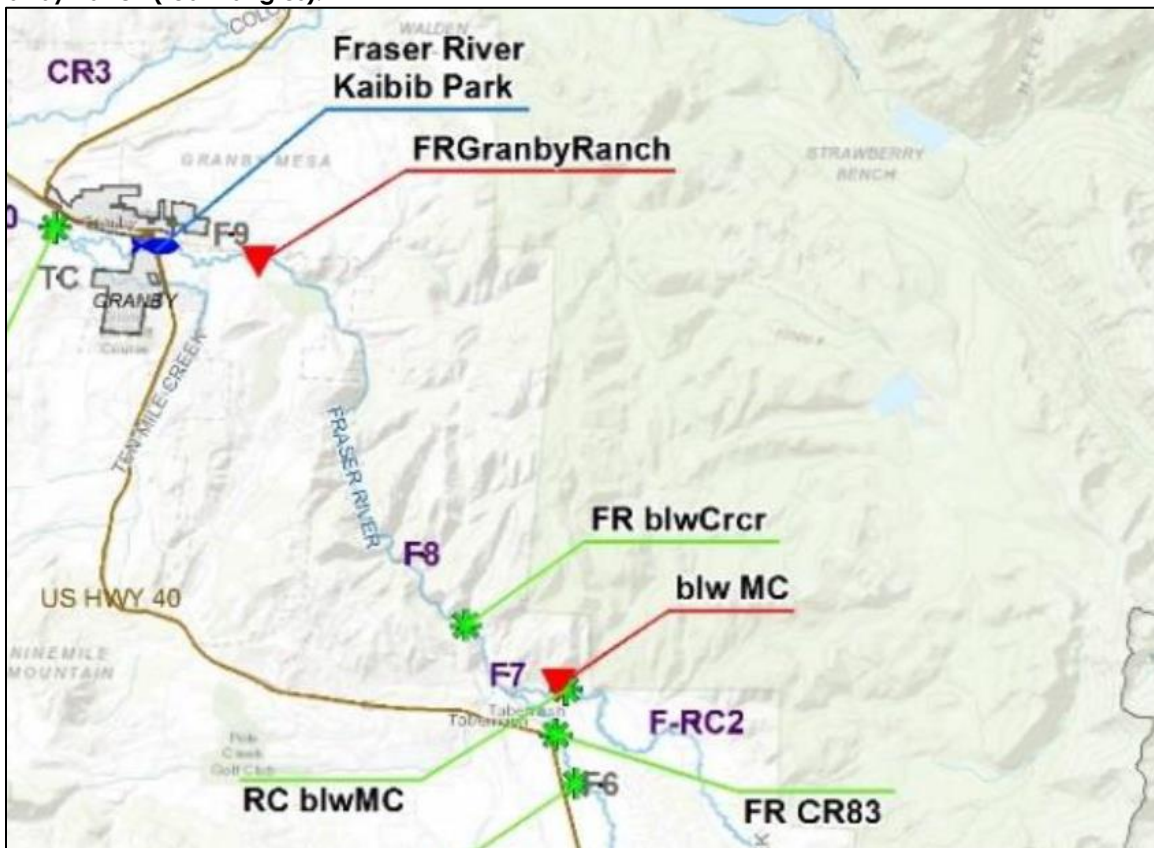
<sup>3</sup> Tetra Tech and HabiTech, *Technical Memorandum, 2018 Substrate Monitoring, April 9, 2019*

# LEARNING BY DOING

Table 2 – LBD Core Sampling Reaches for RSI analyses

Reach Designation	Site Description
F9	Fraser River between the canyon and Granby
F-RC2	Fraser River Trib, Ranch Creek (lower)
CR4	Paul Gilbert or Pioneer Park site depending on site conditions
CR5	Downstream of Williams Fork confluence and Parshall
CR6	Downstream of KB Ditch

