DRAFT REPORT
2017 MONITORING REPORT

GRAND COUNTY, COLORADO

Prepared for:

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with support from
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EXECUTIVE SUMMARY

Fraser River

2017 spring runoff in the Fraser River and Ranch Creek exceeded the magnitude and duration of the recommended flushing flows for the fourth consecutive year. Spawning bar habitat on both the Fraser River and Ranch Creek were in good condition with embeddedness the lowest recorded since monitoring began in 2010. Neither spawning bar was impaired by finer sediments (<8mm) based on the Colorado Water Quality Control Commission (CWQCC 2014) guidelines as outlined in Policy 98-1 (CWQCC guidelines). Riffle bed material mobilization occurred on both streams as it had in 2014, 2015 and 2016. Riffle Stability Index analyses indicated bed material up to small cobble size had been transported, with an estimated 34 to 43% of the riffle substrates mobilized. These findings are supportive of observations that flows in the range of the 3-year return interval, estimated to be 1,072 cubic feet per second for the Fraser River at Granby, Colorado, can initiate cobble mobilization and riffle maintenance.

The Ranch Creek macroinvertebrate community has remained quite stable in recent years and has consistently attained its aquatic life use designation. Fraser River sites have shown more variability. Overall, the health of the Fraser River watershed macroinvertebrate community was the best in the downstream sites. The site downstream of Granby has consistently achieved the highest Colorado Multi-Metric Index (MMI) scores and attained its aquatic life use designation in all sample years and provides habitat for giant stoneflies. Upstream, the 2017 macroinvertebrate sites have been found to be impaired in at least one sample year. In 2017, both the above Winter Park and Rendezvous Bridge sites failed to attain their aquatic life use designation. All riffle habitats sampled in 2017 were well below the CWQCC guidelines threshold for fine sediment impairment (<2 mm).

Trout populations at both the Kaibab Park and the Safeway stations once again exceeded Colorado Parks and Wildlife (CPW) Gold Medal benchmarks in 2017 (Ewert 2018a). At Fraser Flats both trout biomass and quality trout density exceed pre-project levels. The trout population at Confluence Park has shown the greatest variability of the Fraser River stations with both trout biomass and quality trout numbers below the Gold Medal biological benchmarks, with brook and brown trout out-competing stocked rainbow trout. No fish sampling was conducted on Ranch Creek in 2017.

Colorado River

2017 spring runoff in the Colorado River exceeded the magnitude and duration of the recommended flushing flows for the fourth consecutive year. All four spawning bars sampled on the Colorado River were exceptionally clean, with little embeddedness. None of the bars were impaired by finer sediments based on the CWQCC guidelines. Riffle bed material mobilization occurred at all four sites, as it had in 2014, 2015 and 2016, with particles up to medium cobble transported and an estimated 40 to 50% of riffle substrates potentially mobilized. These findings are supportive of 2016 observations that flows in the range of the 3-year return interval, estimated

to be 3,890 cubic feet per second for the Colorado River at Kremmling, Colorado, can initiate cobble mobilization and riffle maintenance.

Overall, the health of the Colorado River macroinvertebrate community appeared satisfactory in 2017, with all sites attaining their designated aquatic life use. Giant stoneflies were collected immediately below Windy Gap for the first time since the LBD macroinvertebrate monitoring began. All riffle habitats sampled in 2017 were well below the CWQCC guidelines threshold for fine sediment impairment. Fish population sampling was only conducted at the Parshall-Sunset station in 2017, with trout biomass and density consistently excellent, similar to 2015 and 2016 levels (Ewert 2018b). However, quality trout numbers (trout greater than 14 inches in length) continue to decline. CPW has raised concerns that this reach of the Colorado River is uncomfortably close to not meeting Gold Medal standards and is a fishery in decline due to long-term trout forage base and habitat degradation.

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List of Acronyms

Acronym or Abbreviation	Full Phrase or Description
cfs	Cubic feet per second
CPW	Colorado Parks and Wildlife
CR4	Colorado River, Fraser River confluence at Windy Gap to Williams Fork confluence
CR4[1]	Colorado River downstream of Windy Gap at Chimney Rock
CR4[2]	Colorado River at Paul Gilbert CPW
CR4[3]	Colorado River below Pioneer Park at Hot Sulphur Springs.
CR5	Colorado River, Williams Fork to KB Ditch
CR6	Colorado River, KB Ditch to Blue River Confluence
CR7	Colorado River, Blue River Confluence to County Line
CWQCC	Colorado Water Quality Control Commission
EPT	Ephemeroptera, Plecoptera, and Trichoptera
F9	Fraser River, Canyon to Granby
F-RC2	Fraser River Trib, Ranch Creek (lower)
HBI	Hilsenhoff Biotic Index
LBD	Learning By Doing
MMI	Colorado Multi-Metric Index
RSI	Riffle Stability Index
SDI	Shannon Diversity Index
SMP	Grand County Stream Management Plan
STE	Survival-To-Emergence
Q_{FF}	Flushing flow, cubic feet per second
Qp	Peak flow, cubic feet per second

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1 INTRODUCTION

The field sampling and analysis described in this monitoring report are undertaken in support of the draft Grand County Stream Management Plan (SMP) (Tetra Tech et al. 2010) and the "Learning By Doing" (LBD) Cooperative Effort. Members of the LBD Management and Technical Committees include Grand County (GC), Denver Water (DW), Northern Colorado Water Conservancy District – Municipal Subdistrict (Northern Water), Middle Park Water Conservancy District (MPWCD), Colorado River Water Conservation District (CRWCD), Colorado Parks and Wildlife (CPW), and Trout Unlimited (TU).

This monitoring effort was originally initiated 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.

Beginning in 2014, the LBD Management Committee requested the scope of the annual monitoring report be expanded to also include the results of macroinvertebrate and fish sampling being conducted by several of the LBD partners. The macroinvertebrate and fish sampling in combination with the habitat monitoring will provide a baseline of conditions to assist in detecting changes over time and to evaluate future projects. The goal of this report has been to provide a more comprehensive description of the health of the aquatic community and the habitats which support it, with a focus on changes relative to flow, spawning habitat quality and other pertinent habitat features.

For 2017, specific study objectives were to:

1. Continue to monitor surface substrate conditions and riffle stability at six long-term spawning bar sites on the Fraser and Colorado Rivers and Ranch Creek;
2. Report on the existing data and results for macroinvertebrate communities at 12 sites on these three streams;
3. Report on the current status of fish populations on the Fraser and Colorado Rivers based on sampling by CPW, and
4. Discuss trends and potential relations between habitat conditions, the benthic community, fish populations, and stream flow regimes relative to the proposed flushing flow recommendations and other LBD management actions.

The surface substrate conditions and riffle stability results stemming from Objective 1 can be used to evaluate the draft flushing flow recommendations, assess the condition of spawning gravel environments to promote survival–to-emergence (STE) of larval trout, investigate stream flows that may be needed periodically to maintain riffle habitat quality, and evaluate effects of LBD management actions. The results of the macroinvertebrate sampling program (Objective 2) inform on trends and changes to the health of the macroinvertebrate communities and can be used to assess compliance with Colorado's aquatic life standard, and evaluate effects of LBD restoration efforts. Likewise, the information generated from Objective 3 can help to inform the LBD on the trends

and changes in the size, health and status of Fraser and Colorado River fish populations and their response to various water, sediment and channel management activities.

Objective 4 covers the discussion of trends and potential relations between habitat conditions, the benthic community, fish populations, and stream flow regimes relative to the proposed flushing flow recommendations and other LBD management actions, and is integrated into the results presented for Objectives 1 to 3.

This report presents the results of the 2017 monitoring and where applicable, compares current with past conditions. The Methods section of the report is organized by objective, while the Results and Discussion chapter, at the request of the LBD in 2016, is organized by major river systems. The Results and Discussion chapter addresses all four objectives and includes a variety of topics such as an evaluation of spawning habitat quality within the context of spring runoff flows and the draft flushing flow recommendations, an assessment of Grand County spawning habitat conditions, and a discussion of the current condition and status of the aquatic communities in both the Fraser and the Colorado Rivers.

2 METHODS

2.1 Objective #1 – Spawning Habitat Monitoring

2017 field sampling was conducted during the week of September 6 at four long-time sampling sites on the Fraser River, Ranch Creek and Colorado River (F9, F-RC2, CR4[4] and CR6), while work at CR5 and CR7 could not be completed until October 27 due to extended high flow releases from William's Fork and Green Mountain Reservoirs. Site descriptions and locations are provided in **Table 1** and **Figure 1**, while the sampling chronology at each of these trout spawning stations is provided in **Appendix A**.

Pebble counts were made at each spawning site to describe the composition of the streambed surface and in particular to document the degree of embeddedness by finer sediments for each of the 100 measured particles. Pebble counts were made following the procedure described by Wolman (1954) and Kappesser (2002), and were in accordance with the guidance provided by the CWQCC in Policy 98-1 (CWQCC guidelines) for the sampling of small, targeted stream habitat types such as the trout spawning bars specifically identified for this study. A surface particle was recorded as embedded if the particle diameter was more than 50% covered by finer sediments. The 50% criterion was based upon the relationship between density of juvenile salmonids and the percent embeddedness of the substrate as reported in Bjornn and Reiser (1991), as well as the embeddedness rating system presented in Bain and Stevenson (1999). In this system, 50%is the lower threshold for the "high" embeddedness classification. The presence of aquatic vegetation at each particle measured was also noted and site photographs were taken to document conditions. McNeil-Ahnell core samples were not collected in 2017 for the LBD monitoring because streamflow was forecast to be similar to recent years and no differences were expected in the inter-gravel environments being sampled.

Riffle Stability Index (RSI) (Kappesser 2002) analyses were also performed in 2017 at each of these six sites because the magnitude and duration of spring runoff flows had been sufficient to cause substantial bed-material mobilization and bar deposition. RSI measurements were taken at a riffle-point bar complex adjacent to or near the measured spawning bar and consisted of a 200-count pebble count within the riffle and the measurement of the 30 largest recently deposited sediment particles on the point bar. A particle size distribution plot was then developed from the measured riffle particles and the mean diameter of the largest point bar particles was calculated. Entering the distribution plot with the mean diameter, the percentage of riffle particles that potentially were mobilized during the preceding spring runoff was determined. Examples of these plots are provided in the Results chapter of this report and include comparisons to previous year's results. Note that there were no RSI analyses were performed in 2012 and 2013 as inspection of spawning bar substrates and adjacent point bars indicated the magnitude and duration of spring runoff flows had not been sufficient to cause substantial bed material mobilization and bar deposition. The RSI protocol is intended for use only following runoff events of sufficient magnitude and duration to cause scour and deposition of coarse bed materials.

2.2 Objective #2 – Macroinvertebrate Sampling

The primary objective of macroinvertebrate data collection is to assess the health of the aquatic community. One way this can be accomplished is with the Colorado Multi-Metric Index (MMI) which was developed by the Colorado Water Quality Control Division (CWQCC) to assess compliance with aquatic life use standards. The MMI is Colorado specific for use across a range of stream classes (e.g., Class 1 – Cold Water, Class 1 – Warm Water, Class 2- Cold and Warm Water) and biotypes (Transition, Mountains, Plains & Xeric). The MMI is composed of separate indices calibrated to respond to stressors affecting aquatic communities in one of these three analytically defined biotypes (CDPHE 2010). MMI's are calibrated for each biotype with each index composed of several metrics selected to represent categories of community characteristics including richness, composition, functional feeding group, mode of locomotion and pollution tolerance. Each metric is scaled from 0 (worst case) to 100 (best case) and these values are then mathematically combined to generate an overall MMI score also scaled from 0 to 100. Aquatic life use thresholds for MMI scores are then applied to determine if a water body is attaining its use or if it is impaired.

Since data collection began (see **Table 3**) there has been a lack of standardization in macroinvertebrate sample collection and analytical procedures. This leads to difficulty in making temporal and spatial comparisons between results. LBD felt there was a need to a standardized approach for sampling and analytical protocols, and documentation of previous protocols that were used. Two documents have been generated by LBD:

1. A table describing the sampling protocols, timing, and analytical procedures used by different LBD partners in recent years (**Table 3**); and
2. Grand County's Learning By Doing 2017 Macroinvertebrate Sampling Program which appears in **Appendix B**.

The MMI requires specific sampling and analytical protocols to be followed to produce the most representative MMI scores. While an MMI score can be calculated using a variety of sampling and analytical protocols, caution should be used when comparing the resulting MMI scores as they may not be totally comparable to those calculated following the protocol specific to the tool. Table 3 shows the various sampling protocols and analytic protocols that have been used to calculate MMI scores since 2011. The CWQCC and Timberline are the only two entities that have followed the MMI specific protocol. The BLM sampling and analytical methods are used nationally in BLM's Assessment, Inventory, and Monitoring (AIM) program, but a formal comparison of results obtained using BLM sampling and analytical protocols versus results from CDPHE methods has not been conducted. The same holds true for the CPW sample and analytical methods. MMI results obtained using these sampling and analytical protocols are likely to be different, and caution is needed when comparing metrics between samples collected by different entities at different times.

2017 LBD macroinvertebrate sampling was conducted by Timberline Aquatics, Inc., Fort Collins, Colorado on September 18 at 12 riffle sites on the Fraser River (6 sites), Ranch Creek (1 site), and Colorado River (5 sites). These sites are described in **Table 2** and their location is shown on **Figure 1**. A detailed description of the sampling and analysis procedures followed in 2017 is provided in the document entitled, "Grand County's Learning By Doing 2017 Macroinvertebrate Sampling Program", in **Appendix B**.

Also in 2017, one macroinvertebrate sample was collected at site CR7 (Tables 1 and 2; Figure 1) by Grand County Water Information Network (GCWIN) personnel on October 27 in support of Grand County's monitoring effort for the Gore Canyon Whitewater Feature. This sample was collected and analyzed following the procedures described in the 2016 LBD monitoring report (Tetra Tech and HabiTech, 2017) and results are reported herein. In addition, CPW's 2017 macroinvertebrate sampling program included 8 sites upstream and downstream of Windy Gap Reservoir with 7 sites on the Colorado River and one site on the Fraser River. These samples have been collected to establish baseline conditions in support of the proposed connectivity channel around Windy Gap Reservoir. Results are not yet available for inclusion in this annual monitoring report, but will be presented in CPW's annual Federal Aid Report at a later date.

MMI Version 3.0 was used to calculate MMI scores for the 2017 macroinvertebrate data collected by both Timberline Aquatics, Inc. and GCWIN and developed by CDPHE.

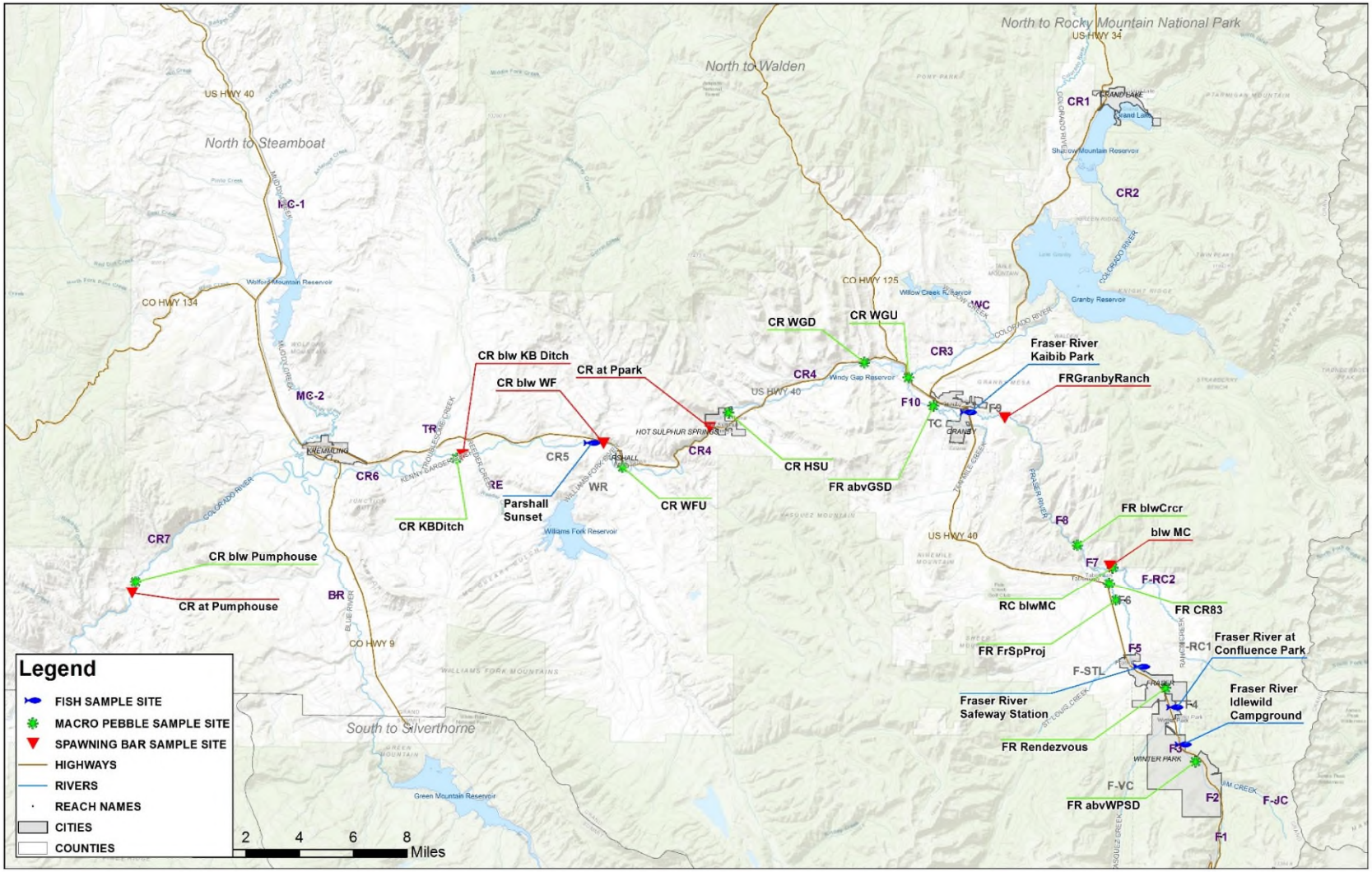


Figure 1 Site map

Table 1 Locations for the six spawning bar sites sampled in 2017.

SMP Reach	Site Name	Description	Latitude	Longitude	Elevation (m)	Years
F-RC2	RC blw MC	Ranch Creek below Meadow Creek (Miller Property)	39.999722	-105.82958	2542	2010-17
F9	FR GranbyRanch	Fraser River at Granby Ranch below golf course	40.079089	-105.904255	2443	2010-17
CR4[3]	CR at Ppark	Colorado River at Pioneer Park	40.072185	-106.111498	2341	2014-17
CR5	CR Blw WF	Colorado River below Williams Fork near Game Warden House	40.062829	-106.186273	2279	2010-17
CR6	CR Blw KB Ditch	Colorado River below KB Ditch	40.055494	-106.285214	2249	2010-17
CR7	CR Blw Pumphouse	Colorado River below Pumphouse below campground area	39.978197	-106.515681	2117	2011-17

Table 2 2017 LBD macroinvertebrate sites in the LBD study area sampled September and October, 2017.

SMP Reach	River Mile ID	Site Name	Description	Latitude	Longitude	Elevation (m)	Collected Sample
F2	FR 23.2	FR abvWPSD	Fraser River upstream of Winter Park Sanitation District	39.8945	-105.7682	2878	Timberline
F4	FR 20	FR Rendezvous	Fraser River at Rendezvous Bridge	39.9341	-105.7896	2678	Timberline
F6	FR 15	FR FrSpProj	Fraser River upstream of Fraser Flats restoration	39.9813	-105.8249	2372	Timberline
F6	FR 14	FR CR83	Fraser River upstream of Tabernash below bridge on CR83	39.9905	-105.8299	2558	Timberline
F-RC2	RC 1.1	RC blwMC	Ranch Creek downstream of Meadow Creek	39.9991	-105.8275	2561	Timberline
F7	FR 12.4	FR blwCrcr	Fraser River downstream of Crooked Creek	40.011	-105.8524	2500	Timberline
F10	FR 1.9	FR abvGSD	Fraser River upstream of Granby Sanitation District	40.0853	-105.9546	2420	Timberline
CR3	CR 31	CR WGU	Colorado River upstream of Fraser and Windy Gap	40.1005	- 105.9725	2401	Timberline
CR4	CR 28.7	CR WGD	Colorado River downstream of Windy Gap	40.1083	-106.0036	2374	Timberline
CR4	CR 22.9	CR HSU	Colorado River upstream of Hot Sulfur Springs	40.0803	-106.0986	2341	Timberline
CR4	CR 16.7	CR WFU	Colorado River upstream of Williams Fork	40.0503	-106.1725	2305	Timberline
CR6	CR 9.1	CR KBDitch	Colorado River at CR39 Bridge at KB Ditch	40.0538	-106.2895	2285	Timberline
CR7		CR blw Pumphouse	Colorado River below Pumphouse at Campsite 11	39.9845	-106.5134	2118	GCWIN

Table 3 Summary of macroinvertebrate sampling protocols used by LBD partners on the Fraser and Colorado Rivers and Ranch Creek, 2008-2017. Table content, except Sample Type, provided by Northern Colorado Water Conservancy District.

Entity	Sampling Device	Sampling Protocol	Analytical Protocol	Maximum Organisms Counted
BLM	Hess Sampler	Collect samples at 8 cross sections, fully scrubbing rocks that are with in the sampler area. Combine the 8 samples into a single sample for analysis.	A grid subsample of 600 organisms	600
CDPHE	Kick Net	Collect one sample by kicking substrate for 60 seconds.	A grid subsample of 300 organisms	300
CPW	Hess Sampler	5 replicate samples @ each site fully scrubbing rocks inside a Hess Sampler (0.086 m^2) with a 350 µm mesh net ; 0.43 m^2 area sampled. Samples collected from wthe same riffle with predominant cobble substrate, and disturbance of streambed to 10 cm.	5 samples per site analyzed separately using the standard USGS 300-count protocol (see Moulton et al. 2000)	1500
Timberline	Hess Sampler	3 replicate samples @ each site, fully scrubbing rocks inside a Hess Sampler; 0.258 m^2 area sampled. Samples collected from riffle habitat with similar size substrate, depth, and velocity.	3 samples per site analyzed separately; entire sample analyzed by identification to the lowest practical taxonomic level and enumeration of all individuals	Full count

Entity	Year	Sampling Protocol	Analytical Protocol	Funding Sources
GCWIN	2010-2014	CDPHE	CDPHE	EPA & State
GCWIN	2015	CDPHE	BLM	Funding Partners & BLM
GCWIN	2016-2017	BLM	BLM	Funding Partners & BLM
Northern	2008-2017	Timberline	Timberline	Northern
Northern - Select sites Colorado	2010-2017	CDPHE	Both Timberline and CDPHE	Northern

The 2017 macroinvertebrate sampling sites on the Fraser and Colorado Rivers, and Ranch Creek, are classified as Class 1 – Cold Water and are in the Transition biotype. Given this designation, the metrics comprising the MMI include the number of mayfly and stonefly (Ephemeroptera and Plecoptera) taxonomic groups present in a sample (the number typically declines with increasing perturbation); the percent of individual organisms that are midge (Chironomid) larvae (typically increases with increasing perturbation); the percent of sensitive families represented (typically decreases with increasing perturbation); the number of predator and shredder taxa (typically decreases with increasing perturbation); the number of clinger taxa (typically decreases with increasing perturbation); and the percent of non-insect taxa present (typically increases with increasing perturbation). Additional explanation of these metrics and the 2017 results are provided in **Appendix B**.