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



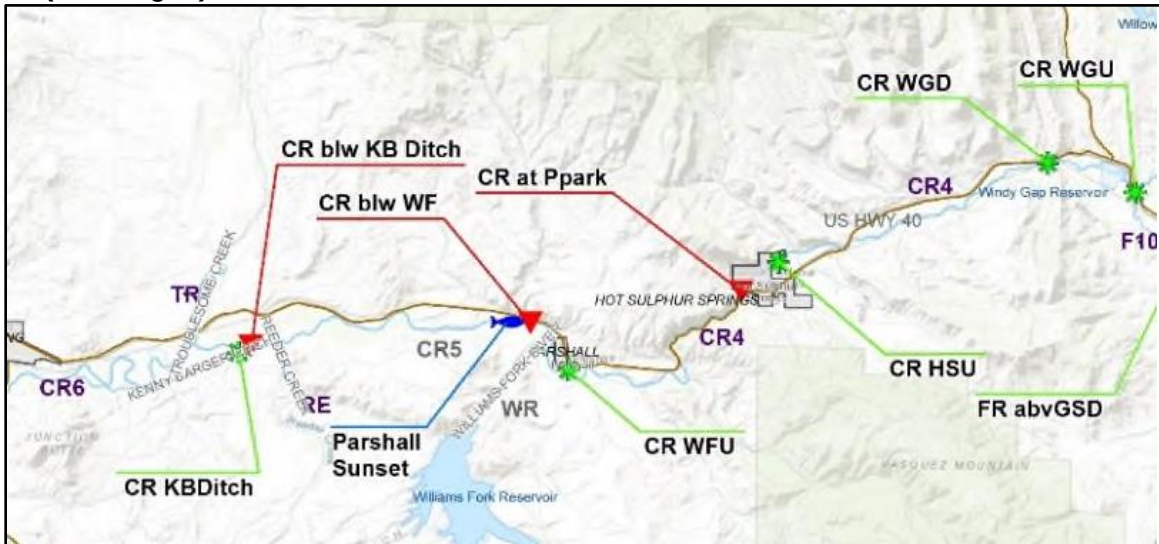
# LEARNING BY DOING

Figure 2 – CR4 Paul Gilbert Core Sample Site



# LEARNING BY DOING

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



## Appendix E – Macroinvertebrate 2019 Monitoring Proposal and Data Gaps Assessment

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# Macroinvertebrate Monitoring Data Gaps Assessment and 2019 Program Proposal

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The following is the Learning By Doing (LBD) Monitoring Subcommittee's (Subcommittee) data gaps assessment and proposal for 2019 macroinvertebrate monitoring within the LBD Cooperative Effort Area (CEA). The proposal includes an overview of the 2017 and 2018 macroinvertebrate monitoring program, Denver Water's and Northern Water's Municipal Subdistrict's (Subdistrict) 2019 macroinvertebrate monitoring plans and the Subcommittee's recommendations on 2019 monitoring needs within the CEA.

Macroinvertebrate monitoring through LBD is intended to supplement existing monitoring efforts and to fill in identified data gaps.

The proposed objectives of the 2019 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 2019. This information is provided for context since the LBD macroinvertebrate monitoring program is intended to supplement existing monitoring efforts.

### *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 Moffat Project and Windy Gap Firming Project 401 Certifications<sup>1,2</sup>.

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 also annually monitors an additional site that is not part of the 401

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<sup>1</sup> 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.

<sup>2</sup> 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.

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 2019 monitoring programs for Denver Water and the Subdistrict.

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 2019. 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). The methodology is described in detail in a subsequent section, **Sample Collection and Macroinvertebrate Analysis**.

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. In addition, two MMI scores will be provided; one using the Division's MMI version 3, and one for the Division's updated tool, MMI version 4.

## 2017 and 2018 Macroinvertebrate Monitoring Review

### Monitoring Summary

As of 2018, there were 12 sites included in the LBD monitoring program (Table 2). Five sites are long-term monitoring locations with historic data sets extending prior to 2017, however 2017 was the first year these sites were funded by LBD. Seven sites were added to the LBD program and sampled for the first time in 2018. 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

Table 2 – 2017 and 2018 LBD Macroinvertebrate Monitoring Sites

River Mile ID	Station Description	Monitoring Frequency	Project Specific	Years Sampled
FR-27.2	Fraser River at USGS Upper Station near Berthoud Pass	1x per 2-3 yrs	No	2018
FR-15	Fraser River upstream of Fraser Flats restoration	Annually	Yes	2017,2018
FR-12.4	Fraser River upstream of Fraser Canyon	1x per 2-3 yrs	No	2017
FR-1.9	Fraser River upstream of Granby Sanitation District	1x per 2-3 yrs	No	2017
STC-0	Saint Louis Creek at Fraser River	1x per 2-3 yrs	No	2018
RC-1.1	Ranch Creek downstream of Meadow Creek	Annually	No	2017,2018
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	1x per 2-3 yrs*	Both	2017,2018
CR-7.4	Colorado River downstream of Troublesome Creek	TBD	Yes	2018
CR-1.7	Colorado River upstream of the Blue River	TBD	Yes	2018
WF-13.1	Williams Fork downstream of Henderson Mill	1x per 2-3 yrs	No	2018
WF-5.5	Williams Fork upstream of Williams Fork Reservoir	TBD	Yes	2018
WF-2	Williams Fork downstream of Williams Fork Reservoir	TBD	Yes	2018

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

### 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 fairly 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 health 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.

Based on these guidelines, six sites in the LBD program are sampled on a rotating basis every 2 - 3 years (Table 2).

There are four sites in the LBD program where long-term sampling frequency has not yet been determined based on insufficient data sets and/or ongoing restoration efforts. These sites are recommended for sampling again in 2019 (at a minimum) in order to establish baseline conditions.

### *Data Collection and Analysis*

Timberline Aquatics collected the samples and conducted the analyses in both 2017 and 2018. Samples were collected with a Hess sampler utilizing protocols approved by the 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). The methodology is described in detail in a subsequent section, **Sample Collection and Macroinvertebrate Analysis**.

### *2017 and 2018 Results Summary*

Nine metrics were calculated in 2017, and 10 metrics were calculated in 2018 for each sample (Table 3). The metrics include Colorado's Multi-Metrix Index (MMI) which is a Colorado specific tool developed by the Division for quantitative bioassessments. For each site 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<sup>3</sup>.

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<sup>3</sup> 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.

Table 3 - 2017 and 2018 Macroinvertebrate Metrics

Metric	Description
<b>Multi-Metric Index (MMI)*</b>	Colorado Division of Water Quality assessment tool. Provides a score which determines health of aquatic community (Scores for V3 and V4)
<b>% Chironomidae (MMI Metric)</b>	MMI score based on percent composition of chironomidae taxa. Chironomidae are tolerant to stress, a high score indicates a stressed environment.
<b>% EPT excluding Baetis (MMI Metric)</b>	MMI score based on a classification of species specific to Colorado which are sensitive to zones that transition from pristine to anthropogenic. Based on community composition rather than the richness of sensitive taxa.
<b>Ephemeroptera Plecoptera Trichoptera (EPT)*</b>	Total number of distinguishable taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera.
<b>Hilsenhoff Biotic Index (HBI)*</b>	Indicator of nutrient enrichment as well as other stressors.
<b>Shannon Diversity Index (SDI)*</b>	Indicator of macroinvertebrate community structure and balance.
<b>Total Taxa Richness</b>	Total number of identifiable taxa, indicator of general community health and stability.
<b>Pteronarcys Californica Density</b>	Pteronarcys Californica abundance, mean number per square meter.
<b>Total Density</b>	Macroinvertebrate abundance, mean number per square meter.
<b>Tolerance Indicator Value (TIV<sub>sed</sub>) *</b>	A biological indicator of impacts by excess fine sediments. The TIV <sub>SED</sub> reflects both the reduction in relative abundance of sediment-sensitive taxa and the increase in relative abundance of sediment-tolerant taxa.