The attainment threshold for the transition biotype is a score of 52, while the impairment threshold is a score of 42 or less. If a score falls in the "gray zone" between 42 and 52, the Hilsenhoff Biotic Index (HBI) and the Shannon Diversity Index (SDI) scores are used to determine if a site has attained use or is impaired. The HBI is a widely-used indicator of organic pollution with high values (>5.4) indicating a predominance of tolerant species (i.e., sensitive species have been lost) and an impaired macroinvertebrate community. SDI values typically range from about 1.5 to 4.0, with high SDI scores (>2.4) indicating a good diversity of species present and a healthier community. If a "gray zone" site fails to meet either of these criteria, it is considered impaired.

Additional metrics provided by Timberline Aquatics, Inc. and GCWIN for each site were the total density of macroinvertebrates (# per m^2), taxa richness (the total number of taxonomic groups represented, typically decreases with increasing perturbation), EPT (the number of mayfly, stonefly and caddisfly taxa present, typically decreases with increasing perturbation), the density of *Pteronarcys californica* (# per m^2, typically decreases with increasing perturbation), the percent EPT excluding family Baetidae (typically decreases with increasing perturbation), and percent Chironomidae (midge larvae, typically increases with increasing perturbation). Again, variation in these metrics may be present because of the different sample collection and analytical methods used by Timberline Aquatics and GCWIN.

A 100-count pebble count was conducted by Tetra Tech during the week of September 6 at riffles in close proximity to 2017 macroinvertebrate sample sites where collections were made by Timberline and GCWIN. Some of these riffle sites are located in the same location as the spawning bar sites, and results are used for both the pebble count and RSI analysis. Embeddedness of each measured particle was evaluated and the presence of aquatic vegetation noted.

2.3 Objective #3 – Fish Sampling

Fish population data were provided in early 2018 by Mr. Jon Ewert, CPW Fisheries Biologist, Hot Sulphur Springs, CO (see Ewert 2018a and 2018b in Appendix C). Fraser River 2017 fish collections were made in September and October at four sites, including Kaibab Park in Granby, Grand County Water and Sanitation District #1 (GCWSD#1) property just upstream of Tabernash, at Safeway in Fraser, and at Confluence Park in Winter Park (**Figure 1**). At each site, mark-recapture population estimates were made by electrofishing while wading. Colorado River 2017

fish collections were made in September at the two-mile Parshall to Sunset monitoring site by raft-mounted electrofishing. A mark-recapture population estimate was made.

2.4 Objective #4 – Trends and Relationships

Where appropriate, statistical analyses were performed using Statistix 10 software (Analytical Software 2013) to investigate trends and relationships between the monitored parameters. For the 2017 analysis, we applied the Wilcoxon Rank Sum Test to compare MMI and other macroinvertebrate metrics between different sample types employed at the same sites and times. Comparisons were also made between MMI values for samples collected in the dry year 2012 with those from more recent wetter years. The significance level was set at $p <= 0.05$. The Wilcoxon Rank Sum Test is a non-parametric procedure that tests for differences in the central values of samples from two independent samples. Non-parametric statistics have been consistently applied since the initiation of this annual monitoring effort due to the lack of normality commonly associated with the distribution of environmental data.

Stream flow data required for the assessment outlined in the four objectives is provisional, obtained from the U. S. Geological Survey (USGS) for gage 09033100 (Ranch Creek below Meadow Creek near Tabernash, CO), gage 09034250 (Colorado River at Windy Gap), and gage 09058000 (Colorado River near Kremmling, CO). Northern Water provided 2017 stream flow data for their gages on Fraser River at Granby, Colorado River at Hot Sulphur Springs, Colorado River near Parshall, and Colorado River below KB Ditch. Flood frequency analysis by the Log Pearson III Method for water years 1986 – 2016 was conducted for the Fraser River at Granby, the Colorado River at Windy Gap, the Colorado River near Parshall, and the Colorado River at Kremmling (http://ponce.sdsu.edu/onlinepearson.php). These analyses can be found in **Appendix A**. The 3-year return interval flow events were estimated for each of these stations by interpolation between the 2- and 5-year events.

Sediment composition in the spawning bars and channel riffles were reviewed and compared to threshold values identified by the CWQCC 2014 guidelines. Threshold values for salmonid spawning habitat protection at spawning bars is based on levels that are less than 20% fines smaller (finer) than 8 mm, and for macroinvertebrate protection these levels are less than 27.5% fines smaller (finer) than 2 mm in the riffles.

3 RESULTS AND DISCUSSION

3.1 Fraser River

3.1.1 2017 Streamflow Regime

2017 spring runoff in the Fraser River watershed was lower than those observed in 2014 to 2016, but 6.5 and 1.6 times higher than those experienced in the dry years of 2012 and 2013, respectively (**Figure 2 and Table 4**). The Fraser River at Granby peaked near mid-June at 1,028 cubic feet per second (cfs), while the peak observed on its tributary Ranch Creek was 272 cfs. The peak on the Fraser has a return interval slightly lower than 3-years based on the 1986 to 2016 period of record (Appendix A). Flows remained high throughout June declining to base levels in July. The recommended flushing flows (Table 4) on the Fraser River and Ranch Creek were exceeded in both magnitude and duration.

3.1.2 Spawning Habitat

The predominant substrate type observed at both the Ranch Creek and Fraser River spawning bar sites in 2017 was coarse gravel (32 – 64 mm), while small cobble was the sub-dominant particle size (64 – 128 mm) (**Table 5**). Both spawning bars were exceptionally clean, with only 5% embeddedness observed at F-RC2 and 2% at F9. Both embeddedness values were the lowest recorded for these sites since monitoring began in 2010 (**Figure 3**) and likely reflect the effects of high spring runoff, which exceeded the flushing flow recommendations at both sites the past several years. Based on the CWQCC 2014 guideline for salmonid spawning habitat protection of less than 20% of surface particles less than 8 mm, neither bar was impaired by sediment. Filamentous green algae were observed at the Ranch Creek site at 38% of the pebble count locations, while no aquatic vegetation was observed on the Fraser River at site F9.

Bed material mobilization occurred in 2017 at both the Fraser River and Ranch Creek sites based upon RSI analyses **(Figure 4 and Table 6**). Calculations indicate that at F9, the mean size of the largest particles transported was 111 mm (small cobble) and 43% of the riffle substrate was estimated to have been mobilized. Results were similar at F-RC2, where the mean was 104 mm (small cobble) and the percent mobilized was estimated to be 34%. These findings are comparable to those of 2014 to 2016 (**Table 7**), and support our observation last year (Tetra Tech and HabiTech 2017) that peak flows in the range of the 3-year return interval (1,072 cfs for the Fraser River at Granby) are sufficient for cobble mobilization and riffle cleaning. Both RSI riffles were found to be clean in 2017, with only 4% embeddedness at F9 and 9% at F-RC2. Observations of the riffles at both sites indicate minimal to non-existent presence of sand and finer sediments (< 2mm), well below the CWQCC guideline threshold of 27.5% to prevent sediment impacts to macroinvertebrate communities in Sediment Region 1.

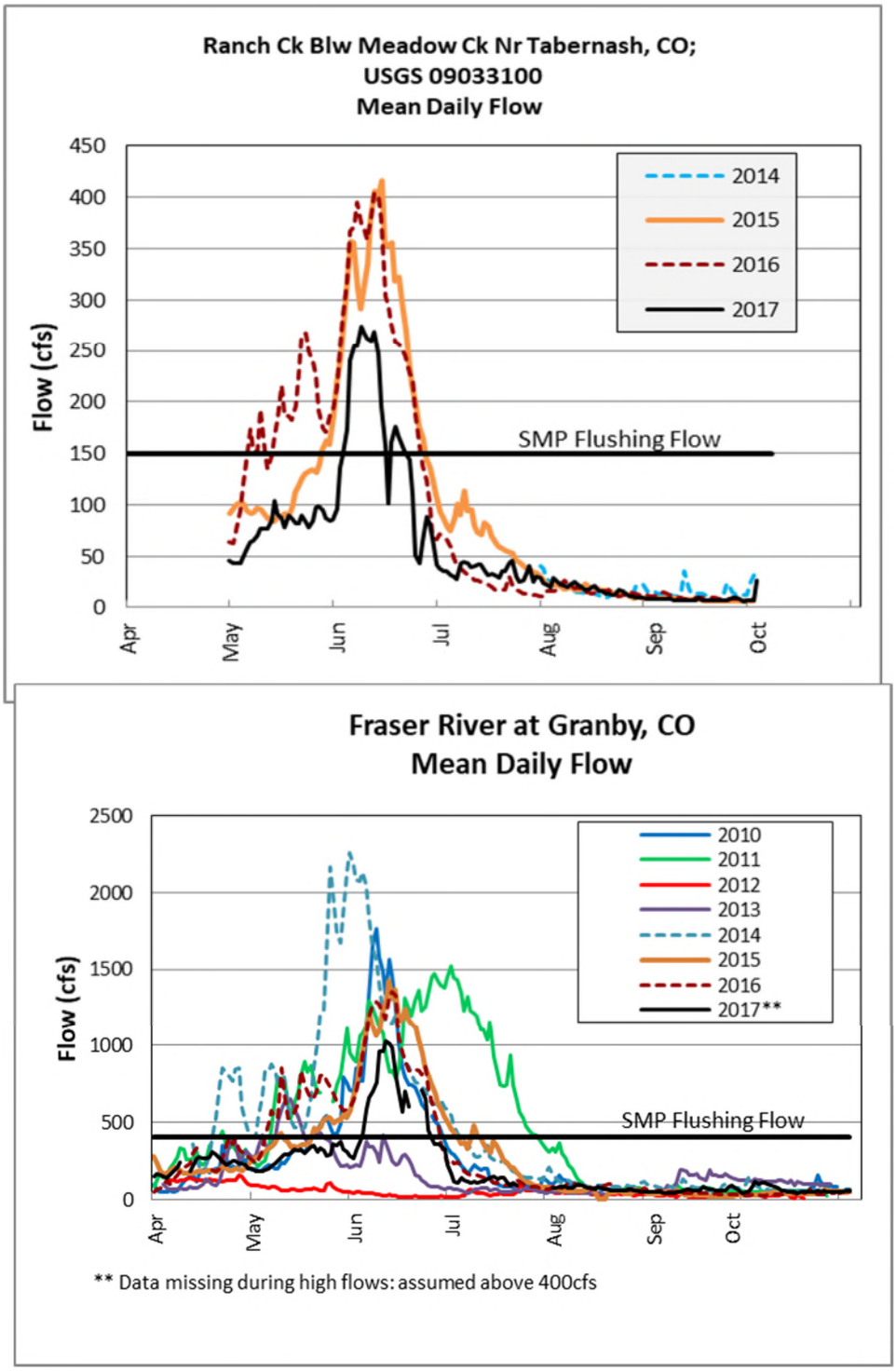


Figure 2 April through October hydrographs for Fraser River (2010-2017) and Ranch Creek below Meadow Creek (2014-2017) in Grand County, CO. Hydrographs depict time period of interest or as limited by available data.

Table 4 Comparison of flushing flow recommendations (Q_{FF})[1] to stream flow records for Fraser River monitoring sites, 2010-2017.

SMP Reach	Q_{FF} SMP Recommended Flushing FLow (CFS)	2010		2011		2012		2013		2014		2015		2016		2017	
		Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days> Q_{FF} [2]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [2]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [2]
F9	400	1767	41	1519	81	157	0	650	16	2256	76	1425	44	1351	54	1028	21
F-RC2	150											417	30	404	6, 43	272	12,5

[1] Recommended minimum peak flow for 3 days, 1 in 2 years.
[2] Multiple consecutive day periods occurred.

Table 5 Pebble count summary for Fraser River Grand County spawning bar study sites, September 2017.

	F-RC2	F9
Class Size (mm)	RC Blw MC	FR Granby Ranch
	Sept 2017	***Sept 2017***
0-2	0	0
2-4	0	0
4-8	0	0
8-16	2	2
16-32	6	17
32-64	58	50
64-128	33	28
128-256	1	2
256-512		1
512-1024		
1024-2048		
2048-4096		
Sum	100	100
% Embedded	5	2

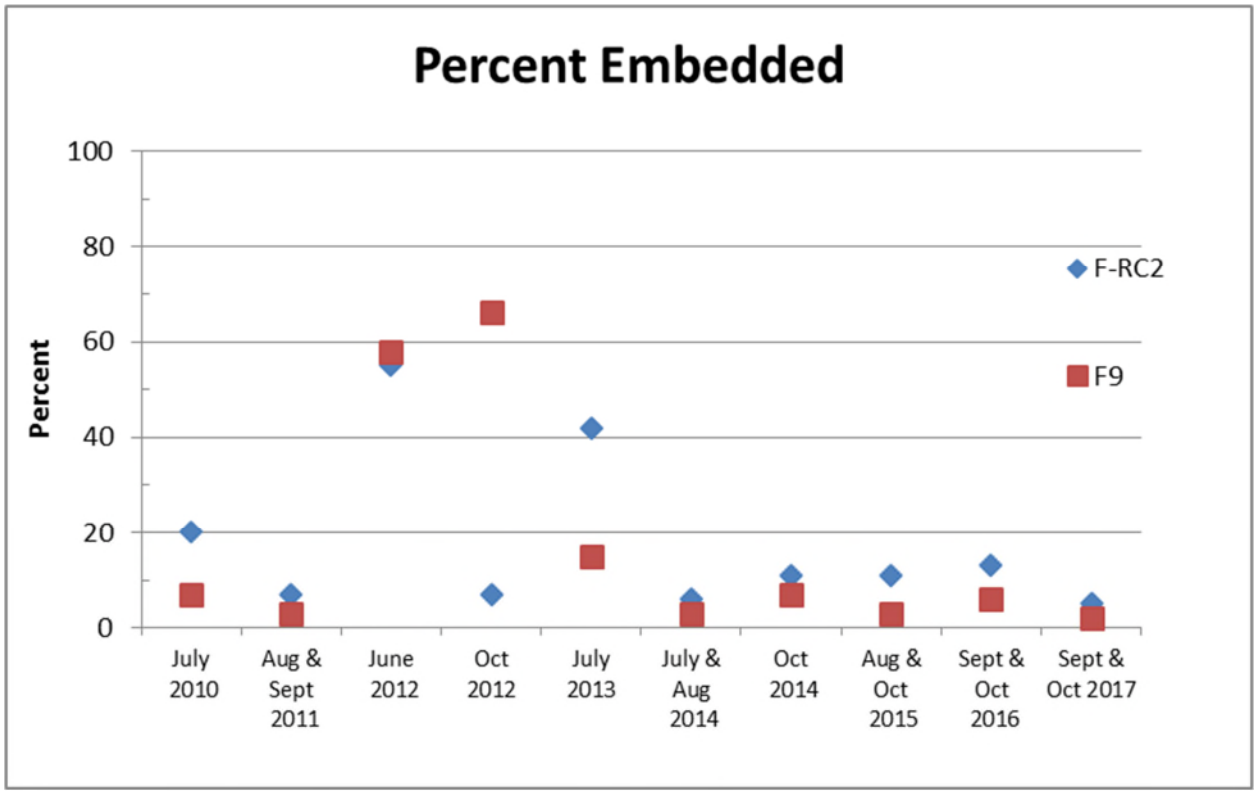


Figure 3 Percent of spawning bar embedded at Fraser River and Ranch Creek sites, 2010-2017.

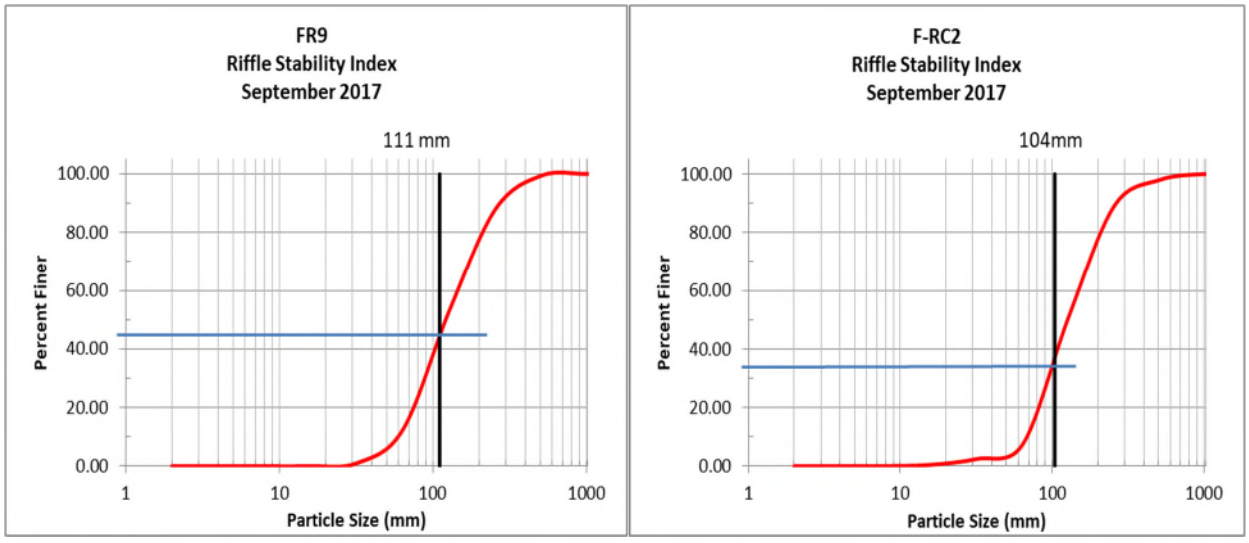


Figure 4 Riffle Stability Index (RSI) results for the Fraser River and Ranch Creek sites, 2017 (red line represents sample gradation, blue line represents percent of mobilized riffle substrate, and black line represents mean of the largest bar size material mobilized).

Table 6 Pebble count summary for Fraser River Grand County Riffle Stability Index (RSI) spawning bar study sites, September 2017.

SMP Reach	F-RC2	F9
Site Name	RC blw MC	FR Granby Ranch
Date	Sept 2017	Sept 2017
Class Size (mm)	Count	Count
0-2	0	0
2-4	0	0
4-8	1	0
8-16	4	2
16-32	10	23
32-64	87	81
64-128	77	70
128-256	18	23
256-512	4	1
512-1024		
1024-2048		
2048-4096		
Sum	201	200
Mean Bar Particle Size (mm)	104	111
RSI (%)	34	43
% embedded	9.0	4.0

Table 7 Comparison of Riffle Stability Index (RSI) at Fraser River monitoring sites, 2014-2017.

LBD Reach	Year	Mean Daily Peak Flow (Q_P)	Q_P Times> Q_{FF}	# Days > Q_{FF}	Mean Bar Particle Size [1]	% Riffle Mobilized [2]	% Riffle Embedded
		(cfs)			(mm)	(%)	(%)
F-RC2	2014	ND		ND	125	49	6.0
	2015	417	2.8	30	114	45	13.2
	2016	404	2.7	49	81	17	13.0
	2017	272	1.8	17	104	34	9.0
F9	2014	2256	5.6	76	136	30	12.2
	2015	1425	3.6	44	105	31	4.5
	2016	1351	3.4	54	59	20	6.5
	2017	1028	2.6	21	111	43	4.0

[1] Mean diameter of 30 largest recently deposited on bar
[2] Estimated % of riffle potentially mobilized
Q_{FF}=flushing flow, Q_P=peak flow

3.1.3 Macroinvertebrate Community

2017 benthic macroinvertebrate sample results are provided in **Tables 8** and **9**. Table 8 presents the individual metric and MMI scores as well as the auxiliary metrics and aquatic life use designations, while Table 9 presents the additional metrics described in the Methods chapter, Section 2.2. The Colorado Division of Water Quality's Bioassessment Reports are provided in **Appendix B**.

Overall, the health of the Fraser River watershed macroinvertebrate community improves in a downstream direction based on the 2017 results (**Figure 5**), with good diversity and density to support the aquatic system. Giant stoneflies (*Pteronarcys californica),* an important food source for trout and other aquatic/riparian organisms, were collected in the lower Fraser River. The two upstream sites, FR-abv WPSD and FR-Rendezvous, were designated as impaired, while the FR-FrSpProj site at the head of Fraser Flats fell into the "gray zone" based on its MMI score, but was designated as not impaired due to its low HBI and high SDI scores. All other Fraser River and Ranch Creek sites attained their aquatic life use designation in 2017.

Individual MMI metrics that rated especially low at the two impaired sites on the Fraser River were the number of clinger taxa and the percent of sensitive families present (Table 8). Clingers are those benthic macroinvertebrates that attach or "cling" to substrate surfaces that are typically free of silt and fine sediment, while the sensitive families' metric varies inversely with a variety of environmental stressors (Rees 2009). Taxa richness and the number of EPT taxa (mayflies, stoneflies, caddisflies) were also the lowest observed at any of the Fraser River watershed sites (Table 9), both of which vary inversely with environmental stress, while the percent of chironomid larvae was the highest observed, a metric which typically increases with perturbation. Although it is difficult to identify the exact cause of impairment at these sites, it is certainly possible that the long history of traction sand loading to the upper Fraser River watershed and the release of semi-volatile organic carbons into the Fraser from the Moffat Railroad Tunnel upstream of Winter Park may have contributed (Tetra Tech and HabiTech 2017).

The health of the Ranch Creek macroinvertebrate community has remained quite stable in recent years and has achieved its aquatic life use designation for all sample years and sites (**Table 10** and **Figure 5**). The Fraser River sites have shown more variability over time, although the improving downstream trend observed in 2017 generally holds true. In all years for which samples were collected, the highest MMI scores occurred at the lowermost site, FR-abvGSD, and in all cases, aquatic life use designation was achieved (Table 10). All other Fraser River sites have been designated as impaired in at least one sample year, with the FR-Rendezvous site so designated in 5 of the 6 years the macroinvertebrate community has been sampled. Likewise, both the FR-abvWPSD above Winter Park and the FR-CR83 upstream of Tabernash have been impaired in 4 of 6 years, although this latter site attained its designated use in both 2016 and 2017. Improved condition was also observed in 2017 at the FR-FrSpPro site at Fraser Flats where the macroinvertebrate community diversity improved sufficiently for the site to achieve attainment. While no clear trends between streamflow and macroinvertebrate community health are evident from Table 10, it is of interest to note the lowest MMI scores were realized at 3 of 4 sample sites

in the low water year of 2012 when flushing flow levels were not reached, embeddedness was the highest observed since monitoring began, and some water quality/contamination effects may have been magnified by the low flow conditions.

Table 8 Individual metrics and MMI scores from benthic macroinvertebrate samples collected in the LBD Fraser River study area by Timberline Aquatics, Inc. on September 18, 2017. All metric scores based on the MMI (v3) subsampling process.