**\*Key Measurable Indicator**

Two MMI scores were provided in 2018; one using the Division's MMI version 3 (v3), and one using the Division's updated tool, MMI version 4 (v4), which was adopted by Colorado's Water Quality Control Commission in August 2017. The base metrics and threshold values (Table 4) for MMI v4 are different than those for MMI v3; therefore, 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
<b>Attainment</b>	52.0 - 100.0	45.3 - 100.0
<b>Grey Zone</b>	42.0 - 52.0	33.7 - 45.2
<b>Impaired</b>	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 placed on the Monitoring & Evaluation List.

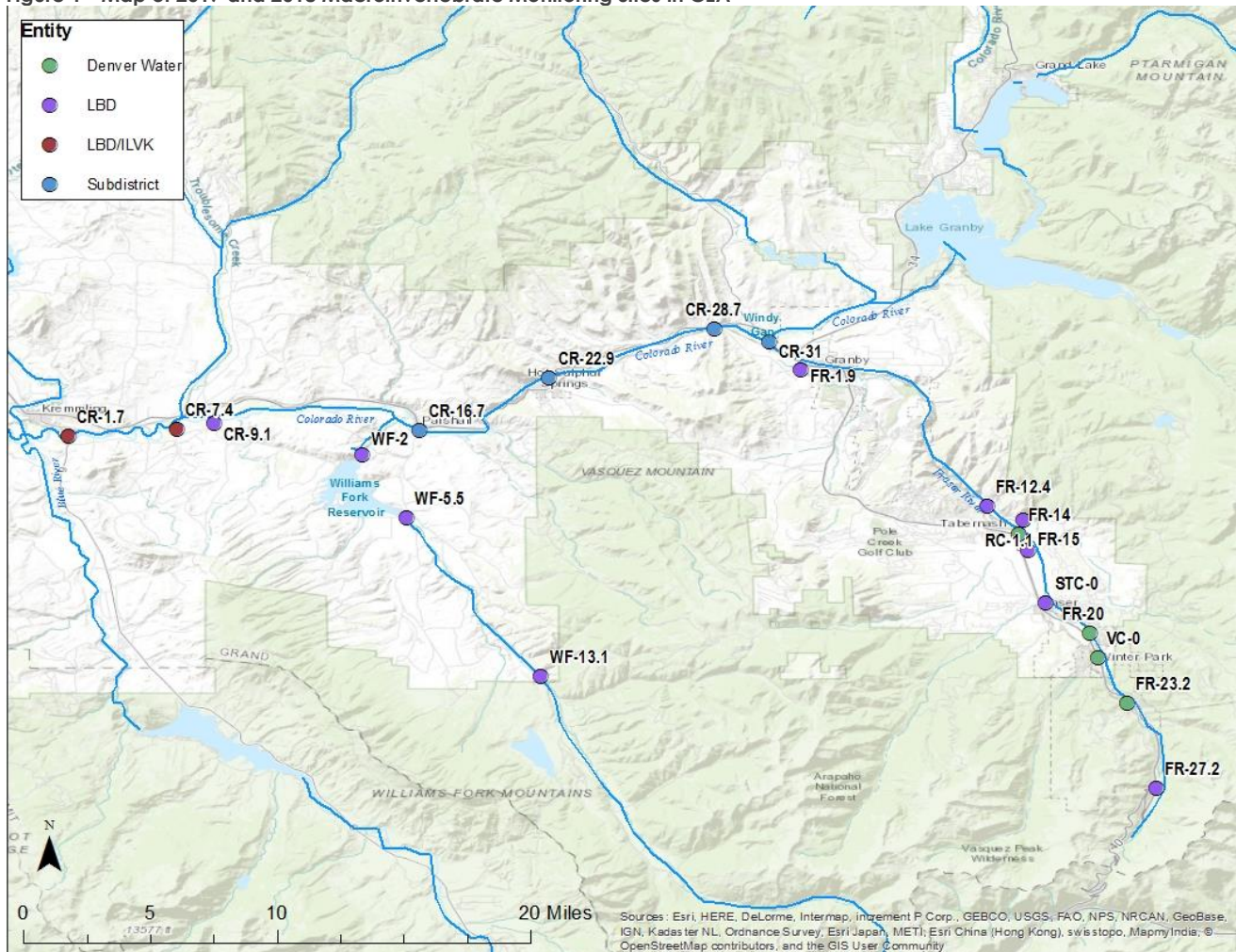
Table 5 summarizes 2017 and 2018 MMI scores for all sites in the CEA (LBD, Denver Water and Northern Water). Figure 1 is a map of the sites.