	Station ID						
SMP Reach	F2	F4	F6	F6	F-RC2	F7	F10
RM	FR-23.2	FR-20	FR-15	FR-14	RC-1.1	FR-12.4	FR-1.9
Site ID	FR abvWPSD	FR Rendezvous	FR FrSpProj	FR CR83	RC blwMC	FR blwCrcr	FR abvGSD
Metric							
EP Taxa	37.3	39.1	68.9	46.6	57.1	93	100
% Chironomidae	31.6	30.4	28.6	64.4	59.6	81.7	85.9
% Sensitive Families	14.2	10	10	64.1	33.2	45.4	71.2
Predator/Shredder							
Taxa	85.7	92.9	64.3	100	100	100	100
Clinger Taxa	0	2.5	71.7	60.7	69	55.6	100
% Non-Insect Taxa	28.8	36.4	44.4	56.9	34.4	39	64.4
MMI	32.9	35.2	**48**	**65.4**	**58.9**	**69.1**	**86.9**
Aquatic Life Use Designation	Impair	Impair	Attain	Attain	Attain	Attain	Attain
Diversity	3.44	3.08	3.49	3.82	3.97	3.46	4.24
HBI	4.23	4.78	4.69	3.54	3.37	2.94	3.16

Table 9 Additional metrics for benthic macroinvertebrate samples collected in the LBD Fraser River study area. All metric scores based on full count Hess samples.

Station ID							
SMP Reach	F2	F4	F6	F6	F-RC2	F7	F10
RM	FR-23.2	FR-20	FR-15	FR-14	RC-1.1	FR-12.4	FR-1.9
Site Name	FR abvWPSD	FR Rendezvous	FR FrSpProj	FR CR83	RC blwMC	FR blwCrcr	FR abvGSD
Metric							
Density (#/m2)	3,866	10,789	8,284	8,908	9,388	11,725	7,934
Taxa Richness	34	39	42	47	43	53	50
EPT	15	14	16	22	19	24	28
Density of *Pteronarcys californica* (#/m2)	0	0	0	0	0	0	4
Percent EPT excluding Baetidae	14.49%	10.36%	22.50%	46.51%	40.28%	55.51%	57.79%
Percent Chironomidae	48.99%	47.45%	48.57%	25.33%	25.89%	15.01%	11.56%

Table 10 Colorado MMI and other key metric scores at the Fraser River and Ranch Creek sites sampled from 2011-2017. Sample types are described in Table 3.

SMP Reach	Site Name	Year	MMI	HBI [1]	Shannon [2]	Use Status	Sample Type[4]
CR3	CR WGU	2011	61.2	3.11	4.03	Attain	4
		2015	66.6	2.41	3.01	Attain	4
		2016	74.8	2.27	3.52	Attain	4
		2016	69.2	2.35	3.13	Attain	2
		2017	66.6	3.21	4.23	Attain	4
CR4	CR WGD	2011	62.70	-	-	Attain	2
		2011	70.80	2.36	2.97	Attain	4
		2012	43.90	4.93	4.28	Attain	2
		2012	60.80	2.37	3.29	Attain	2
		2012	65.60	2.34	3.49	Attain	4
		2015	59.60	3.89	2.10	Attain	2S,1A
		2015	61.80	2.48	2.50	Attain	2
		2015	61.00	2.80	2.83	Attain	4
		2016	64.70	3.10	2.43	Attain	1
		2016	83.00	2.67	3.62	Attain	2
		2016	80.20	2.63	3.77	Attain	4
		2017	74.60	2.28	3.94	Attain	4
CR4	CR HSR	2011	51.20	-	-	ID[3]	2
		2012	54.10	5.58	4.05	Attain	2
		2014	50.00	3.61	3.38	Attain	2
		2015	57.90	2.83	2.12	Attain	2S, 1A
		2016	62.30	4.14	2.37	Attain	1
		2017	77.70	2.64	3.40	Attain	4
CR4	CR WFU	2017	78.80	2.38	2.38	Attain	4
CR5	CR Kids' Pond	2011	52.50	-	-	Attain	2
		2012	61.40	1.54	2.53	Attain	2
		2014	59.70	3.33	4.00	Attain	2
		2015	59.90	3.01	2.50	Attain	2S, 1A
		2016	63.40	3.61	2.27	Attain	1
CR6	CR KBDitch	2011	61.70	-	-	Attain	2
		2012	42.30	3.63	4.17	Attain	2
		2014	45.80	3.22	3.61	Attain	2
		2015	68.30	2.51	2.02	Attain	2S,1A
		2016	64.00	3.50	2.38	Attain	1
		2017	73.20	3.03	4.23	Attain	4
CR7	CR Blw Pumphouse	2015	53.70	4.77	1.75	Attain	2S, 1A
		2016	73.90	4.52	1.90	Attain	1
		2017	60.10	4.33	1.98	Attain	1

[1]Hilsenoff Biotic Index
[2]Shannon Diversity Index (log base 2)
[3]Based on Hilsenoff Biotic and Shannon Diversity Indices
[4]Sample types are described in Table 3 and A = analytical protocol; S = sampling protocol
NS = Not Sampled; "-" = Data not provided

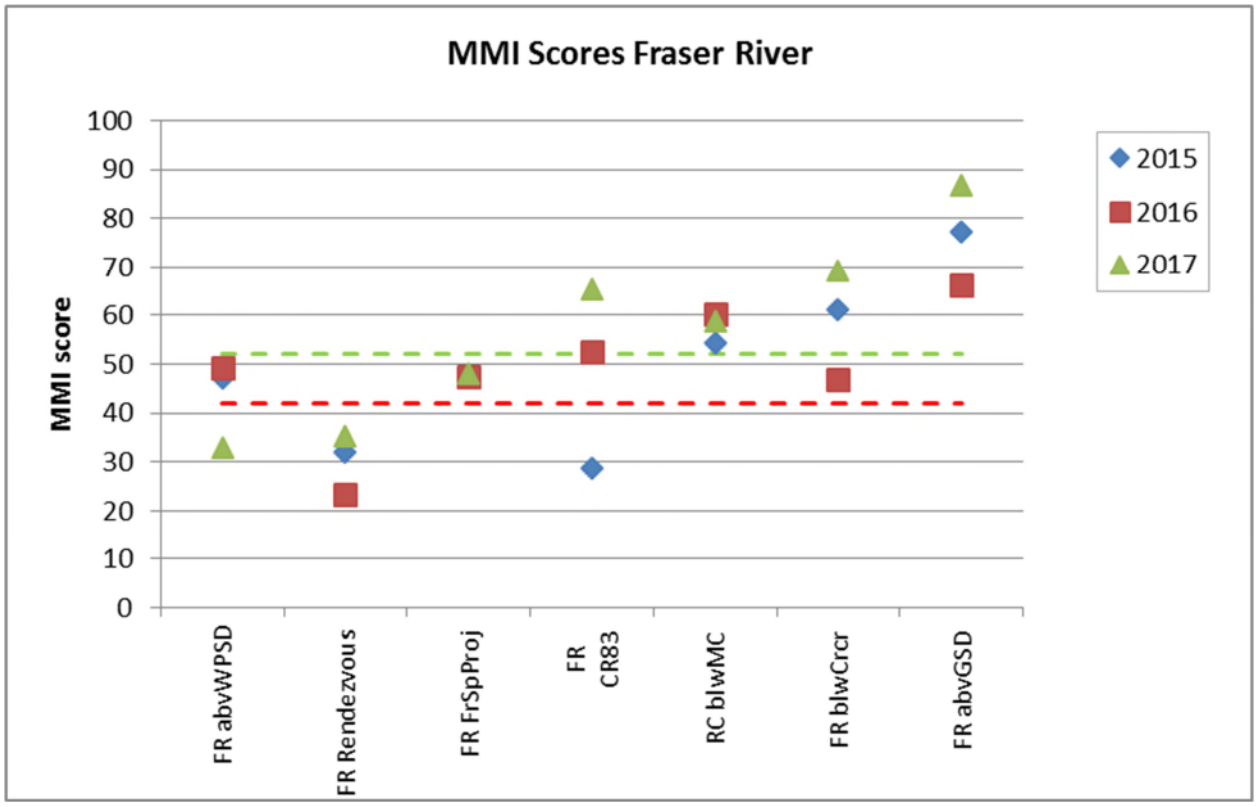


Figure 5 Trend of Fraser River and Ranch Creek MMI scores from upstream to downstream for 2015-2017. Red and green dashed lines depict boundaries of MMI "gray zone."

Pebble count summaries for each of the 2017 macroinvertebrate sample sites on the Fraser River and Ranch Creek are presented in **Table 11** and compared with 2015 and 2016 values. Small cobble (64-128 mm) was the predominant substrate size at each riffle site, while the sub-dominant varied between very coarse gravel (32-64 mm) and medium cobble (128-256 mm), dependent upon site and year. Areas of sand and finer sediments (< 2 mm) at the time of sampling were minimal to non-existent at all sites, well below the CWQCC guideline threshold of 27.5% to prevent sediment impacts to macroinvertebrate communities in Grand County (Sediment Region 1). Substrate embeddedness was low in 2017 ranging from about 4 up to 17%. The highest degree of embeddedness occurred on the Fraser River above County Road 83, Fr CR83 83 at the FrSpProj site.

Table 11 Pebble count summary at macroinvertebrate sites on the Fraser River and Ranch Creek, 2015-2017.

Fraser River Watershed																					
SMP Reach	**F2**			**F4**			**F6**			**F6**			**F7**			**F10**			**F-RC2**		
RM	**FR 23.2**			**FR 20**			**FR 15**			**FR 14**			**FR 12.4**			**FR 1.9**			**RC-1.1**		
Site Name	**FR AbvWPSD**			**FR Rendevous**			**FR FrSpProj**			**FR CR83**			**FR blw CrCk**			**FR abv GSD**			**RC blw MC**		
Class Size (mm)	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
0-2						1		1	4												
2-4																					
4-8														1	1						1
8-16			1					1	1					1	1					5	2
16-32	5	3	7	3		3		2	1	2	3			5	6	2	1	1	2	26	4
32-64	19	30	27	18	11	7		18	25	9	8	15		28	24	19	32	20	37	58	29
64-128	56	50	48	46	71	53		46	57	57	57	49		45	56	67	46	55	55	10	44
128-256	15	16	16	27	18	35		29	13	28	33	35		20	11	14	22	24	6	2	17
256-512	8	2	2	10	1	4		3	2	5	5	2		1	1						4
512-1024	1									1	0			0							
1024-2048																					
2048-4096																					
Sum	104	101	101	104	101	103		100	103	102	106	101		101	100	102	101	100	100	101	101
% Embedded	27	2	8	14	1	4		20	17	6	10	13		12	9	36	2	4	5	8	13

3.1.4 Fish Populations

A summary of Fraser River fish population estimates made by CPW in 2017 are presented in **Figure 6** and **Table 12**, and compared with other years and sites. 2017 results are presented and discussed in greater detail in the CPW publication, "Fraser River, Fish Survey and Management Information" (Ewert 2018a) which is provided in **Appendix C**.

At the Kaibab Park site, located immediately downstream of Highway 40 in Granby, brown trout (*Salmo trutta*) standing crop (114 lbs/acre) and fish per mile (1464 > 6" per mile) estimates were the highest observed since monitoring began in 2009. An estimated nineteen brown trout exceeded 14" in length. Applying the CPW biological criteria of 60 lbs/acre and at least 12 trout > 14"/acre to be classified as a "Gold Medal" fishery, the Kaibab Park site would qualify again in 2017 as it did in 2009 to 2011 and 2013 to 2015. "Gold Medal" is an administrative designation placed on a water body by the CPW Commission and at present, no section of the Fraser River has been so designated. Ewert (2018a) points out that these high brown trout numbers and biomass may be due to 2017 being a mid-range flow year with high flows not great enough to flush out juvenile fish and lower flows sufficient to hold larger fish. Few rainbow trout (*Oncorhynchus gairdneri*) and no brook trout (*Salvelinus fontinalis*) were captured at this site in 2017. Mottled sculpin (*Cottus bairdi*) were again collected at Kaibab Park in 2017.

The Fraser River on the GCWSD#1 property located between Fraser and Tabernash has been sampled several times in recent years and serves as the monitoring site to gauge success of the habitat improvement project just completed on Fraser Flats, which is also located on the GCWSD#1 property. Project objectives were to reduce the high width-to-depth ratio, provide better thalweg definition, increase the number and depth of pools, and reduce excessive riffles (Ewert 2018a). Based on the 2017 fish collections made just several weeks after completion, early results suggest the project has been a success. The total trout biomass, predominantly brown trout, increased from 33 lbs/acre in 2016 to 127 lbs/acre in fall 2017, almost a four-fold increase, and the number of quality trout (>14") went from 8 to 41/acre, a five-fold increase (Figure 6 and Table 12). These numbers well-exceed the Gold Medal benchmarks discussed earlier. Also encouraging was the continued collection of wild-spawned age-0 rainbow trout, suggesting a wild rainbow fishery may be developing in this area. Mottled sculpin were again collected in 2017.

The Safeway station at Fraser is the most long-term of the Fraser River fish collection sites, with sampling initiated in 2003 just prior to a habitat improvement project located within the sampling station. Based upon the results presented in Figure 6 and Table 12, it is apparent the project has been a success. In recent years the total trout biomass has been stable, measuring 190 lbs/acre in 2017, with brown trout the predominant species accounting for about 64% of this total. Rainbow trout accounted for 14%, a proportion that has been declining in recent years with the cessation of rainbow stocking in 2013. The remaining 22% of the total trout biomass was composed of brook trout in 2017. The number of quality trout (>14") has been gradually declining in recent years, with an estimate of 19/acre in 2017, down from 40/acre in 2013 and 70/acre in 2008. The high number observed in 2008 was the result of stocking large rainbows in an attempt to initiate a wild-spawned population. However, it is interesting to note that in recent years the percentage of these trophy fish that are rainbow trout has been increasing from 25% in 2013 to 58% in 2017. Ewert

(2018a) indicates 2018 fish collections will be important for determining if the rainbow trout population here will be capable of sustaining itself in the long-term. Several factors may contribute to the decline in larger brown trout, including 1) the loss of small stocked rainbows as a food source, 2) recent high water years that may displace juvenile browns downstream thereby reducing recruitment, and 3) cooler water temperatures associated with high spring runoff that may place brown trout at a disadvantage (Ewert 2018a). Despite the observed decline in trophy fish numbers, this site continues to exceed the "Gold Medal" biological benchmarks. Mottled sculpin have been collected over the years at the Safeway site.

The trout population at the Confluence Park station, located at the confluence of the Fraser and Vasquez Creek in Winter Park, has been more variable than at other Fraser River long-term sites. In 2017, total trout biomass was estimated at 54 lbs/acre, the lowest estimate in the 8 years of sampling since 2006, and only 2 fish of trophy size were collected, both metrics less than the "Gold Medal" benchmarks. An interesting aspect of this fish population has been the shift in species composition over the period of record. In 2006, brook trout accounted for over 90% of the biomass. By 2012, following successful stocking of fingerlings, rainbow trout comprised over 96% of the population by weight and brook and brown trout had virtually disappeared. Once rainbow trout stocking ceased in 2013, both brook and brown trout populations rebounded, comprising 48 and 37%, respectively, of the total trout biomass by 2017. Most of these fish were small (< 10") reflecting the small size of the stream at this location and the cooler water temperatures at this elevation, although one 18" brown trout was collected. These findings suggest a rainbow trout population can't be sustained here in the absence of stocking (Ewert 2018a) and has rapidly been outcompeted by both other species. Mottled sculpin have been collected over the years at Confluence Park since 2006.

Fish sampling was not conducted at the Idlewild Campground station, located near Winter Park ski resort, in 2017, where declines were reported for populations of all three trout species present in 2016. This site will again be monitored in the future (Ewert 2018a). The Behler Creek station was also not sampled in 2017.

Table 12 Summary of CPW fish population data for the Fraser River in Grand County, 2003-2017.

Site	Year	Brown Trout		Rainbow Trout		Brook Trout	Total Trout	Sculpin
		(lbs/acre)	(#>14"/acre)	(lbs/acre)	(#>14"/acre)	(lbs/acre)	(lbs/acre)	(#)
Idlewild	2014	15	0	34	0	65	114	69
	2016	11	0	16	0	39	66	60
Confluence Park	2006	6	0	2	0	81	89	80
	2007	2	0	40	8	29	71	188
	2009	4	3	13	3	48	65	38
	2012	0	0	123	0	4	127	211
	2013	0	0	53	0	10	63	234
	2014	3	0	74	0	31	108	99
	2015	7	0	48	0	34	89	121
	2017	20		8		26	54	
Safeway	2003	1	0	1	0	10	12	159
	2006	34	0	35	13	29	98	178
	2007	56	10	70	23	15	141	260
	2008	81	17	139	53	27	247	191
	2009	57	20	30	10	19	106	176
	2010	47	17	7	3	44	98	431
	2011	55	27	30	3	17	102	292
	2012	69	17	69	0	25	163	550
	2013	116	30	48	10	16	180	355
	2014	92	20	53	14	15	160	122
	2015	94	11	50	11	39	183	249
	2016	100	11	46	17	31	177	148
	2017	121	8	27	11	42	190	
GCWSD#1	2007	33	3	9	3	2	44	
	2016	26	6	6	2	1	33	971
	2017	111	33	16	8	0	127	264
Behler Creek	2015	148	39	9	4		157	452
Granby Ranch	2016	41	11	-	-		41	45
Kaibab Park	2009	76	18				76	256
	2010	62	23				62	466
	2011	60	14				60	533
	2012	56	4				56	1279
	2013	87	16				87	521
	2014	73	22				73	262
	2015	71	16				71	469
	2017	114	19				114	249

Figure 6 CPW trout biomass estimates (2003-2017) for Fraser River sites sampled in 2017.

3.2 Colorado River

3.2.1 2017 Streamflow Regime

2017 spring runoff on the Colorado River through Grand County was somewhat lower than those observed in 2014 to 2016, but 3.7 to 9.1 times higher than those experienced in the dry years of 2012 and 2013 (**Figure 7** and **Table 13**). Streamflows peaked in mid- to late June and ranged from 2,238 cfs below Windy Gap to 4,280 cfs at Kremmling. These peaks had an estimated return interval of about 4 years based upon the 1986 to 2016 period of record (**Appendix A**). Flows generally remained high through June and early July declining toward base flow levels by mid-July. Late summer releases from William's Fork and Green Mountain Reservoirs kept baseflows somewhat elevated through Reaches CR5, 6, and 7, delaying some field sampling until October. The recommended flushing flows (Table 13) on the Colorado River through Grand County were exceeded in both magnitude and duration during 2017.

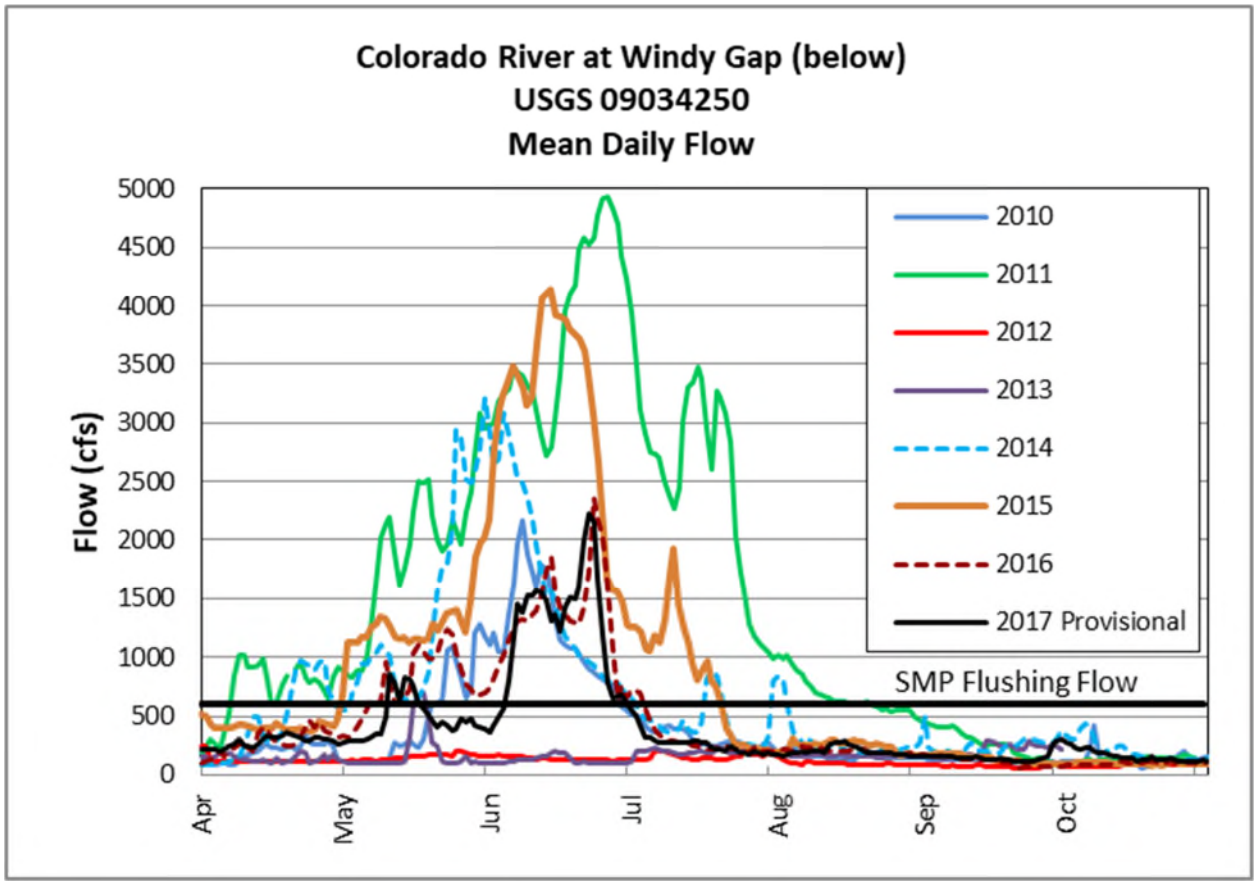


Figure 7 Hydrographs for April through October 2010-2017 for five Colorado River stream gage stations in Grand County, Colorado. Hydrographs depict time period of interest or as limited by available data.

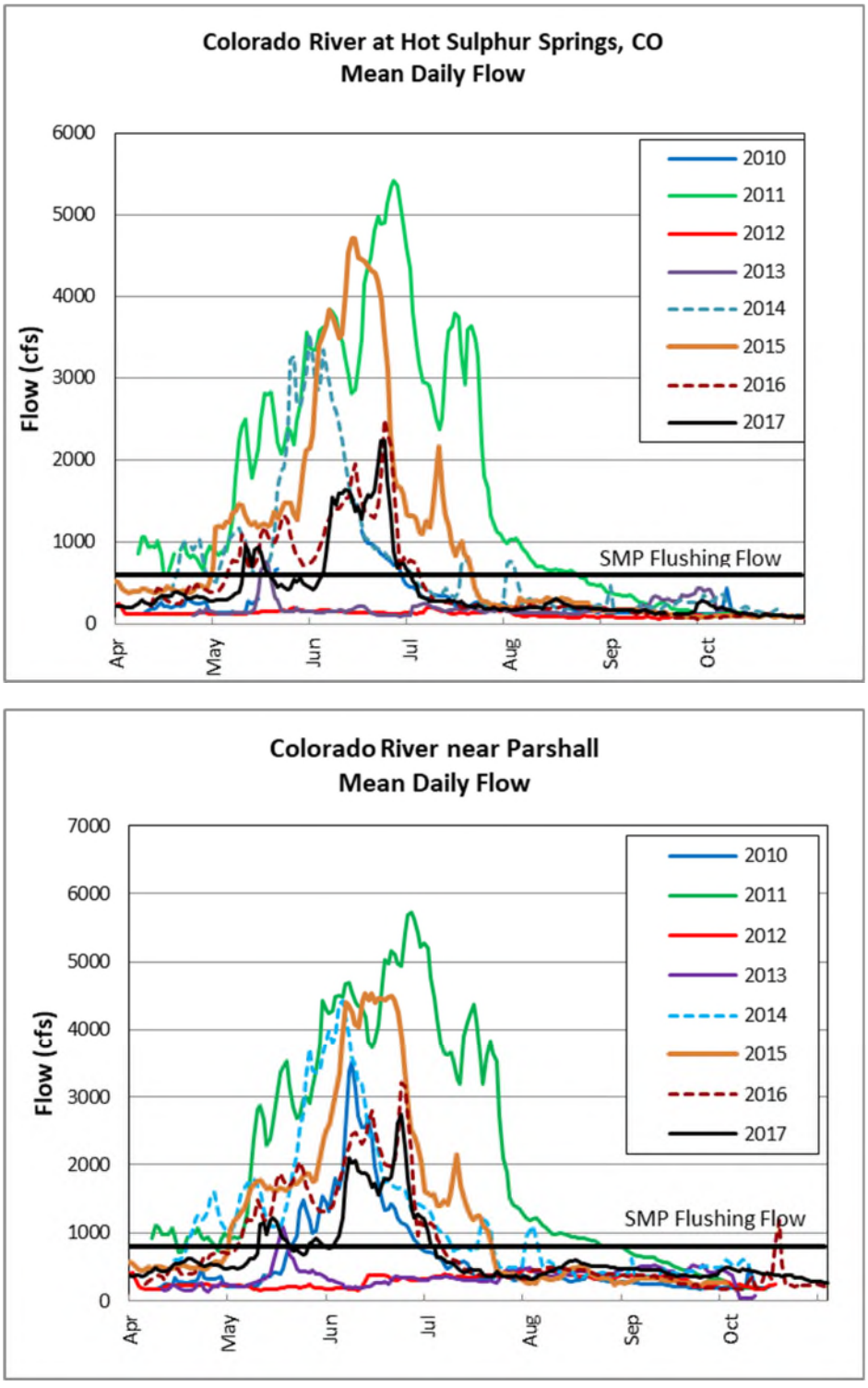
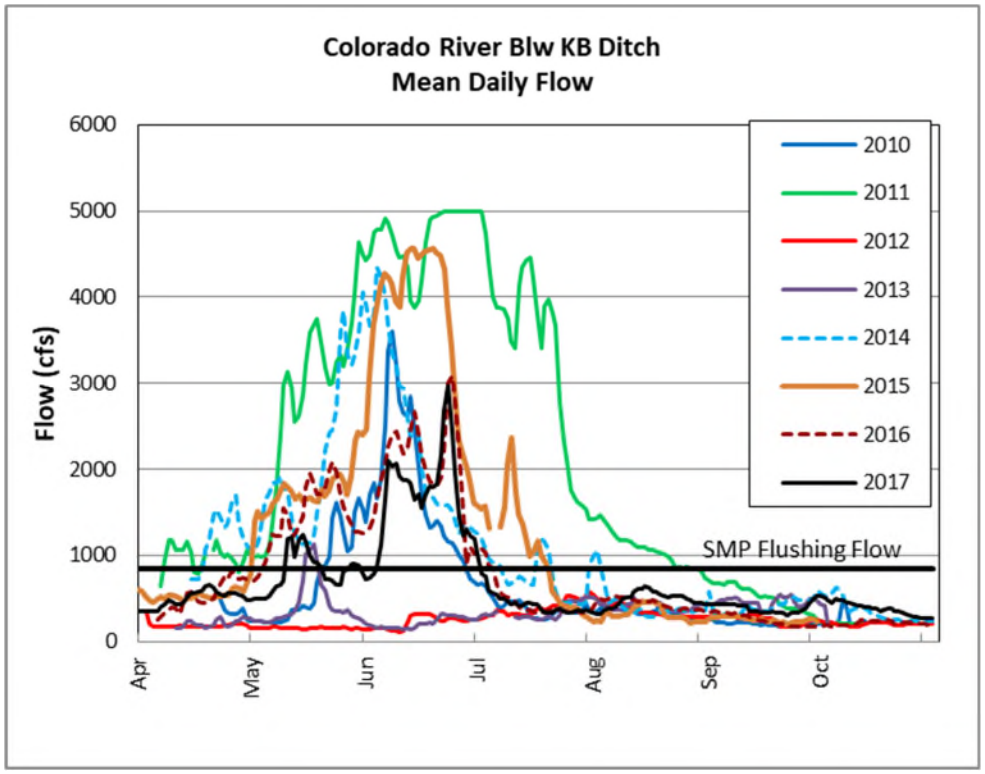


Figure 7 continued. Hydrographs for April through October 2010-2017 for five Colorado River stream gage stations in Grand County, Colorado. Hydrographs depict time period of interest or as limited by available data.



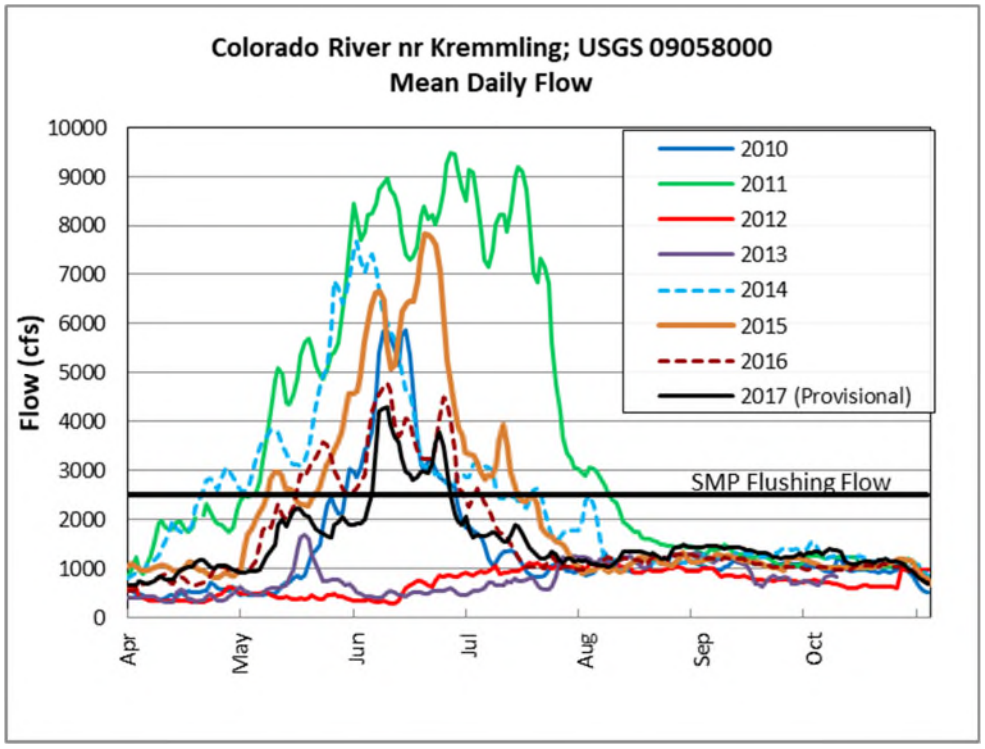


Figure 7 continued. Hydrographs for April through October 2010-2017 for five Colorado River stream gage stations in Grand County, Colorado. Hydrographs depict time period of interest or as limited by available data.

Table 13 Comparison of flushing flow recommendations (Q_{FF})[1] to stream flow records for Colorado River monitoring sites, 2010-2017.

SMP Reach	Q_{FF} SMP Recommended Flushing FLow (CFS)	2010		2011		2012		2013		2014		2015		2016		2017	
		Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days> Q_{FF} [2]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [2]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [2]
CR4	600	2160	40	4930	134	245	0	693	3	3210	10,60,4,4	4140	81	2501	60	2238	8, 28
CR5	800	3512	40	5718	137	460	0	1088	3	4419	93,4	4539	80	3206	63	2739	10, 5, 30
CR6	850	3596	38	4993	141	573	0	1119	4	4348	80,4,4	4565	77	3080	61	2972	10, 3, 28
CR7	2500	5870	30	9480	96	1160	0	1680	0	7670	79,3	7820	8,54	4770	49	4280	21

[1] Recommended minimum peak flow for 3 days, 1 in 2 years.
[2] Multiple consecutive day periods occurred.

3.2.2 Spawning Habitat

The predominant substrate type observed at three of the four Colorado River spawning bar sites in 2017 was very coarse gravel (32 – 64 mm), similar to previous years, with small cobble (64 – 128 mm) and coarse gravel (16 – 32 mm) the sub-dominant particle sizes (**Table 14**). At the CR5 site, small cobble again predominated the substrate, with very coarse gravel the sub-dominant. All four spawning bars were exceptionally clean, with no embedded particles at CR4 and CR6, and less than 3% at CR5 and CR7. These embeddedness values were among the lowest recorded for these sites since monitoring began in 2010 (**Figure 8**) and likely reflect the effects of high spring runoff, which exceeded flushing flow recommendations at all four sites. Based on the CWQCC (2014) guideline for salmonid spawning habitat protection of less than 20% of surface particles less than 8 mm, none of the four Colorado River spawning bars were impaired by sediment. Pebble counts at CR5 and CR7 indicated only about 1% of their bed surfaces were < 8 mm, while no such areas were observed at CR4 and CR6. Aquatic vegetation was sparse in 2017, with filamentous green algae observed at 1% of pebble count locations at CR4 and 6% at the CR6 site. No aquatic vegetation was noted at CR5 and CR7.

Table 14 Pebble count summary for Colorado River Grand County spawning bar study sites, September 2017.

Class Size (mm)	CR4	CR5[1]	CR6	CR7
	CR at Ppark	CR Blw WF	CR Blw KB Ditch	CR Blw Pumphouse
	Sept 2017	***Oct 2017***	***Sept 2017***	***Oct 2017***
0-2	0	2	0	0
2-4	0	0	0	0
4-8	0	0	0	1
8-16	2	0	0	14
16-32	20	6	7	37
32-64	59	78	74	45
64-128	18	91	17	4
128-256	3	22	2	
256-512		2	0	
512-1024				
1024-2048				
2048-4096				
Sum	102	201	100	101
% Embedded	0	2.5	0	3

[1]RSI conducted at spawning bar sample site

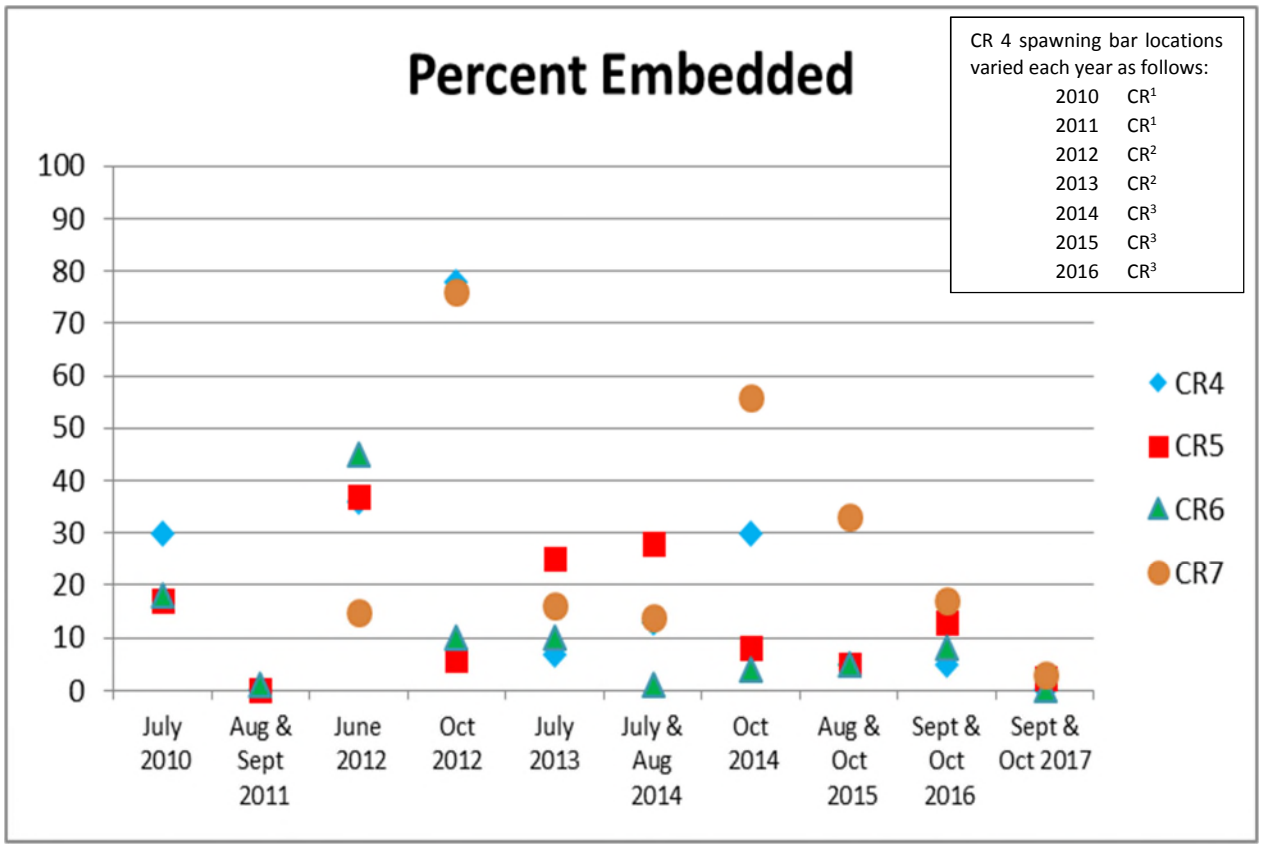


Figure 8 Percent of spawning bar embedded at the four Colorado River sites, 2010-2017.

Bed material mobilization occurred in 2017 at all four Colorado River sites based upon RSI analyses (**Figure 9** and **Table 15**). Calculations indicate that at CR4, the mean size of the largest particles transported was 129 mm (medium cobble) and an estimated 50% of the riffle substrate was mobilized. Results were similar at the other sites, with a mean size of 126.5 mm (small cobble) and up to 42% mobilization at CR5, 112 mm mean (small cobble) and up to 40% mobilization at CR6, and 132.9 mm mean (medium cobble) and up to 42% mobilization at CR7.

These findings are comparable to those of 2014 to 2016 (**Table 16**), and are supportive of observation last year (Tetra Tech and HabiTech 2017) that peak flows in the range of the 3-year return interval event are sufficient to initiate cobble mobilization and riffle maintenance. The 3-year events for the three Colorado River gage stations analyzed are estimated to be 1,702 cfs at Windy Gap, 2,239 cfs near Parshall, and 3,890 cfs at Kremmling (Appendix A). All four of the Colorado River RSI riffles were exceptionally clean in 2017, with less than 3% embeddedness at each. Likewise, sand and finer (<2 mm) substrate was observed at less than 1% of pebble count locations in the RSI riffles, well below the CWQCC guideline threshold of 27.5% to prevent impacts to macroinvertebrate communities in Sediment Region 1.

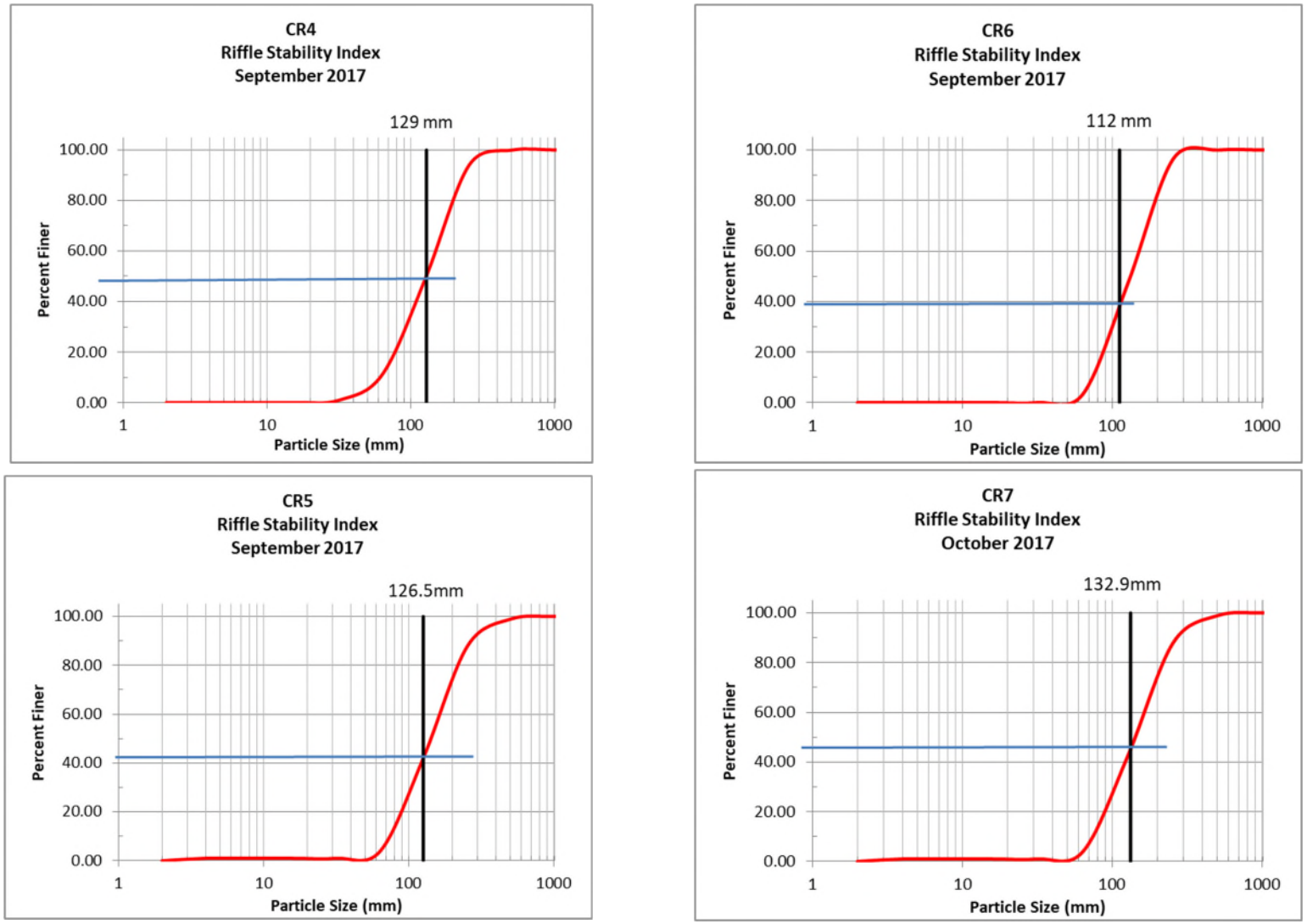


Figure 9 Riffle Stability Index (RSI) results for the four Colorado River spawning bar sites, 2017 (red line represents sample gradation, blue line represents percent of mobilized riffle substrate, and black line represents mean of the largest bar size material mobilized).

Table 15 Pebble count summary for Colorado River, Grand County Riffle Stability Index (RSI) spawning bar study sites, September 2017.

SMP Reach	CR4	CR5	CR6	CR7
Site Name	CR at Ppark	CR Blw WF	CR Blw KB Ditch	CR blw Pumphouse
Date	Sept 2017	Oct 2017	Sept 2017	Oct 2017
Class Size (mm)	Count	Count	Count	Count
0-2	0	2	0	0
2-4	0	0	0	0
4-8	0	0	0	0
8-16	2	0	0	3
16-32	21	6	7	50
32-64	78	78	90	131
64-128	90	91	100	25
128-256	12	22	7	
256-512		2	0	
512-1024				
1024-2048				
2048-4096				
Sum	203	201	204	209
Mean Bar Particle Size (mm)	129	126.5	112	133
RSI (%)	50	42	40	46
% embedded	0.5	2.5	0.5	3.0

Table 16 Comparison of Riffle Stability Index (RSI) at Colorado River monitoring sites, 2014-2017.

LBD Reach	Year	Mean Daily Peak Flow (Q_P)	Q_P Times> Q_{FF}	# Days > Q_{FF}	Mean Bar Particle Size [1]	% Riffle Mobilized [2]	% Riffle Embedded
		(cfs)			(mm)	(%)	(%)
CR4	2014	3210	5.4	78	139	22	100.0 [3]
	2015	4140	6.9	81	144	44	3.9
	2016	2501	4.2	60	117	12	5.0
	2017	2238	3.7	36	129	50	0.5
CR5	2014	4419	5.5	97	134	21	7.9
	2015	4539	5.7	80	129	39	4.6
	2016	3206	4.0	63	133	34	12.9
	2017	2739	3.4	45	126.5	42	2.5
CR6	2014	4348	5.1	88	121	32	3.8
	2015	4565	5.4	77	110	30	4.5
	2016	3080	3.6	61	96	30	6.5
	2017	2972	3.5	41	112	49	0.5
CR7	2014	7670	3.1	82	105	37	18.0
	2015	7820	3.1	62	136	40	8.5
	2016	4770	1.9	49	132	37	6.4
	2017	4280	1.7	21	132.9	46	3.0

[1] Mean diameter of 30 largest recently deposited on bar
[2] Estimated % of riffle potentially mobilized
[3] Heavy didymo bloom
Q_{FF}=flushing flow, Q_P=peak flow

3.2.3 Macroinvertebrate Community

2017 benthic macroinvertebrate sample results are provided in **Tables 17** and **18.** Table 17 presents the individual metric and MMI scores as well as the auxiliary metrics and aquatic life use designations, while Table 18 presents the additional metrics described in the Methods chapter, Section 2.2. The Colorado Division of Water Quality's Bioassessment Reports are provided in **Appendix B**. Samples from CR3, CR4, and CR6 were collected by Timberline Aquatics, Inc. The sample from CR7 was collected by GCWIN.