Table 5 – Macroinvertebrate 2017 and 2018 MMI Scores at all sites in CEA

River Mile ID	Station Description	Entity	2017 MMI v3	2018 MMI v3	2018 MMI v4
<b>FR-27.2</b>	Fraser River at USGS Upper Station near Berthoud Pass	LBD	--	54.1	74.5
<b>FR-23.2</b>	Fraser River upstream of Winter Park San District	DW	32.9	40.5	49.8
<b>FR-20</b>	Fraser River at Rendezvous Bridge	DW	35.2	38.6	42
<b>FR-15</b>	Fraser River upstream of Fraser Flats restoration	LBD	48	54.8	67.8
<b>FR-14</b>	Fraser River upstream of Tabernash	DW	65.4	68.1	79.7
<b>FR-12.4</b>	Fraser River upstream of Fraser Canyon	LBD	69.1	--	--
<b>FR-1.9</b>	Fraser River upstream of Granby Sanitation District	LBD	86.9	--	--
<b>VC-0</b>	Vasquez Creek at the town of Winter Park	DW	--	59.6	55.1
<b>STC-0</b>	Saint Louis Creek at Fraser River	LBD	--	67.4	66.5
<b>RC-1.1</b>	Ranch Creek downstream of Meadow Creek	LBD	58.9	70.3	76.8
<b>CR-31</b>	Colorado River upstream of Fraser and Windy Gap	NW	66.6	70.2	73.9
<b>CR-28.7</b>	Colorado River downstream of Windy Gap	NW	74.6	72.3	80.4
<b>CR-22.9</b>	Colorado River upstream of Hot Sulphur Springs	NW	77.7	64.6	75.4
<b>CR-16.7</b>	Colorado River upstream of Williams Fork	NW	78.8	72.7	78.6
<b>CR-9.1</b>	Colorado River at CR39 Bridge at KB Ditch	LBD	73.2	72.3	79.5
<b>CR-7.4</b>	Colorado River downstream of Troublesome Creek	LBD/ILVK	--	75.2	86.2
<b>CR-1.7</b>	Colorado River upstream of the Blue River	LBD/ILVK	--	50.2	43.2
<b>WF-13.1</b>	Williams Fork downstream of Henderson Mill	LBD	--	54.1	75.4
<b>WF-5.5</b>	Williams Fork upstream of Williams Fork Reservoir	LBD	--	51.4	63.5
<b>WF-2</b>	Williams Fork downstream of Williams Fork Reservoir	LBD	--	13.7	44.2