Based on benthic macroinvertebrate sampling in 2017 the overall the health of the Colorado River through Grand County appears to have good diversity and density and is supportive of the aquatic community. All sites attained their designated use, with none found to be impaired. Giant stoneflies were collected at 5 of the 6 Colorado River sites and for the first time for LBD sampling,

the species was found at all sites downstream of Windy Gap reservoir. As noted in Table 3, Timberline sampling methodologies used in 2017 use a full count method whereas in past years the sampling used a partial set, so it is possible that results differ in part due to methodology. Densities ranged from 4 per m^2 below Windy Gap and KB Ditch sites up to 175 per m^2 at the most downstream site, Pumphouse. The Pumphouse site did have the lowest overall density and diversity of the Colorado River sites, perhaps the result of extended late season flows delaying sample collection until October 27, well past the October 1 deadline recommended by CDPHE (CDPHE 2010) for evaluating optimum benthic macroinvertebrate conditions. Also, the difference in sampling and analytical protocols used at the Pumphouse site (Type 1versus Type 4 at all other sites, (see Table 3) .

Table 17 Individual metrics and MMI scores from benthic macroinvertebrate samples collected in September and October, 2017. All metric scores based on MMI (v3) subsampling process.

	Station ID					
SMP Reach	CR3	CR4	CR4	CR4	CR6	CR7
RM	CR 31	CR 28.7	CR 22.9	CR 16.7	CR 9.1	
Site Name	CR WGU	CR WGD	CR HSU	CR WFU	CR KBDitch	CR blw Pumphouse
Metric						
EP Taxa	100	100	100	100	100	63.4
% Chironomidae	52.9	99.8	92	90.1	75	47.6
% Sensitive Families	21.3	36.8	48.8	36.4	46.2	16.5
Predator/Shredder Taxa	78.6	92.9	92.9	100	78.6	57.1
Clinger Taxa	100	100	100	100	100	100
% Non-Insect Taxa	46.6	17.9	32.7	46.6	39.2	76.3
MMI	66.6	74.6	77.7	78.8	73.2	60.1
	Auxiliary Metrics					
Aquatic Life Use Designation	Attain	Attain	Attain	Attain	Attain	Attain
Diversity	4.23	3.94	3.4	4.11	4.23	1.98
HBI	3.21	2.28	2.64	2.38	3.03	4.33

Table 18 Additional metrics and comparative values for macroinvertebrate samples collected at Colorado River sampling sites in September and October, 2017.

	Station ID					
SMP Reach	CR3	CR4	CR4	CR4	CR6	CR7
RM	CR 31	CR 28.7	CR 22.9	CR 16.7	CR 9.1	
Site Name	CR WGU	CR WGD	CR HSU	CR WFU	CR KBDitch	CR blw Pumphouse
Metric						
Density (#/m^2)	8,488	6,589	8,736	6,938	8618	5791
Taxa Richness	52	49	49	53	49	24
EPT	25	28	27	29	25	15
Density of *Pteronarcys californica* (#/m^2)	0	4	19	116	4	175
Percent EPT excluding Baetidae	27.8	24.7	32.8	33.7	48.4	25.2
Percent Chironomidae	31.7	2.1	6.9	5.7	17.0	35.5

Most individual MMI metrics at the Colorado River sites in 2017 scored near or well above the mid-range of the 0 to 100 scale (Table 18). Those metrics scoring near or at the optimum (100) for most or all sites were the number of clinger taxa, the number of mayfly and stonefly taxa, and the number of predator/shredder taxa present. All of these metrics are known to be inversely related to perturbation, with increasing numbers as environmental stress declines (CDPHE 2010). Two metrics were generally found to score lower system-wide, percent sensitive insect families and percent non-insect taxa, the cause of which is unknown at this time.

A summary of Colorado River MMI analyses conducted since 2011 and made available by LBD partners for this monitoring report are presented in **Table 19** and **Figure 10**. For years and sites having multiple MMI values, the highest value is plotted in Figure 10. The sample type, as described previously in Table 3, for each site and year is provided. A concern discussed by the LBD at their June 2017 meeting was the equitable comparison of these findings due to the different sample protocols employed over the years for collecting and analyzing these data. The data provided by Northern Water for samples collected and analyzed on the same dates at site CR-WGU in 2016 and at site CR-WGD in 2012, 2015 and 2016 present an opportunity, albeit limited by small sample size, to compare results from the Type 2 and Type 4 protocols. Results of the paired comparisons indicated no differences in MMI scores based on protocol type ($p= 0.47$). Likewise, no differences were found in HBI scores ($p = 0.68$). However, when SDI scores were compared, differences were found between the two protocols ($p = 0.02$), with diversity of Type 4 samples higher than Type 2 samples. While these results are based on a sample size of just four data pairs, they do suggest that equitable comparisons of MMI and HBI values developed through these two sample types may be possible, but comparison of SDI scores should be viewed with caution. Other such comparisons between sample types are limited by small sample sizes.

Table 19 Colorado MMI and other key metric scores at the Colorado River sites sampled by GCWIN and Timberline Aquatics, Inc. from 2011-2017.

SMP Reach	Site Name	Year	MMI	HBI [1]	Shannon [2]	Use Status	Sample Type[4]
CR3	CR WGU	2011	61.2	3.11	4.03	Attain	4
		2015	66.6	2.41	3.01	Attain	4
		2016	74.8	2.27	3.52	Attain	4
		2016	69.2	2.35	3.13	Attain	2
		2017	66.6	3.21	4.23	Attain	4
CR4	CR WGD	2011	62.70	-	-	Attain	2
		2011	70.80	2.36	2.97	Attain	4
		2012	43.90	4.93	4.28	Attain	2
		2012	60.80	2.37	3.29	Attain	2
		2012	65.60	2.34	3.49	Attain	4
		2014	45.90	5.22	4.30	Attain	4
		2015	59.60	3.89	2.10	Attain	2S,1A
		2015	61.80	2.48	2.50	Attain	2
		2015	61.00	2.80	2.83	Attain	4
		2016	64.70	3.10	2.43	Attain	1
		2016	83.00	2.67	3.62	Attain	2
		2016	80.20	2.63	3.77	Attain	4
		2017	74.60	2.28	3.94	Attain	4
CR4	CR HSR	2011	51.20	-	-	ID[3]	2
		2012	54.10	5.58	4.05	Attain	2
		2014	50.00	3.61	3.38	Attain	2
		2015	57.90	2.83	2.12	Attain	2S, 1A
		2016	62.30	4.14	2.37	Attain	1
		2017	77.70	2.64	3.40	Attain	4
CR4	CR WFU	2017	78.80	2.38	2.38	Attain	4
CR5	CR Kids' Pond	2011	52.50	-	-	Attain	2
		2012	61.40	1.54	2.53	Attain	2
		2014	59.70	3.33	4.00	Attain	2
		2015	59.90	3.01	2.50	Attain	2S, 1A
		2016	63.40	3.61	2.27	Attain	1
CR6	CR KBDitch	2011	61.70	-	-	Attain	2
		2012	42.30	3.63	4.17	Attain	2
		2014	45.80	3.22	3.61	Attain	2
		2015	68.30	2.51	2.02	Attain	2S,1A
		2016	64.00	3.50	2.38	Attain	1
		2017	73.20	3.03	4.23	Attain	4
CR7	CR Blw Pumphouse	2015	53.70	4.77	1.75	Attain	2S, 1A
		2016	73.90	4.52	1.90	Attain	1
		2017	60.10	4.33	1.98	Attain	1

[1]Hilsenoff Biotic Index
[2]Shannon Diversity Index (log base 2)
[3]Based on Hilsenoff Biotic and Shannon Diversity Indices
[4]Sample types are described in Table 3 and A = analytical protocol; S = sampling protocol
NS = Not Sampled; "-" = Data not provided

From Table 19, it is important to note that although the sampling methods differ, across all Colorado River macroinvertebrate sample sites and years, aquatic life use designation was attained and there are similar trends. Since the exceptionally dry year of 2012, when flushing flow levels were not achieved at any site, MMI values have generally been improving. Comparisons between years found that 2012 values did not differ from those of either 2014 ($p = 0.71$) or 2015 ($p = 0.39$), but did differ significantly from 2016 ($p = 0.03$) and 2017 ($p = 0.02$). Results indicate MMI scores improved significantly in these wetter years likely due to improved habitat quality. As discussed in the 2016 monitoring report (Tetra Tech and HabiTech 2017), percent embeddedness was found to be significantly higher in 2012 than in those years when flushing flow levels were met or exceeded. Reduced embeddedness likely contributed to the improved health of the benthic community, and changes in other water quality-related parameters.

Pebble count summaries for each of the 2017 macroinvertebrate sample sites on the Colorado River are presented in **Table 20** and compared with 2015 and 2016 values. Small cobble (64 – 128 mm) was the predominant particle size at each riffle in 2017, with medium cobble (128 – 256 mm) the sub-dominant. Areas of sand and finer sediments (< 2 mm) at the time of sampling were non-existent at all sites, well below the CWQCC guideline threshold of 27.5% to prevent sediment impacts to macroinvertebrate communities in Sediment Region 1. Substrate embeddedness was again low in these riffle habitats, being observed on less than 2% of particles. These results are supportive of those presented above regarding habitat conditions in years when flushing flows were met or exceeded.

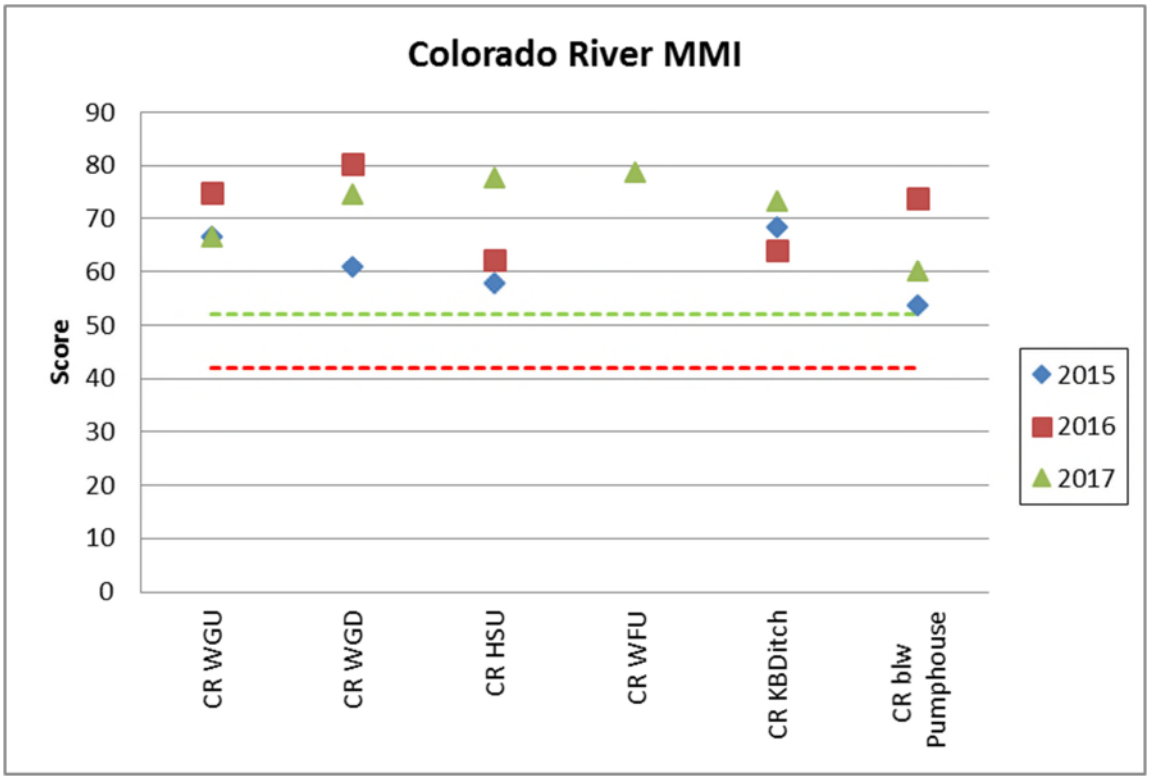


Figure 10 Trend of Colorado MMI scores from upstream to downstream, 2015-2017. Red and Green dashed lines depict boundaries of MMI "gray zone."

Table 20 Pebble count summary at Colorado River Macroinvertebrates sampling sites. 2015-2017.

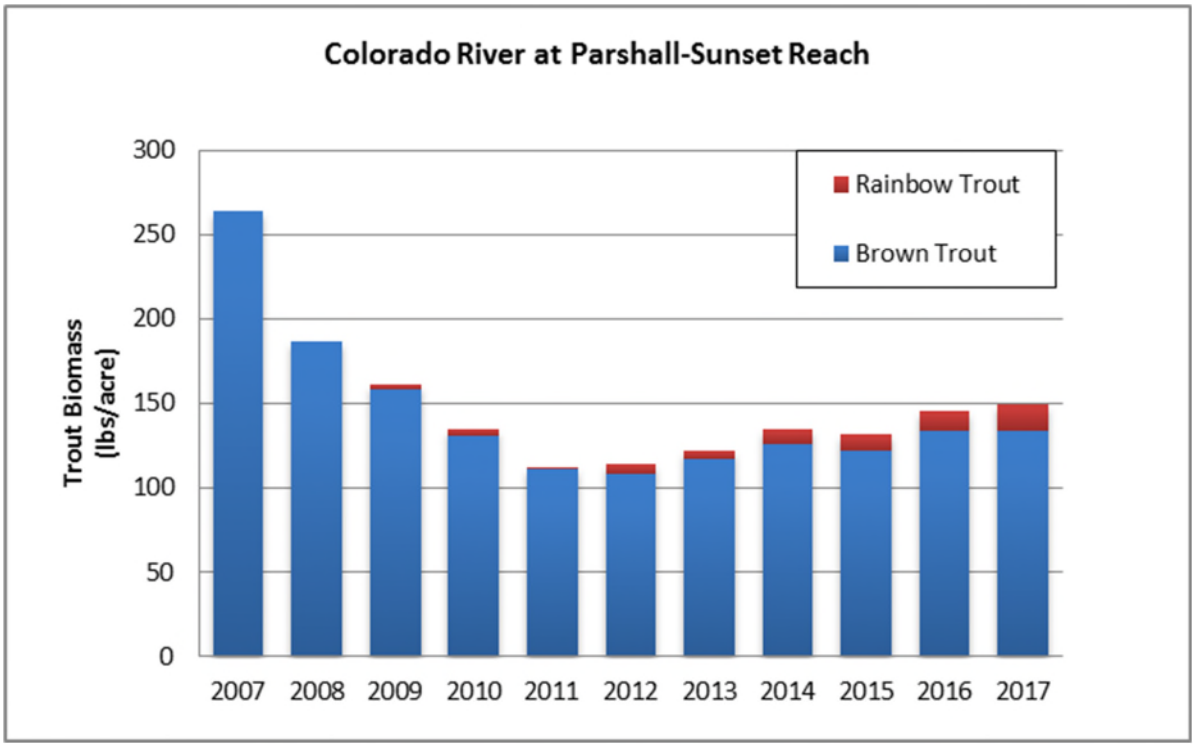
Colorado River														
SMP Reach	**CR3**	**CR4**			**CR4**			**CR4**	**CR6**			**CR7**		
Site Name	**CR WGU**	**CR WGD**			**CR HSU**			**CR WFU**	**CR KBDitch**			**CR Blw Pumphouse**		
Class Size (mm)	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
0-2														
2-4														
4-8														
8-16						2				0				
16-32	2		0		7	16	1	1		1		1		
32-64	8	12	8	5	40	59	19	12	14	23	4	11	6	6
64-128	61	72	68	71	48	19	72	59	86	71	82	49	52	58
128-256	30	20	24	26	5	4	9	26	9	7	16	38	37	36
256-512			1	1				2				1	5	1
512-1024														
1024-2048														
2048-4096														
Sum	101	104	101	103	100	100	101	100	109	102	102	100	100	101
% Embedded	2	5	3	2	7	5	1	0	0	8	0	1	4	2

3.2.4 Fish Populations

A summary of the Colorado River fish sampling through the Parshall to Sunset reach by CPW in 2017 is presented in **Figure 11** and compared with other sites and years in **Table 20**. 2017 results are presented and discussed in greater detail in the CPW publication, "Colorado River near Parshall, Fish Survey and Management Information" (Ewert 2018b) which is provided in Appendix C. The Parshall to Sunset reach is located downstream of the confluence with the William's Fork.

Total trout population estimates for Parshall-Sunset in 2017 were relatively stable when compared with the past several years (Figure 11 and **Table 20**). Total trout biomass was estimated to be 149 lbs/acre, up slightly from the 146 lbs/acre estimated in 2016 and 132 lbs/acre in 2015. Brown trout comprised 90% of the standing crop in 2017, a similar proportion to the 2016 and 2015 results. Total trout numbers have also remained steady over the short-term, with 4298 trout > 6"/mile in 2017 compared to 4129 in 2016 and 4087 in 2015. When compared to the record high year of 2007 as reported in Ewert (2018b) however, 2017 values reflect a substantial decline in the fishery. Over this 11-year period, both trout biomass and numbers declined 44%. Quality trout (>14") density estimates were down to 18 fish in 2017, compared to 32 in 2016 and 42 in 2015. The 2017 total is the lowest since 2013 and the second lowest recorded since 2007. While these declines in the trout population within the Parshall-Sunset reach are substantial, without confidence limits around these estimates it is not known if they are statistically significant reductions.

The Parshall-Sunset reach is an officially designated "Gold Medal" fishery. The 2017 trout population estimates continue to support this status with 149 lbs/acre and 18 trout > 14", as did the low estimates in 2012 and 2013. However, these declining trends have lead Ewert (2018b) to conclude this reach of the Colorado River has come uncomfortably close to not meeting the Gold Medal benchmarks and a case could be made this is a declining fishery. These declines are likely due to several inter-related factors including long-term degradation in the quality of the forage base, long-term degradation in the quality of physical habitat, especially over-winter habitat, and as a result, more frequent weak juvenile year classes and poor recruitment to adulthood (Ewert 2018b). Several CPW studies have documented the decline in the forage base due to sparse populations of giant stoneflies and mottled sculpin, both important trout food items, below Windy Gap reservoir (Nehring et al 2011a; Nehring et al 2011b). It is encouraging however, that giant stonefly nymphs were collected in 2017 at all five Colorado River sites below Windy Gap, with the second highest density (116 per m^2) at the site immediately upstream of the Williams Fork confluence, a short distance above the Parshall-Sunset reach. Regarding habitat degradation, the surveys conducted for the draft Stream Management Plan (Tetra Tech et al 2010) identified the same habitat deficiencies as noted by Ewert (2018b). The channel through much of this section of the river is wide and shallow with a high width-to-depth ratio, high quality pools are limited, and trout cover is sparse, all characteristics which can foster severe winter icing conditions and poor over-winter trout habitat. These habitat conditions coupled with the forage base deficiencies point toward the importance of the Windy Gap Connectivity Channel project now being planned and the downstream physical habitat improvement effort being developed for downstream of Windy Gap. These projects, when implemented, should address such issues and improve trout recruitment and population size in the affected reaches.



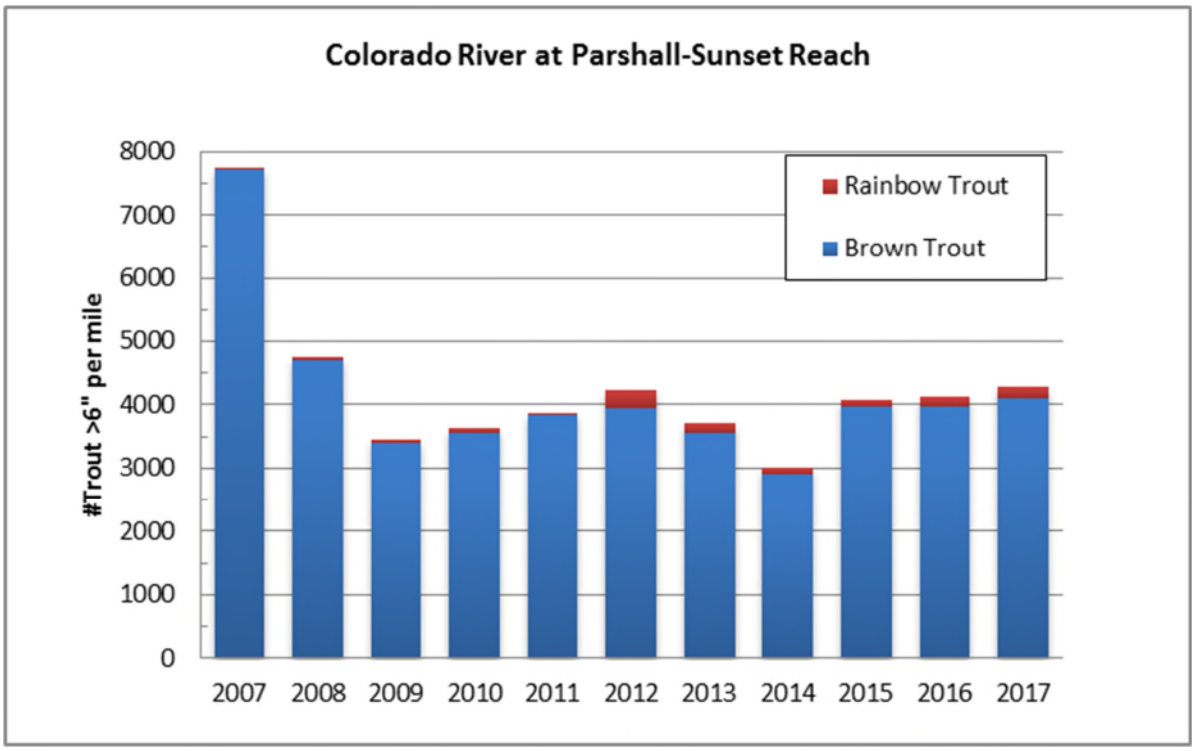


Figure 11 CPW trout population estimates for Colorado River Parshall-Sunset reach, 2007-2017.

Rainbow trout density in the Parshall-Sunset reach continued to respond positively in 2017 to the fry stocking policy adopted in 2010 (Ewert 2018b). The population estimate for rainbows > 6" climbed to 205 fish/mile and contributed about 10% of the total trout biomass estimated in the reach and about 17% of the quality trout. Successful natural reproduction has been documented, but it is not yet known if this will be sufficient to increase their proportion of the total trout population. Also in 2017, mountain whitefish (*Prosopium williamsoni*) were again collected indicating the "invasion" first documented in 2013 continues. In total, 33 were collected in 2017 with size ranging from 4 to 16" and several age classes represented. Effects of mountain whitefish on the trout population are not yet known (Ewert 2018b). Once again, no mottled sculpin were reported in the 2017 fish collections, not an unexpected finding as sampling was done by raft-mounted electrofishing. The status of mottled sculpin in this section of the Colorado River remains unclear. .

Table 21 Summary of CPW fish population data by year for the Colorado River, 2007-2017.