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

Figure 1 - Map of 2017 and 2018 Macroinvertebrate Monitoring Sites in CEA



## Monitoring Subcommittee Recommendations for 2019 Monitoring

### 2019 Monitoring Recommendations for Existing Sites

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

- FR-27.2 – This site was added in 2018 to expand data collection into Segment COUCUC10a\_C, Fraser River tributaries at and above Jim Creek. This segment is on the 303d list of impaired waters for aquatic life use (macroinvertebrates). MMI scores for data collected in 2018 show attainment. The recommended monitoring frequency for this site is every 2 – 3 years.
- 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. Although this site's MMI scores have varied over the last 3 years, the 2017 score was well above the attainment threshold. Additionally, Denver Water will collect annual macroinvertebrate samples at a site located 1.6 river miles upstream (FR-14). Macroinvertebrate data from FR-14 will be a good indicator of conditions at FR-12.4. Consider monitoring in 2020.
- FR-1.9 – Maintain monitoring frequency every 2 – 3 years. Data were not collected at this site in 2018. Monitoring recommended in 2019.
- 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 – This site was added to the program in 2018 to obtain a baseline of data on Saint Louis Creek. MMI scores for data collected in 2018 show attainment. The recommended monitoring frequency for this site is every 2 – 3 years.
- CR-9.1 – Recommended monitoring frequency at this site is every 2 – 3 years. MMI scores from 2011-2018 were all above the attainment threshold. Since this site is upstream of the ILVK restoration project, annual monitoring is recommended until the project and post-project assessment period is complete.
- 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 – This site was added in 2018 to collect a baseline of data downstream of the Henderson Mill. MMI scores for data collected in 2018 show attainment. The recommended monitoring frequency for this site is 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.
- WF-2 – Continue annual monitoring. This site is monitored to assess the effectiveness and improvements of the Denver Water restoration efforts. In addition, MMI scores from 2018 were in the grey zone.

### 2019 Proposed New Sampling Sites

Fraser River upstream of the UP Moffat Tunnel discharge – There are known water quality issues related to the unauthorized discharges from Union Pacific Railroad (UPRR). The effect of this on the macroinvertebrate community is unknown. The monitoring subcommittee's recommendation is that an upstream site closer to the discharge be added to establish a baseline of data which can be used to compare to conditions downstream or in cases of unauthorized discharges.

Fraser River downstream of UP Moffat Tunnel discharge – This recommendation is a placeholder for an emergency sampling event to be collected in case of a spill or unauthorized discharge event by UPRR. Funding will be set aside so that sampling can be done in a timely matter if needed.

Williams Fork at Kemp Breeze, upstream of the confluence of the Colorado River – This site is near a Denver Water restoration project. Data collected in 2019 will represent pre-project conditions.

### Summary of 2019 Proposed Sampling Sites

The Monitoring Subcommittee recommends macroinvertebrate monitoring at 10 sites in 2019, including 2 new monitoring locations (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 2019 is not recommended at four sites in the monitoring program as the monitoring frequency at these sites is every 2-3 years.

Table 6 - Proposed 2019 macroinvertebrate monitoring sites

River Mile ID	Station Description	Proposed for 2019	New Site
<b>FR-26</b>	Fraser River upstream of UP Moffat Tunnel discharge	X	X
<b>FR-15</b>	Fraser River upstream of Fraser Flats restoration	X	
<b>FR-1.9</b>	Fraser River upstream of Granby Sanitation District	X	
<b>RC-1.1</b>	Ranch Creek downstream of Meadow Creek	X	
<b>CR-9.1</b>	Colorado River at CR39 Bridge at KB Ditch	X	
<b>CR-7.4</b>	Colorado River downstream of Troublesome Creek	X	
<b>CR-1.7</b>	Colorado River upstream of the Blue River	X	
<b>WF-5.5</b>	Williams Fork upstream of Williams Fork Reservoir	X	
<b>WF-2</b>	Williams Fork downstream of Williams Fork Reservoir	X	
<b>WF-0.5</b>	Williams Fork downstream WF Reservoir at Kemp Breeze	X	X
<b>FR-27.2</b>	Fraser River upstream of Jim Creek and Mary Jane entrance		
<b>FR-12.4</b>	Fraser River upstream of Fraser Canyon		
<b>STC-0</b>	Saint Louis Creek at Fraser River		
<b>WF-13.1</b>	Williams Fork downstream of Henderson Mill		

## Sample Collection 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, samplers, and laboratories make it difficult to perform trend analyses or compare data between sites sampled through separate programs. Denver Water and Northern Water will maintain consistent sampling methodology and analysis as was done in 2017 and 2018, including:

- 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<sup>4</sup>.
- 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.

In order to preserve the integrity of the dataset being developed by LBD and to allow integration with and comparison to Denver Water's and Northern Water's 2019 macroinvertebrate monitoring, the Monitoring Subcommittee recommends monitoring done for LBD in 2019 maintain consistent methodologies, regardless of the consultant selected for macroinvertebrate sampling and identification.

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<sup>4</sup> 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.