Site	Year	Brown Trout		Rainbow Trout		Brook Trout	Total Trout	Sculpin	Mountain Whitefish
		(lbs/acre)	(#>14"/acre)	(lbs/acre)	(#>14"/acre)	(lbs/acre)	(lbs/acre)	(#)	(#)
Shorefox - Lower	2016	223	65	3	2		226	19	
Shorefox-Upper	2016	193	75	12	6		205	27	
Paul Gilbert	2013	74	11	13	5		87		
	2016	132	28	13	6		145		1
Parshall-Sunset	2007	264	19				264		
	2008	187	24				187		
	2009	158	28	3	1		161		
	2010	131	52	4	2		135		
	2011	111	44	1	1		112		
	2012	108	17	6	3		114		
	2013	117	13	5	4		122		4
	2014	126	33	9	5		135		2
	2015	122	39	10	3		132		22
	2016	134	26	12	6		146		49
	2017	134	15	15	3		149		33
Radium	2010	103	36	17	10		120		307
	2011	110	44	47	28		157		162
	2012	143	46	6	3		149		273
	2013	162	50	4	2		166		248
	2015	129	56	26	**		155		219

**Equipment problems prevented valid brown trout population estimate

4 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary and Conclusions

4.1.1 Fraser River and Ranch Creek

2017 spring runoff in the Fraser River watershed was again relatively high with peak flows well exceeding the magnitude and duration of the recommended flushing flows for the fourth consecutive year. Spawning bar habitats had the lowest embeddedness recorded since monitoring began in 2010 and neither bar was impaired by finer sediments (<8mm) based on the CWQCC guideline. Riffle bed material mobilization occurred on both streams, as it had in 2014-2016. Riffle Stability Index analyses indicated bed material up to small cobble size had been transported, with an estimated 34 to 43% of the riffle substrates mobilized. Overall, the health of the Fraser River watershed macroinvertebrate community improved in a downstream direction. The Ranch Creek macroinvertebrate community has remained quite stable in recent years and has consistently attained its aquatic life use designation. Fraser River sites have shown more variability. The lowermost site in Granby has consistently achieved the highest MMI scores, has attained its aquatic life use designation in all sample years and provides habitat for giant stoneflies. Upstream, the remainder of the 2017 macroinvertebrate sites have been found to be "impaired" in at least one sample year. In 2017, both the above Winter Park and Rendezvous sites failed to attain their aquatic life use designation. All riffle habitats sampled in 2017 were well below the CWQCC guideline threshold for fine sediment impairment. Trout populations at both the Kaibab Park and the Safeway stations once again exceeded CPW Gold Medal benchmarks in 2017 (Ewert 2018a). At Fraser Flats, early results following completion of the habitat improvement project indicate success, with both trout biomass and quality trout density well exceeding pre-project levels. The trout population at Confluence Park has shown the greatest variability of the Fraser River stations. Both trout biomass and quality trout numbers here are below the Gold Medal biological benchmarks, with brook and brown trout out-competing stocked rainbow trout. No fish sampling was conducted on Ranch Creek in 2017.

4.1.2 Colorado River

2017 spring runoff on the Colorado River was relatively high with peak flows exceeding the magnitude and duration of the recommended flushing flows for the fourth consecutive year. All four spawning bars sampled were exceptionally clean, with little embeddedness. None of the bars were impaired by finer sediments based on the CWQCC guideline. Riffle bed material mobilization occurred at all four sites, as it had in 2014 to 2016, with particles up to medium cobble transported and an estimated 40 to 50% of riffle substrates potentially mobilized. These findings are supportive of our 2016 observation that flows in the range of the 3-year return interval event can initiate cobble mobilization and riffle maintenance. Overall, the health of the Colorado River macroinvertebrate community appeared satisfactory in 2017, with all sites attaining their designated aquatic life use. Giant stoneflies were collected at all LBD sites below Windy Gap. All riffle habitats sampled in 2017 were well below the CWQCC guideline threshold for fine sediment impairment. Fish population sampling was only conducted at the Parshall-Sunset station in 2017, with trout biomass and density similar to 2015 and 2016 levels (Ewert 2018b). However, quality trout numbers continue to decline. CPW has raised concerns that this reach of the Colorado River is uncomfortably close to not meeting Gold Medal standards and is a fishery in decline due

to long-term trout forage base and habitat degradation. These conditions emphasize the importance of the Windy Gap Connectivity Channel project and the downstream Habitat Project improvement efforts now being planned.

4.2 Recommendations

Recommendations at this time are general, awaiting improved spring runoff forecasts and guidance from the LBD Committees on future direction of monitoring activities. Following are several general recommendations which can be revised as the review process proceeds into spring 2018:

1. If spring runoff forecasts indicate 2018 flows will be low, similar to the drier 2012-2013 period, we recommend the LBD Committee consider a full scope of sampling and reporting for both spawning bar and pebble counts at macroinvertebrate sampling sites to provide additional documentation of aquatic habitats and communities under these more extreme conditions and to further examine the efficacy of the flushing flow recommendations.

2. If spring runoff forecasts indicate 2018 flows will be relatively high, similar to the 2014 to 2017 period, the LBD Committee may wish to consider a reduced scope and extent of the spawning bar monitoring effort to avoid continued duplication of recent results. Spawning bar monitoring could be delayed until such time as flow forecasts for future years indicate reduced spring runoff conditions.

3. The LBD may wish to consult with Timberline Aquatics, Inc. on a potential reduction in macroinvertebrate sampling that could be implemented without jeopardizing the knowledge gained to date from previous years efforts. In particular if there are trends relating the health of the macroinvertebrate community relative to flow magnitude and duration perhaps monitoring could be curtailed accordingly.

4. The LBD Committee may wish to consider having the entity conducting the macroinvertebrate sampling and analysis to also prepare the associated macroinvertebrate monitoring report.

5. Continue to work with CPW who has responsibility for sampling and managing fish populations throughout the LBD study area and in recent years have authored comprehensive and concise summary reports describing current conditions of the Fraser and Colorado River fisheries (e.g. Ewert 2018a and 2018b).

6. Consider employing an independent fourth party to review and assess trends in stream health and flows, by combining the annual monitoring reports for aquatic habitat (spawning bar and pebble counts at macroinvertebrates sampling sites), macroinvertebrate sampling, and fish sampling. It is possible this effort could be done less frequently than sampling. The timing and frequency of the assessments should consider project implementation and other factors that may influence trends and conclusions.

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APPENDIX A

Chronology of Spawning Bar Site Sampling
Flood-frequency Analyses

Table A1. Sampling chronology at Grand County spawning bar monitoring sites, 2010-2017.

Location Information			Sample Date (month/year)										
River	LBD Reach	Site Name	July 2010	Aug & Sep 2011	Oct 2011	June 2012	Oct 2012	July 2013	July-Aug 2014	Oct 2014	Aug &Oct 2015	Sept &Oct 2016	Sept &Oct 2017
Fraser River	F2	F2 Blw SedPond		√		√	√	√	√	√	√	√[6]	
	F-RC2	F-RC2 Blw MC	√	√		√	√	√	√	√	√	√	√[7]
	F9	F9 GranbyRanch	√	√		√	√	√	√	√	√	√	√[7]
Colorado River	CR4	CR4 ChimRk[1]	√	√									
	CR4	CR4 Gilbert[2]			√	√	√	√	√				
	CR4	CR4 PPark[3]								√	√	√	√[7]
	CR5	CR Blw WF	√	√	√	√	√	√	√	√	√	√	√[7]
	Cr6	CR BlwKB Ditch	√	√	√	√	√	√	√	√	√	√	√[7]
	CR7	CR7 Pumphouse			√	√	√	√	√	√	√	√	√
Tributaries	MC2	MC2 BlwWolford	√	√	√	√	√	√	√	√	√		
	BR	BR-TRoad[4]	√										
	BR	BR-BVR-L[5]	√	√		√	√	√	–	–	√		

[1] At Chimney Rock Ranch: sampling discontinued due to absence of spawning gravels
[2] At Paul Gilbert Public Access Area; trout spawning observed in fall 2011; Cr4 site moved due to lack of spawning gravels Oct 2014
[3] Below Pioneer Park at Hot Sulphur Springs; trout spawning observed October 2014
[4] Access denied at Blue River Trough Road site after 2010
[5] Stream restoration work at Blue Valley Ranch site removed spawning bar site in 2014
[6] Ocular survey only in 2016
[7] Core samples not collected on spawning bar

Table A1. Fraser River at Granby, Colorado.

Return period T	Probability P	Frequency factor K	y = log	Peak flood discharge Q
(yr)	(percent)		(Q)	(cfs)
1.05	95.24	-1.874	2.245	176
1.11	90.09	-1.34	2.43	269
1.25	80	-0.76	2.631	428
2	50	0.162	2.95	892
3				1072 [1]
5	20	0.852	3.19	1547
10	10	1.131	3.286	1932
25	4	1.372	3.37	2342
50	2	1.5	3.414	2594
100	1	1.599	3.448	2806
200	0.5	1.677	3.475	2986

[1]Based on interpolation of log values, the 3-yr event was estimated to be about 1072 cfs.

Table A2. Colorado River at Windy Gap Reservoir, Colorado.

Return period T	Probability P	Frequency factor K	y = log	Peak flood discharge Q
(yr)	(percent)		(Q)	(cfs)
1.05	95.2	-1.707	2.51	323
1.11	90.1	-1.303	2.654	451
1.25	80	-0.828	2.825	668
2	50	0.037	3.135	1366
3				1702 [1]
5	20	0.851	3.427	2675
10	10	1.254	3.572	3735
25	4	1.67	3.721	5266
50	2	1.93	3.815	6529
100	1	2.158	3.897	7882
200	0.5	2.363	3.97	9337

[1]Based on interpolation of log values, the 3-yr event was estimated to be about 1702 cfs.

Table A3. Colorado River near Parshall below Williams Fork Reservoir, Colorado.

Return period T	Probability P	Frequency factor K	y = log	Peak flood discharge Q
(yr)	(percent)		(Q)	(cfs)
1.05	95.2	-1.732	2.65	447
1.11	90.1	-1.311	2.794	622
1.25	80	-0.821	2.961	915
2	50	0.054	3.26	1821
3	33			2239 [1]
5	20	0.853	3.533	3413
10	10	1.241	3.666	4629
25	4	1.633	3.799	6301
50	2	1.874	3.882	7618
100	1	2.083	3.953	8977
200	0.5	2.268	4.017	10388

[1]Based on interpolation of log values, the 3-yr event was estimated to be about 2239 cfs.

Table A4. Colorado River at Kremmling, Colorado.

Return period T	Probability P	Frequency factor K	y = log	Peak flood discharge Q
(yr)	(percent)		(Q)	(cfs)
1.05	95.2	-1.656	3.026	1063
1.11	90.1	-1.286	3.134	1362
1.25	80	-0.84	3.264	1836
2	50	0.007	3.51	3236
3	33			3890 [1]
5	20	0.844	3.753	5666
10	10	1.277	3.879	7574
25	4	1.736	4.013	10300
50	2	2.031	4.099	12549
100	1	2.295	4.175	14974
200	0.5	2.537	4.246	17604

[1]Based on interpolation of log values, the 3-yr event was estimated to be about 2890 cfs.

Appendix B

Macroinvertebrate Sampling

Learning By Doing (LBD) 2017 Macroinvertebrate Sampling Program

CDPHE Benthic Macroinvertebrate Bioassessment Reports
Fraser River and Ranch Creek, 2017

CDPHE Benthic Macroinvertebrate Bioassessment Reports for Colorado River, 2017

2017 Macroinvertebrate Sample Analysis Information for CR7-Pumphouse from BLM/USU
National Aquatic Monitoring Center

Sample results on Excel File Appended in CD

Taxa List for 2017 Fraser River and Ranch Creek Benthic Macroinvertebrate Samples

Taxa List for 2017 Colorado River Benthic Macroinvertebrate Samples

Grand County's Learning By Doing 2017 Macroinvertebrate Sampling Program

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, monitoring the health of the macroinvertebrates is a better indicator of fluctuating environmental conditions. Changes in macroinvertebrate communities signal whether there might be impacts from urban development land use changes and changes in 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 objectives of this macroinvertebrate monitoring program are to:

- Assess the existing state of macroinvertebrate communities in the Colorado and Fraser Rivers and their tributaries;
- Monitor trends and changes to the health of the macroinvertebrate communities;
- Support 401 Certification and U.S. Army Corps of Engineers permit conditions (Colorado Department of Public Health and Environment, Water Quality Control Division, WGFP, 2016) (Colorado Department of Public Health and Environment, Water Quality Control Division, Moffat, 2016).
- 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. LBD has elected to compute additional standard 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.

The program is reviewed annually.

Monitoring Sites

The 2017 macroinvertebrate monitoring program consists of 12 sites; 5 sites in the Colorado River, 6 sites in the Fraser River and one site in a Fraser River tributary, Ranch Creek. Generally, monitoring sites are intended to provide a long-term record. It is anticipated that only minor changes in the location of the sites sampled 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.

Table 1 summarizes all 2017 sites and indicates which sites are long-term monitoring sites. A map of the 2017 macroinvertebrate sampling sites is provided at the end of the program summary. In effort to normalize the naming convention of the monitoring sites, each site is assigned a river mile ID. The river mile ID is composed of abbreviated text representing the water body followed by a numeric value representing the river mile. For example, the river mile ID for the Colorado River at river mile 10 is CR-10. River mile zero is located at the most downstream portion of a waterbody, generally the confluence with a larger river. The river miles increase at upstream sites. For the Colorado River, river mile zero is at the Cooperative Effort Area boundary (the confluence with the Blue River).

Table 1 - 2017 Macroinvertebrate Sampling Sites

River Mile ID	Station ID	Station Description	Latitude	Longitude	Long-Term Site?
FR-23.2	FR-abvWPSD	Fraser River upstream of Winter Park Sanitation District	39.8945	-105.7682	Yes
FR-20	FR-Rendezvous	Fraser River at Rendezvous Bridge	39.9341	-105.7896	Yes
FR-15	FR-FrSpProj	Fraser River upstream of Fraser Flats restoration	39.9813	-105.8249	No
FR-14	FR-CR83	Fraser River upstream of Tabernash below bridge on CR83	39.9905	-105.8299	Yes
RC-1.1	RC-blwMC	Ranch Creek downstream of Meadow Creek	39.9991	-105.8275	Yes
FR-12.4	FR-blwCrcr	Fraser River downstream of Crooked Creek	40.0110	-105.8524	Yes
FR-1.9	FR-abvGSD	Fraser River upstream of Granby Sanitation District	40.0853	-105.9546	Yes
CR-31	CR-WGU	Colorado River upstream of Fraser and Windy Gap	40.1005	-105.9725	Yes
CR-28.7	CR-WGD	Colorado River downstream of Windy Gap	40.1083	-106.0036	Yes
CR-22.9	CR-HSU	Colorado River upstream of Hot Sulfur Springs	40.0803	-106.0986	Yes
CR-16.7	CR-WFU	Colorado River upstream of Williams Fork	40.0503	-106.1725	Yes
CR-9.1	COR-KBDitch	Colorado River at CR39 Bridge at KB Ditch	40.0538	-106.2895	Yes

Project Specific Sampling Sites

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 2017, the site FR-15 (FR-FrSpProj) is associated with the Fraser Flats Restoration Project; this site is not considered a long-term monitoring site

Funding

The cost of the macroinvertebrate monitoring program is shared between LBD's cooperative partners. Some sites are individually sponsored by parties with interest in a specific site. The rest of the sites are equally cost-shared between the parties that have a stake in those sites. Table 2 shows what partners funded each site in 2017.

Table 2 - Funding Partners for Monitoring Sites

River Mile ID	Denver Water	Grand County	LBD	Northern Water	River District	Town of Winter Park	Trout Unlimited	Winter Park WSD
FR-23.2	X	X			X	X	X	X
FR-20	X	X			X	X	X	X
FR-15			X					
FR-14	X	X			X		X	
RC-1.1	X	X			X		X	
FR-12.4	X	X			X		X	
FR-1.9	X	X			X		X	
CR-31				X				
CR-28.7				X				
CR-22.9				X				
CR-16.7				X				
CR-9.1	X	X			X		X	

Sample Collection

Macroinvertebrate sampling will be conducted 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 Division's methodology for macroinvertebrate sampling (Colorado Department of Public Health and Environment, 2010).

Sample Collection with a Hess Sampler

All samples are collected by Timberline Aquatics, Fort Collins, Colorado. Three (3) quantifiable samples (Hess samples) are taken from riffle habitat at each of the sites during the fall season. 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 (Timberline Aquatics, Inc., 2017). Samples are collected per the Division's Section *303(d) Listing Methodology 2018 Listing Cycle* (Colorado Department of Public Health and Environment, Water Quality Control Division, March 2017)

Macroinvertebrate Analysis

Timberline Aquatics performs the macroinvertebrate analysis for all samples. Experienced taxonomists conduct the analysis utilizing a wide selection of the most recent species

keys for aquatic insects. They are familiar with common and uncommon species that are specific to Colorado.

Timberline Aquatics performs identification and enumeration for each entire sample (i.e. all macroinvertebrates in the sample are counted), or a full-count method of analysis. Macroinvertebrates are identified to the "lowest practical taxonomic level" based primarily on Merritt et al. (Merritt, 2008) and Ward et al. (Ward, 2002). The "lowest practical taxonomic level" means that all specimens will be identified to a level that is permitted by available physical characteristics and species keys using a dissecting microscope. This level of identification will be consistent with the Operational Taxonomic Unit (OTU) developed by the Division, which usually consists of genus or species for mayflies, stoneflies, caddisflies and many dipterans. Chironomidae will also 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 (Timberline Aquatics, Inc., 2017).

Laboratory Reports

Final data from Timberline Aquatics are provided in Excel files to the LBD Monitoring Committee. The files include a species list and count of all identified macroinvertebrates for each sample at each site. Nine metrics are calculated for each site and included in the excel file. The metrics are shown in Table 3.

Table 3 – Timberline Aquatics Reported Metrics and Description

Metric	Description
Multi-Metric Index (MMI)	Colorado Division of Water Quality assessment tool. Provides a score which determines health of aquatic community.
% Chironomidae (MMI Metric)	MMI score based on percent composition of chironomidae taxa. Chironomidae are tolerant to stress, a high score indicates a stressed environment.
% EPT excluding Baetis (MMI Metric)	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.
Ephemeroptera Plecoptera Trichoptera (EPT)	Total number of distinguishable taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera.
Hilsenhoff Biotic Index (HBI)	Indicator of nutrient enrichment as well as other stressors.
Shannon Diversity	Indicator of macroinvertebrate community structure and balance.
Total Taxa Richness	Total number of identifiable taxa, indicator of general community health and stability.
Pteronarcys Californica Density	Pteronarcys Californica abundance, mean number per square meter.
Total Density	Macroinvertebrate abundance, mean number per square meter.

Colorado Parks and Wildlife Sampling

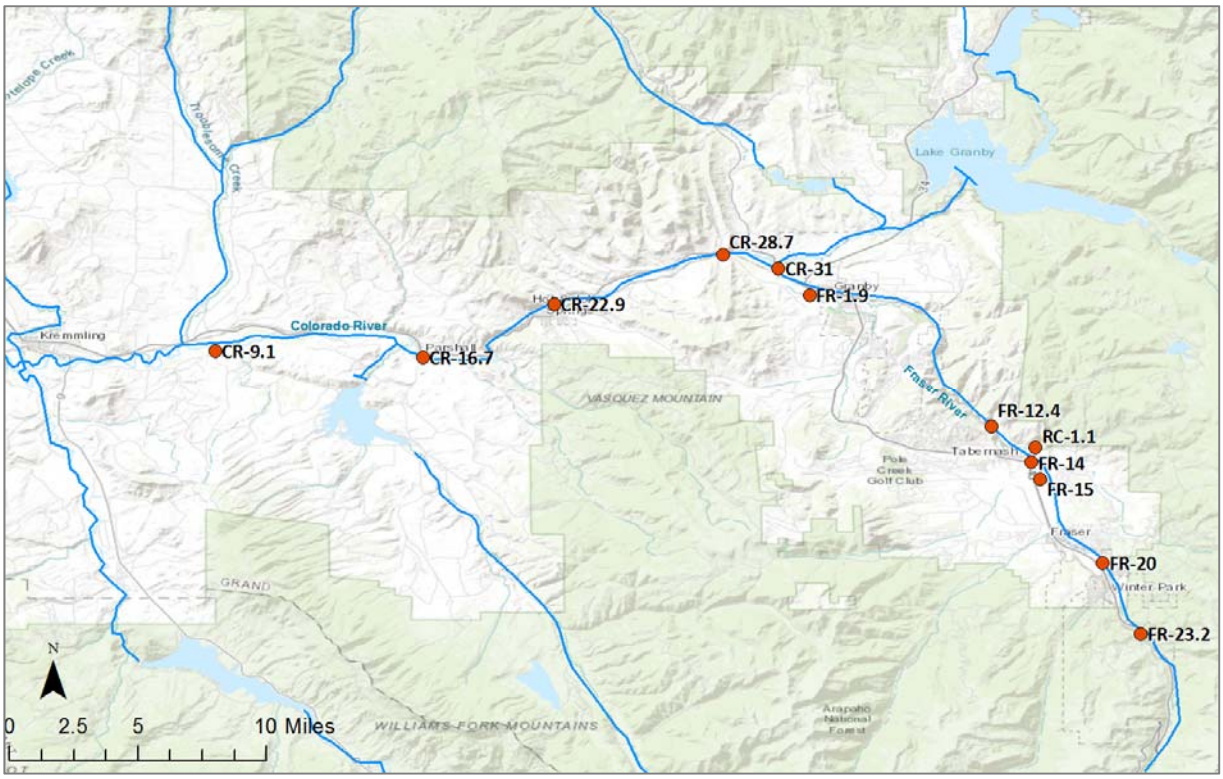
Colorado Parks and Wildlife's (CPW) 2017 macroinvertebrate sampling includes 8 additional sites upstream and downstream of Windy Gap Reservoir; 7 sites in the Colorado River and 1 site in the Fraser River (Table 4).

Table 4 - 2017 CPW Monitoring Sites

River Mile ID	Station ID	Station Description	Latitude	Longitude
FR-0.1	FR-WGU	Fraser River upstream of Windy Gap	40.0986	-105.9729
CR-31	CR-WGU	Colorado River upstream of Fraser River and Windy Gap	40.1005	-105.9725
CR-30.8	CR-FRD	Colorado River downstream of Fraser, upstream of Windy Gap	TBD	TBD
CR-28.7	CR-WGD	Colorado River downstream of Windy Gap	40.1083	-106.0036
CR-22.9	CR-HSU	Colorado River at Pioneer Park upstream of Hot Sulfur Springs	40.0803	-106.0986
CR-16.7	CR-WFU	Colorado River upstream of Williams Fork	40.0503	-106.1725
CR-14.9	CR-WFD	Colorado River downstream of Williams Fork at Kid's Pond	40.0634	-106.1907
CR-12.6	CR-CON	Colorado River at ConRitschard	40.0656	-106.2318

CPW's 2017 sampling was done to establish baseline conditions in support of the proposed connectivity channel around Windy Gap Reservoir. The macroinvertebrate data generated by CPW are specific to their sampling and analytical protocols and objectives. Therefore, although these data are of value, they may not be appropriate for comparison to macroinvertebrate data generated by LBD. These data are not included in Grand County's annual Stream Management Plan Monitoring Report but will be available in CPW's annual Federal Aid Report.

Map of LBD 2017 Macroinvertebrate Sampling Sites



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Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**CR-9.1**			Sample Date:	9/18/2017
Waterbody Name:	**Colorado River**				
Location:	at CR39 Bridge - KB Ditch				
Latitude:	40.05377	Reference Status:	Not Reference or Degraded		
Longitude:	-106.28945	BenSampID: 1		RepNum: 1	
Biotype:	1				

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	73.2

Metric Name	Metric Value	Metric Score
Total Taxa:	41	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	13	100.0
Chironomidae Pct:	17.7	75.0
Sensitive Plains Fammilies Pct:	28.6	46.2
Predator+ Shredder Taxa:	11	78.6
Clinger Taxa:	21	N/A
Clinger Taxa adjuested with Elevation:	21	100.0
Insect Taxa:	34	N/A
Non-Insct % of taxa:	17.1	39.2
Ephemeroptera Pct:	15.0	N/A
BeckBI:	37.0	N/A
Dominant01 Taxon Pct:	17.0	N/A
Sprawler Pct:	1.0	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**FR-1.9**	Sample Date:	9/18/2017
Waterbody Name:	**Fraser River**		
Location:	abv Granby Sanitation District		
Latitude:	40.08526	Reference Status:	Not Reference or Degraded
Longitude:	-105.95464	BenSampID: 2	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	86.9

Metric Name	Metric Value	Metric Score
Total Taxa:	40	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	13	100.0
Chironomidae Pct:	10.5	85.9
Sensitive Plains Fammilies Pct:	44.0	71.2
Predator+ Shredder Taxa:	14	100.0
Clinger Taxa:	21	N/A
Clinger Taxa adjuested with Elevation:	21	100.0
Insect Taxa:	36	N/A
Non-Insct % of taxa:	10.0	64.4
Ephemeroptera Pct:	16.2	N/A
BeckBI:	41.0	N/A
Dominant01 Taxon Pct:	18.4	N/A
Sprawler Pct:	6.4	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**FR-12.4**			Sample Date:	9/18/2017
Waterbody Name:	**Fraser River**				
Location:	blw Crooked and Ranch Creeks				
Latitude:	40.011	Reference Status:	Not Reference or Degraded		
Longitude:	-105.852417	BenSampID: 3		RepNum: 1	
Biotype:	1				

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	69.1

Metric Name	Metric Value	Metric Score
Total Taxa:	35	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	12	93.0
Chironomidae Pct:	13.3	81.7
Sensitive Plains Fammilies Pct:	28.0	45.4
Predator+ Shredder Taxa:	15	100.0
Clinger Taxa:	12	N/A
Clinger Taxa adjuested with Elevation:	12	55.6
Insect Taxa:	29	N/A
Non-Insct % of taxa:	17.1	39.0
Ephemeroptera Pct:	39.6	N/A
BeckBI:	26.0	N/A
Dominant01 Taxon Pct:	33.5	N/A
Sprawler Pct:	2.6	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**FR-14**	Sample Date:	9/18/2017
Waterbody Name:	**Fraser River**		
Location:	at Tabernash below bridge on CR83		
Latitude:	39.99053	Reference Status:	Not Reference or Degraded
Longitude:	-105.8299	BenSampID: 4	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	65.4

Metric Name	Metric Value	Metric Score
Total Taxa:	33	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	8	46.6
Chironomidae Pct:	24.6	64.4
Sensitive Plains Fammilies Pct:	39.6	64.1
Predator+ Shredder Taxa:	14	100.0
Clinger Taxa:	13	N/A
Clinger Taxa adjuested with Elevation:	13	60.7
Insect Taxa:	29	N/A
Non-Insct % of taxa:	12.1	56.9
Ephemeroptera Pct:	17.5	N/A
BeckBI:	27.0	N/A
Dominant01 Taxon Pct:	14.6	N/A
Sprawler Pct:	8.2	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**FR-15**			Sample Date:	9/18/2017
Waterbody Name:	**Fraser River**				
Location:	upstream Fraser Flats restoration				
Latitude:	39.981338	Reference Status:	Not Reference or Degraded		
Longitude:	-105.824946	BenSampID: 5		RepNum: 1	
Biotype:	1				

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	48.0

Metric Name	Metric Value	Metric Score
Total Taxa:	32	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	9	68.9
Chironomidae Pct:	48.1	28.6
Sensitive Plains Fammilies Pct:	6.2	10.0
Predator+ Shredder Taxa:	9	64.3
Clinger Taxa:	13	N/A
Clinger Taxa adjuested with Elevation:	13	71.7
Insect Taxa:	27	N/A
Non-Insct % of taxa:	15.6	44.4
Ephemeroptera Pct:	21.2	N/A
BeckBI:	25.0	N/A
Dominant01 Taxon Pct:	30.1	N/A
Sprawler Pct:	16.8	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**FR-20**	Sample Date:	9/18/2017
Waterbody Name:	**Fraser River**		
Location:	at Rendezvous Bridge		
Latitude:	39.93412	Reference Status:	Not Reference or Degraded
Longitude:	-105.7896	BenSampID: 6	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	35.2

Metric Name	Metric Value	Metric Score
Total Taxa:	28	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	8	39.1
Chironomidae Pct:	46.9	30.4
Sensitive Plains Fammilies Pct:	6.2	10.0
Predator+ Shredder Taxa:	13	92.9
Clinger Taxa:	7	N/A
Clinger Taxa adjuested with Elevation:	7	2.5
Insect Taxa:	23	N/A
Non-Insct % of taxa:	17.9	36.4
Ephemeroptera Pct:	6.2	N/A
BeckBI:	21.0	N/A
Dominant01 Taxon Pct:	42.9	N/A
Sprawler Pct:	2.2	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**FR-23.2**	Sample Date:	9/18/2017
Waterbody Name:	**Fraser River**		
Location:	abv Winter Park Sanitation District		
Latitude:	39.89445	Reference Status:	Not Reference or Degraded
Longitude:	-105.76821	BenSampID: 7	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):		Model Test:	

Multimetric Index Model Results

MMI:	32.9

Metric Name	Metric Value	Metric Score
Total Taxa:	30	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	9	37.3
Chironomidae Pct:	46.2	31.6
Sensitive Plains Fammilies Pct:	8.8	14.2
Predator+ Shredder Taxa:	12	85.7
Clinger Taxa:	8	N/A
Clinger Taxa adjuested with Elevation:	8	0.0
Insect Taxa:	24	N/A
Non-Insct % of taxa:	20.0	28.8
Ephemeroptera Pct:	15.4	N/A
BeckBI:	22.0	N/A
Dominant01 Taxon Pct:	36.6	N/A
Sprawler Pct:	5.5	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**RC-1.1**	Sample Date:	9/18/2017
Waterbody Name:	**Ranch Creek**		
Location:	blw Meadow Creek		
Latitude:	39.99912	Reference Status:	Not Reference or Degraded
Longitude:	-105.82746	BenSampID: 8	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	58.9

Metric Name	Metric Value	Metric Score
Total Taxa:	38	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	9	57.1
Chironomidae Pct:	27.8	59.6
Sensitive Plains Fammilies Pct:	20.5	33.2
Predator+ Shredder Taxa:	14	100.0
Clinger Taxa:	14	N/A
Clinger Taxa adjuested with Elevation:	14	69.0
Insect Taxa:	31	N/A
Non-Insct % of taxa:	18.4	34.4
Ephemeroptera Pct:	19.3	N/A
BeckBI:	31.0	N/A
Dominant01 Taxon Pct:	17.8	N/A
Sprawler Pct:	2.4	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**CR-HSU**	Sample Date:	9/19/2017
Waterbody Name:	**Colorado River**		
Location:	Hot Sulphur upstream		
Latitude:	40.07394	Reference Status:	Not Reference or Degraded
Longitude:	-106.10959	BenSampID: 1	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	77.7

Metric Name	Metric Value	Metric Score
Total Taxa:	37	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	12	100.0
Chironomidae Pct:	6.6	92.0
Sensitive Plains Fammilies Pct:	30.1	48.8
Predator+ Shredder Taxa:	13	92.9
Clinger Taxa:	18	N/A
Clinger Taxa adjuested with Elevation:	18	100.0
Insect Taxa:	30	N/A
Non-Insct % of taxa:	18.9	32.7
Ephemeroptera Pct:	32.8	N/A
BeckBI:	34.0	N/A
Dominant01 Taxon Pct:	29.9	N/A
Sprawler Pct:	5.7	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**CR-WFU**	Sample Date:	9/19/2017
Waterbody Name:	**Colorado River**		
Location:	Williams Fork upstream		
Latitude:	40.04689	Reference Status:	Not Reference or Degraded
Longitude:	-106.14299	BenSampID: 2	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	78.8

Metric Name	Metric Value	Metric Score
Total Taxa:	40	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	13	100.0
Chironomidae Pct:	7.8	90.1
Sensitive Plains Fammilies Pct:	22.5	36.4
Predator+ Shredder Taxa:	14	100.0
Clinger Taxa:	20	N/A
Clinger Taxa adjuested with Elevation:	20	100.0
Insect Taxa:	34	N/A
Non-Insct % of taxa:	15.0	46.6
Ephemeroptera Pct:	37.8	N/A
BeckBI:	39.0	N/A
Dominant01 Taxon Pct:	24.4	N/A
Sprawler Pct:	4.4	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**CR-WGD**	Sample Date:	9/19/2017
Waterbody Name:	**Colorado River**		
Location:	below Windy Gap		
Latitude:	40.1083	Reference Status:	Not Reference or Degraded
Longitude:	-106.00356	BenSampID: 3	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	74.6

Metric Name	Metric Value	Metric Score
Total Taxa:	39	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	14	100.0
Chironomidae Pct:	1.4	99.8
Sensitive Plains Fammilies Pct:	22.8	36.8
Predator+ Shredder Taxa:	13	92.9
Clinger Taxa:	18	N/A
Clinger Taxa adjuested with Elevation:	18	100.0
Insect Taxa:	30	N/A
Non-Insct % of taxa:	23.1	17.9
Ephemeroptera Pct:	27.4	N/A
BeckBI:	34.0	N/A
Dominant01 Taxon Pct:	19.6	N/A
Sprawler Pct:	1.8	N/A

Colorado Department of Public Health and Environment

Water Quality Control Division

Benthic Macroinvertebrate Bioassessment Report

StationID:	**CR-WGU**	Sample Date:	9/19/2017
Waterbody Name:	**Colorado River**		
Location:	WG upstream		
Latitude:	40.10045	Reference Status:	Not Reference or Degraded
Longitude:	-105.97248	BenSampID: 4	RepNum: 1
Biotype:	1		

Predictive Model Results

O/E (p>half):	Model Test:

Multimetric Index Model Results

MMI:	66.6

Metric Name	Metric Value	Metric Score
Total Taxa:	40	N/A
Ephemeroptera + Plecoptera Taxa (adjusted with Elevation):	15	100.0
Chironomidae Pct:	32.2	52.9
Sensitive Plains Fammilies Pct:	13.2	21.3
Predator+ Shredder Taxa:	11	78.6
Clinger Taxa:	18	N/A
Clinger Taxa adjuested with Elevation:	18	100.0
Insect Taxa:	34	N/A
Non-Insct % of taxa:	15.0	46.6
Ephemeroptera Pct:	29.2	N/A
BeckBI:	33.0	N/A
Dominant01 Taxon Pct:	21.3	N/A
Sprawler Pct:	15.5	N/A

Table D.1. Colorado River at Pump House macroinvertebrate summary.

Colorado river at Pumphouse macroinvertebrate collection summary, taxonomy and abundance (#/m^2)								
			SampleID		164310			
			Station (NAMC)		COR-Pump			
			Station (Customer)		COR-Pumphouse			
			Waterbody		COR-Pumphouse			
			County		Grand			
			State		CO			
			Latitude		39.984714			
			Longitude		-106.514223			
			Collection Date		10/27/2017			
			Habitat Sampled		Targeted Riffle			
			Collection Method		Hess net			
			Field Notes		NULL			
			Lab Notes		NULL			
			Area sampled (m^2)		0.688			
			Field Split		100			
			Lab Split		15.63			
			Split Count		616			
OUT Code	**Phylum**	**Class**	**Order**	**Family**	**Genus**	**Species**	**OTUName**	**#/m^2**
5915	Annelida	Clitellata	NULL	NULL	NULL	NULL	Oligochaeta	19
5020	Arthropoda	Arachnida	NULL	NULL	NULL	NULL	Trombidiformes	37
51285	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	NULL	NULL	Sperchon	74
5012	Arthropoda	Insecta	Coleoptera	Elmidae	NULL	NULL	Optioservus	121
5929	Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	NULL	Optioservus quadrimaculatus	1
51424	Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	NULL	Zaitzevia parvulus	9
5266	Arthropoda	Insecta	Diptera	Chironomidae	NULL	NULL	Chironominae	9
5381	Arthropoda	Insecta	Diptera	Chironomidae	NULL	NULL	Diamesinae	97
5942	Arthropoda	Insecta	Diptera	Chironomidae	NULL	NULL	Orthocladiinae	1946
51269	Arthropoda	Insecta	Diptera	Simuliidae	NULL	NULL	Simulium	178
5098	Arthropoda	Insecta	Diptera	Tipulidae	Antocha	NULL	Antocha monticola	28
5029	Arthropoda	Insecta	Ephemeroptera	Baetidae	NULL	NULL	Acentrella	11
5139	Arthropoda	Insecta	Ephemeroptera	Baetidae	NULL	NULL	Baetis	1798
5007	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	NULL	NULL	Ephemerella	290
5454	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	NULL	NULL	Epeorus	65
51210	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	NULL	NULL	Rhithrogena	87
51379	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	NULL	NULL	Tricorythodes	19
51034	Arthropoda	Insecta	Plecoptera	NULL	NULL	NULL	Perlodidae	37
5690	Arthropoda	Insecta	Plecoptera	Perlodidae	NULL	NULL	Isoperla	19
51183	Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys	NULL	Pteronarcys californica	175
5543	Arthropoda	Insecta	Trichoptera	NULL	NULL	NULL	Glossosomatidae	67
5660	Arthropoda	Insecta	Trichoptera	NULL	NULL	NULL	Hydropsychidae	74
5181	Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	NULL	Brachycentrus americanus	19
5540	Arthropoda	Insecta	Trichoptera	Glossosomatidae	NULL	NULL	Glossosoma	67
51148	Arthropoda	Insecta	Trichoptera	Glossosomatidae	NULL	NULL	Protoptila	19
5260	Arthropoda	Insecta	Trichoptera	Hydropsychidae	NULL	NULL	Cheumatopsyche	19
5655	Arthropoda	Insecta	Trichoptera	Hydropsychidae	NULL	NULL	Hydropsyche	302
5662	Arthropoda	Insecta	Trichoptera	Hydroptilidae	NULL	NULL	Hydroptila	169
5721	Arthropoda	Insecta	Trichoptera	Lepidostomatida	NULL	NULL	Lepidostoma	28
51213	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	NULL	NULL	Rhyacophila	9

Appendix C

CPW Fish Population Data

Fraser River

FISH SURVEY AND MANAGEMENT INFORMATION

Jon Ewert - Aquatic Biologist (Hot Sulphur Springs)

General Information: The Fraser River is a highly diverse river offering many transitions in habitat type through the course of its length. Public access is somewhat limited in some sections and care should be taken to avoid trespass problems. Please consult with local agencies regarding access locations. Guided fishing is available on some privately held reaches.
Location: Eastern Grand County—towns of Winter Park, Fraser, and Granby.
Recreational Management: US Forest Service, towns of Winter Park, Fraser and Granby, and BLM.

Amenities and General Info.

- The Fraser River flows through multiple towns which offer general amenities in close proximity to the river.
- Guide services available through several area outfitters.

Regulations

Fraser River - Grand County
a. From the headwaters downstream to the confluence with St. Louis Creek:
1. Fishing is by artificial flies and lures only.
2. All rainbow trout must be returned to the water immediately upon catch.
b. From the confluence with St. Louis Creek downstream to the Colorado River:
1. The bag and possession limit for trout is two fish.

Previous Stocking

Whirling Disease-resistant Rainbow trout were stocked at various sizes from 2010-2013 with the goal of establishing a wild, self-sustaining rainbow fishery. Due to the success of this stocking, beginning in 2014 rainbow trout stocking ceased in order to give the rainbows a chance to sustain themselves. See discussion on following pages.

Sportfishing Notes

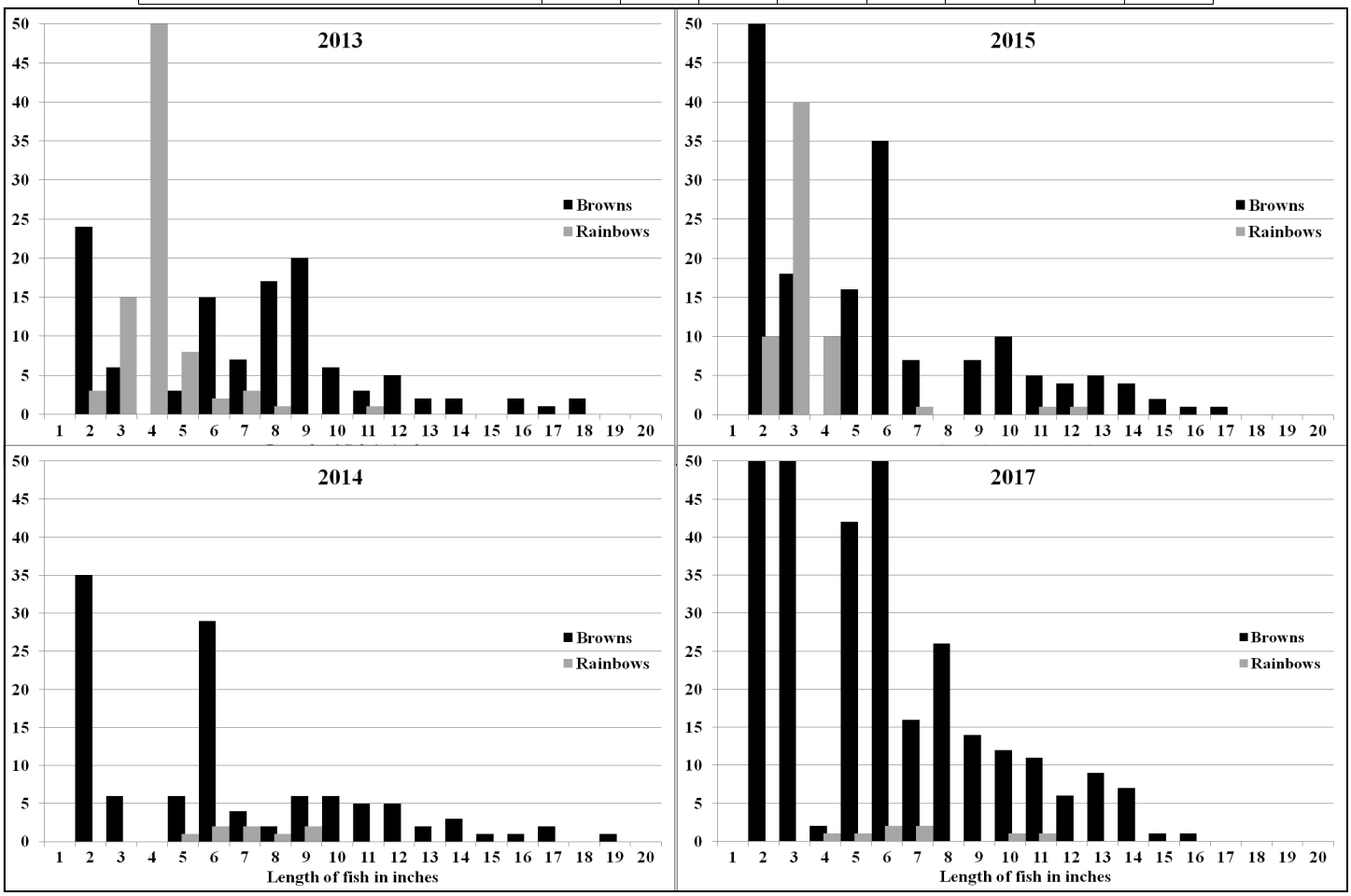
- The Fraser offers an enjoyable mix of fishing for brook, rainbow and brown trout. The composition of these three species depends on the location in the river one fishes. It is home to the highest densities of mottled sculpin in the area. Streamer fishing for large browns beneath undercut banks is always an option. The most prolific insect hatch is caddis, which takes place after runoff. Golden stoneflies and various mayflies are also abundant. Terrestrial fishing can be productive in late summer as well.

This 5” sculpin had recently consumed a 3” dace. This is the only time we have documented sculpin piscivory in this area.

This brown trout, captured in the same reach, had recently eaten a sculpin.

Fraser River at Kaibab Park

Population Estimates								
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**
Date of survey	9/1	9/2	9/1	9/6	9/3	9/4	9/3	9/6
Brown trout: pounds per acre	76	62	60	56	87	73	71	114
>14" per acre	18	23	14	4	16	22	16	19
>6" per mile	857	607	578	1,409	845	715	729	1,464
Total number mottled sculpin	256	466	533	1,279	521	262	469	249



The Kaibab Park station is located in the town of Granby where the river flows between the park and the fire station, immediately downstream of the Highway 40 crossing. This is the farthest downstream site on the Fraser that we survey regularly. Population estimates are shown in the table above and the graphs display the size distribution of brown and rainbow trout. Only brown trout population estimates appear in the table because rainbow trout have not constituted a significant portion of the fish population, despite the fact that rainbows have been stocked here on the same occasions that have been successful farther upstream.

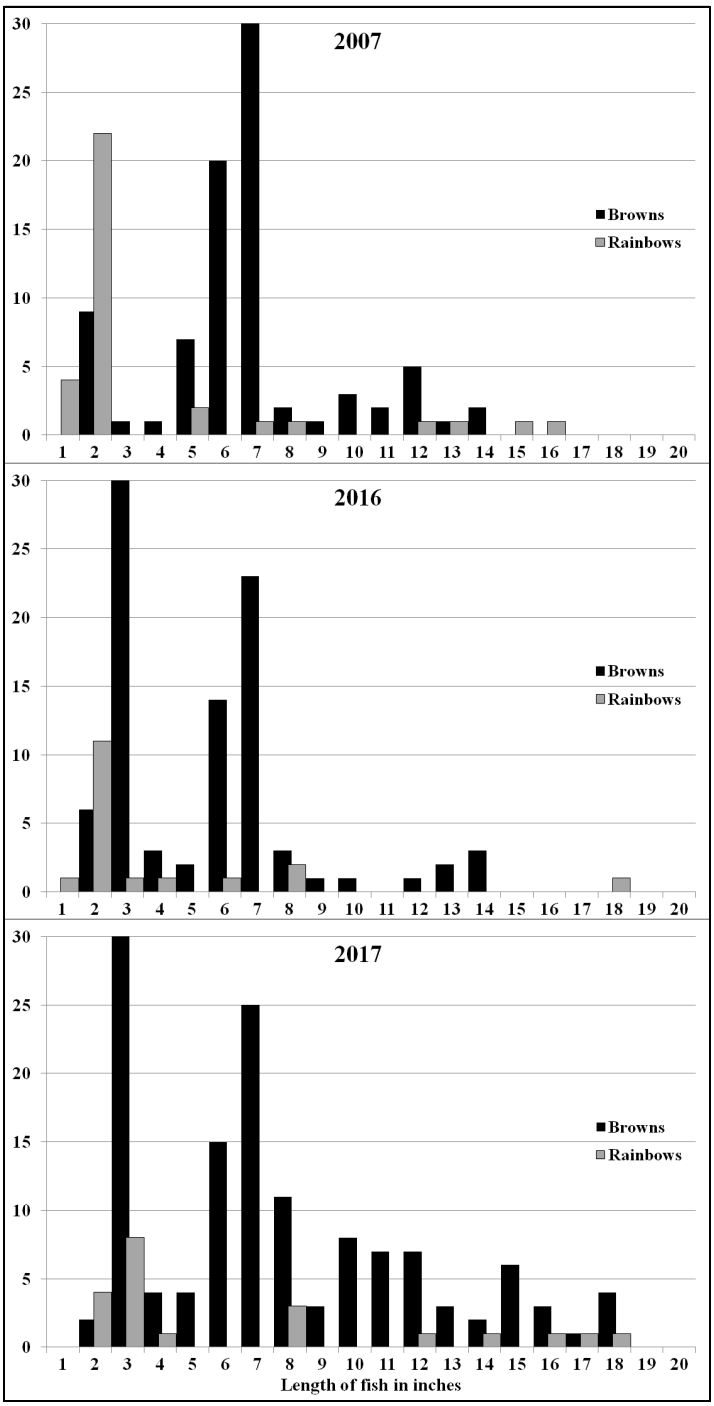
2017 saw the highest biomass and fish-per-mile estimates to date for brown trout in this reach. Extreme high-water years such as 2014 likely have a flushing effect on juvenile brown trout in this reach, while drought years such as 2012 see decreases in large fish density estimates. 2017 conditions probably represent a "happy medium" situation in which the river has benefitted from the flush of recent high water years, yet the 2017 runoff wasn't high enough to displace juveniles.

The rainbow trout appearing in the 2015 sample were fingerlings stocked that year. This is the only location on the Fraser that rainbow fingerlings have been stocked since 2013. The 2014 and 2017 samples found that recruitment from rainbow fingerling stocking in this reach was poor.

Peak flows at Granby	
Date	**Flow (cfs)**
6/4/09	991
6/8/10	1767
7/1/11	1519
4/27/12	157
5/18/13	651
5/31/14	2256
6/12/15	1425
6/13/16	1351
6/11/17	1027

Fraser River on Grand County Water and Sanitation Property

Fraser River GCW&S Population Estimates			
Year	**2007**	**2016**	**2017**
Date of survey	9/3	10/5	10/5
Brown trout			
Biomass (pounds per surface acre)	33	26	111
Fish >14" per acre	3	6	33
Fish > 6" per mile	752	430	923
Rainbow trout			
Biomass	9	6	16
Fish >14" per acre	3	2	8
Fish > 6" /mile	53	35	70
Brook trout			
Biomass	2	1	0
Fish > 6" /mile	44	9	0
Total trout biomass	44	33	127
Total sculpin captured	726	971	264



This reach is on property owned by Grand County Water and Sanitation District 1 immediately outside of Tabernash, and is slated to be opened to public access in 2018. In 2017 an in-stream physical habitat improvement project was constructed on the site. This project was a cooperative effort by the Learning By Doing stakeholder group (for more information visit https://co.grand.co.us/737/Learning-by-Doing). Prior to the habitat project, this reach had relatively poor trout habitat, characterized by a high width-to-depth ratio, poor thalweg definition, sparse and shallow pools, and excessive riffles. All of these deficiencies were addressed in the habitat improvement project.

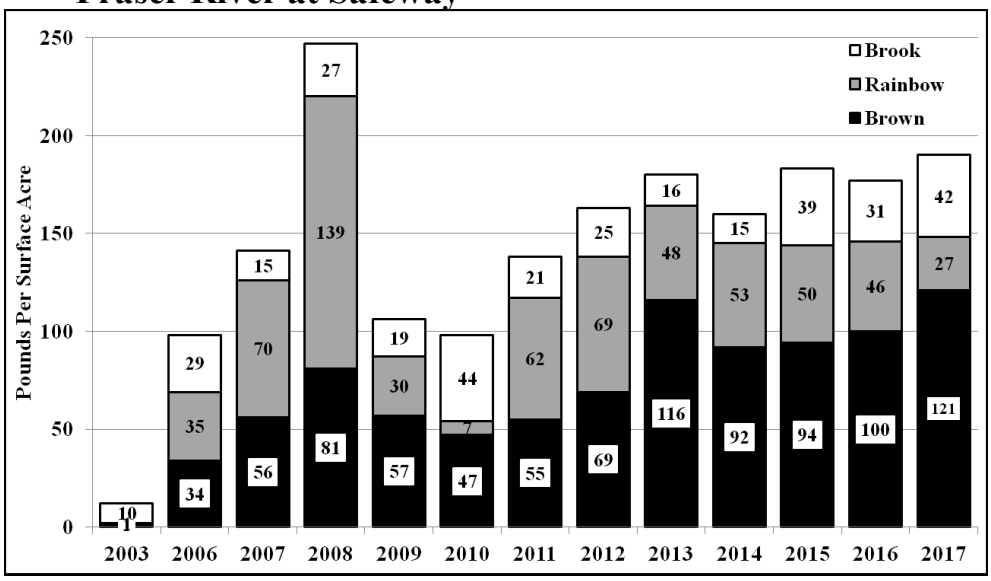
The table above contains the trout population estimates obtained on the three occasions that we have surveyed the site. Prior to the habitat project (2007 and 2016), this site yielded the poorest estimates of any location discussed in this report, and among the lowest population estimates ever obtained in any location on the Fraser. We observed an immediate benefit after completion of the project, with greatly increased numbers of adult fish and a nearly four-fold increase in total trout biomass from 2016 to 2017.

Rainbow and brown trout size distribution is displayed in the graphs above. Prior to the habitat project, we found high numbers of juvenile trout in their first two years of life, but by age 3 the fish had mostly vacated the reach in search of more suitable habitat. This did not appear to be the case any more after completion of the project. Interestingly, on all occasions we collected a number of age-0 rainbow fry. These fish were not stocked, and are the product of wild reproduction. This is an encouraging observation suggesting that a productive wild rainbow fishery may develop in this reach.

The sharp decline in sculpin numbers captured in 2017 is most likely due to the fact that the elecrofishing survey took place approximately two weeks after the habitat work was completed, which is a short amount of time for sculpin to recolonize after a high level of disturbance to the stream bed. If adult trout numbers continue to improve in the future, sculpin numbers may not return to their previous levels, due to increased predation.

Fraser River at Safeway

The Safeway station is located immediately behind the Safeway store in the town of Fraser. This station has the longest and most consistent history of surveys. The Town of Fraser, in partnership with other entities including Trout Unlimited and the Colorado Division of Wildlife (now CPW), completed a habitat improvement project in this area in 2005. These surveys show that the habitat project has proven to be overwhelmingly successful.

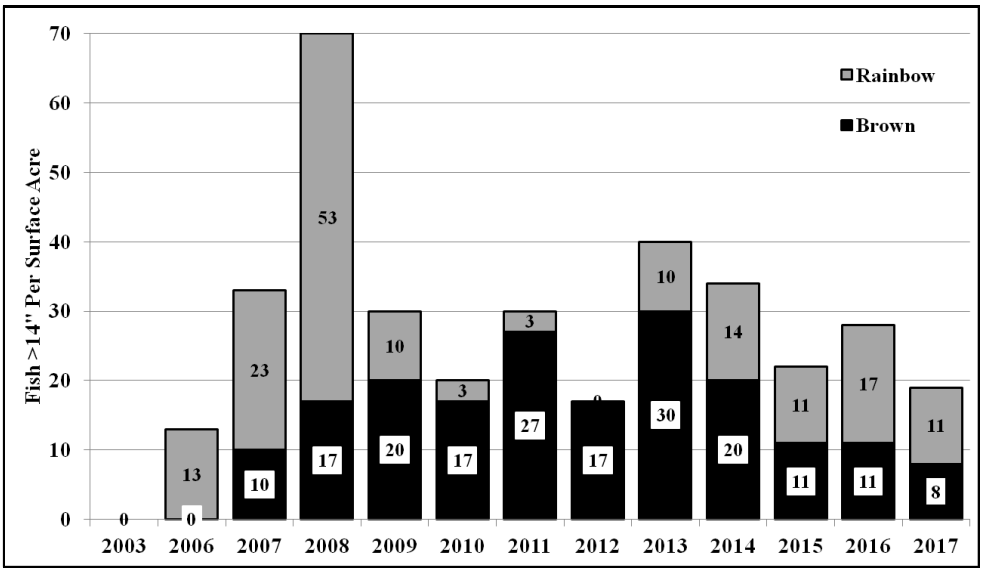


Trout biomoass estimates (in pounds per surface acre) for the Safeway station.

2003 was the only year that this station was surveyed prior to the habitat project construction. The survey that year yielded population estimates that were quite poor in all parameters of the trout population. All subsequent sampling occasions have produced estimates that are many times greater than the 2003 values.

The figure above contains biomass estimates in pounds per surface acre by species. Many of the changes in the rainbow population can be directly attributed to stocking patterns. Soon after the habitat project was completed, we stocked rainbows in this reach at high densities in order to quickly occupy habitat and possibly gain a competitive advantage over the brown trout. In 2007 and 2008, we stocked several hundred large brood fish, averaging 14-15", which produced the elevated rainbow biomass and quality fish density estimates in those years. The intention of stocking those fish was to "kick start" the rainbow population in the newly-improved habitat. These fish occupied the stream for a couple of seasons but did not accomplish natural reproduction. In 2010, we began a four-year period of stocking approximately 50,000 whirling-disease resistant rainbow fingerlings at 3-5". These plants had good success, and rainbow fingerling stocking ceased after 2013 due to the success of the program. We were concerned about overstocking, and we also wanted to observe whether or not the rainbows would begin sustaining themselves through natural reproduction. 2017 yielded the lowest biomass estimate for rainbows since fingerling stocking ceased, which may indicate that more stocking in the future is warranted.

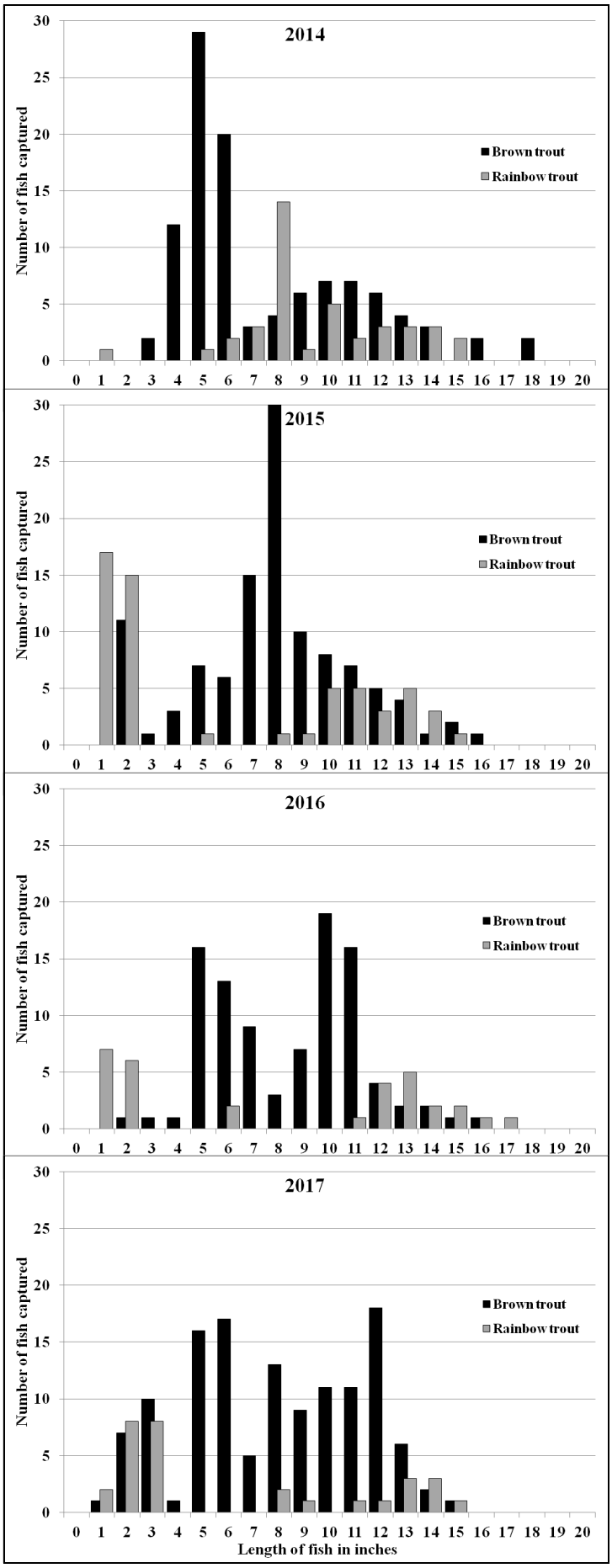
The figure below contains estimates of fish greater than 14" per surface acre. No brook trout >14" have been captured at this site, which is not unexpected. The general downward trend in large fish that we have observed since 2013 is probably an effect of the cessation of rainbow stocking, because in addition to establishing a rainbow fishery, the abundance of small rainbows also provided forage for large, predatory browns, likely enhancing their numbers in the 2011-2014 period. It is encouraging that large rainbows outnumbered large browns in 2016 and 2017, and 2018 will be a critical year in determining whether or not the rainbows will sustain themselves long-term (see discussion on following page).



Estimates of fish larger than 14" per surface acre

High water years may disadvantage brown trout on this section, probably by displacing juveniles to points downstream. Those years produce colder temperature regimes, which would also disadvantage browns. The lower-water years of 2012 and 2013 saw much higher recruitment of brown trout, resulting in increased population estimates beginning in 2012. The period of 2013-2017 saw the highest brown trout biomass estimates on this reach to date.

Fraser River at Safeway, continued



The graphs at left display the size distribution of rainbow and brown trout captured at the Safeway station over the past four years.

2013 was the last year that rainbow fingerlings were stocked. They were stocked on August 1, averaging 3.75" in length. In 2013 we also caught a large number of 2" rainbows, which were not explained by stocked fish and were likely the result of wild reproduction. Because of this, and the success of these plants that we have observed here and at Confluence Park, after 2013 we ceased the stocking of rainbows in order to observe whether or not they will sustain themselves through natural reproduction. This data set nicely captures the progression of the 2013 year class of brown trout, which had grown to 5" by 2014, 8" in 2015, 10" in 2016, and 12+" in 2017. This is actually the last large year class of browns that we observed in this reach. We did not capture any Age-0 fish in 2014, which is probably a reflection of the high water that year having an impact on fry survival.

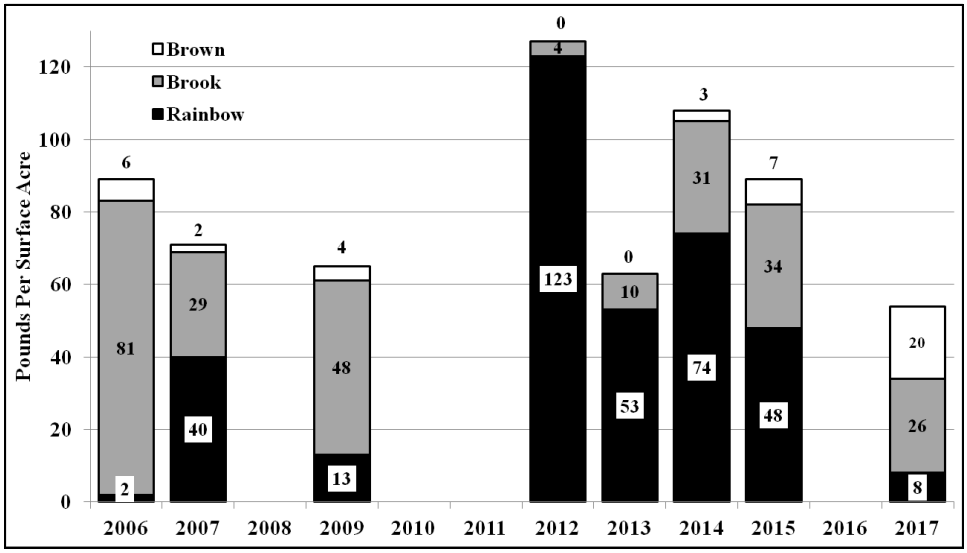
In 2015, 2016, and 2017 we captured moderate numbers of age-0 rainbow fry. Because we have not stocked since 2013, we know that these fish are the product of natural reproduction. It is especially encouraging to note that in '15 and '16, age-0 rainbows outnumbered age-0 brown trout by a significant margin. We found roughly equal numbers of age-0 fish of the two species in 2017. However, recruitment of rainbows from age-0 to age-1 appears to be poor, which is evident in the overall lack of rainbow trout in the 5-10" range from 2015 onward. If this trend continues into 2018 and adult rainbow densities dwindle, we will likely stock rainbow fingerlings again beginning in 2019.

Dates of Safeway Station surveys	
9/30/2003	9/6/2012
10/21/2006	9/4/2013
8/23/2007	9/3/2014
10/03/2008	9/2/2015
9/3/2009	8/31/2016
9/7/2010	9/5/2017
9/1/2011	

A Fraser River sculpin. Photo by Kevin Birznieks

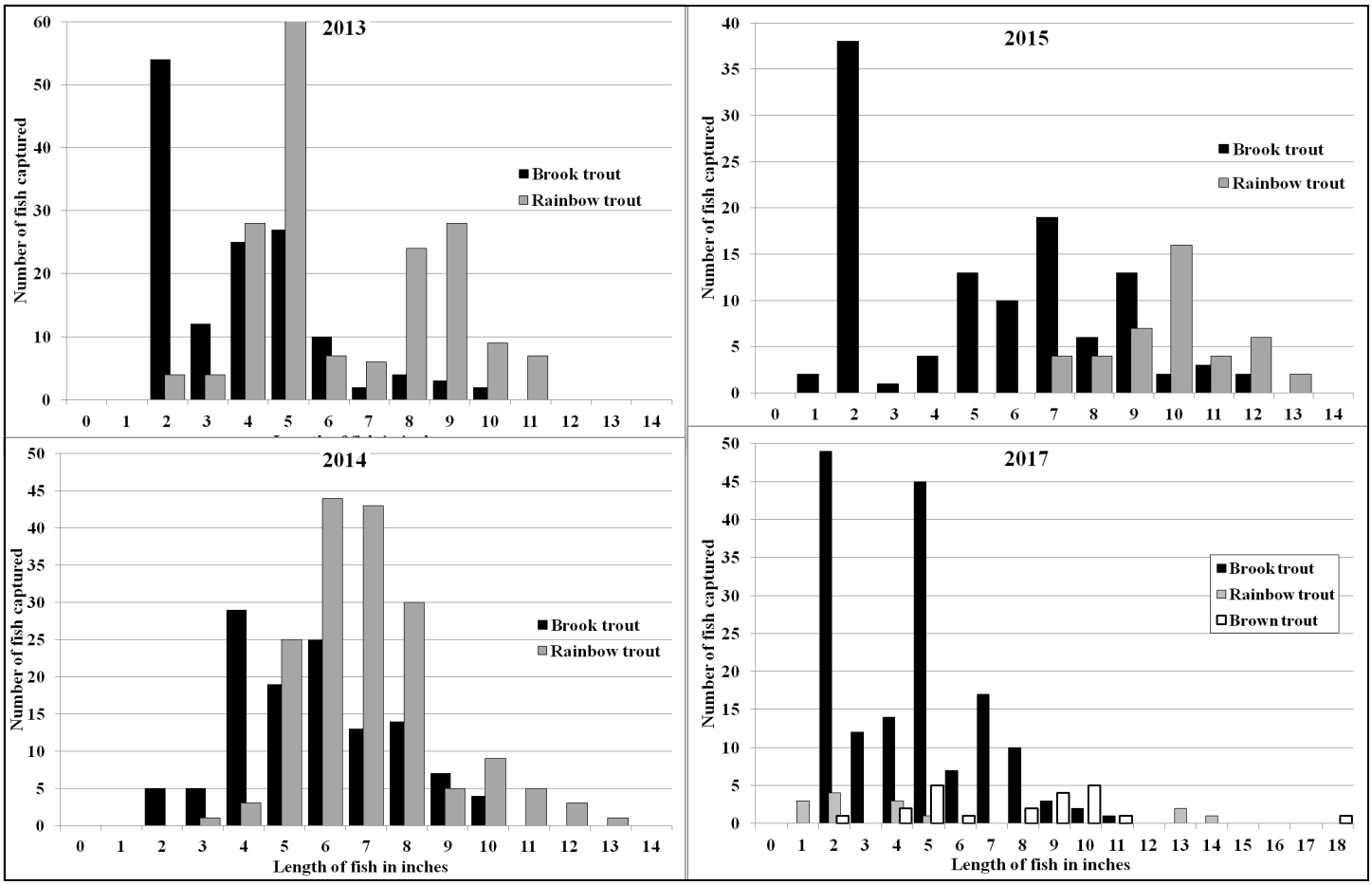
Fraser River at Confluence Park

The Confluence Park station is located in the town of Winter Park. The upstream end of the station is the pool where Vasquez Creek joins the Fraser. The graph at right contains biomass estimates in pounds per surface acre. This reach was not sampled in the years with no data. This is a higher-gradient, forested reach with a colder temperature regime, which explains the relative scarcity of brown trout. Trout populations here have been highly dynamic, with 2017 revealing an unprecedented influx of brown trout, but also the lowest total trout biomass estimates to date.



Fingerling rainbow trout stocking in 2010-2013 was very successful at this site. By 2012 the data suggested that our rainbow stocking may be overpopulating the reach, which was one of the factors that led to the decision to cease rainbow stocking as discussed previously. The 2017 data suggests that rainbow trout will not sustain themselves here without fingerling stocking.

The size distribution of the trout captured in the last four surveys is displayed below. These data reflect a dynamic situation with regard to competition between brook trout and stocked rainbows. During the period of 2012-2014, the high density of rainbows in the 5-12" range appeared to be suppressing the adult brook trout population, which is an unusual occurrence. By 2015, brook trout began regaining the upper hand, with multiple age classes in the smaller sizes outnumbering juvenile rainbows, which were nonexistent in that survey. Two distinct size-groups of brown trout appeared for the first time in 2017, as well as an 18" brown, the largest ever captured here. It is unlikely that the influx of brown trout was due to spawning movements, because the survey has occurred close to the same date on every occasion.



Fraser River at Idlewild Campground

This site is located adjacent to the Forest Service campground just upstream of the town of Winter Park. This station is 675 feet in length and averages 20.2 feet in width. The table at right contains population estimates collected on the two occasions we have surveyed this reach. Every parameter of the trout population listed in this table experienced significant declines in 2016, and the estimate of total trout biomass declined by 49.6%. Sculpin capture declined only slightly, and this was not by a significant margin.

Fraser River Idlewild Fish Population Estimates

Year	2014	2016
Date of survey	9/3	8/31
Brown trout		
Biomass (pounds per surface acre)	40 lbs/acre	11
Fish > 6" per mile	150/mile	55
Rainbow trout		
Biomass	33	16
Fish > 6" /mile	297	55
Brook trout		
Biomass	58	39
Fish > 6" /mile	794	443
Total trout biomass	131 lbs/acre	66
Total sculpin captured	69	60

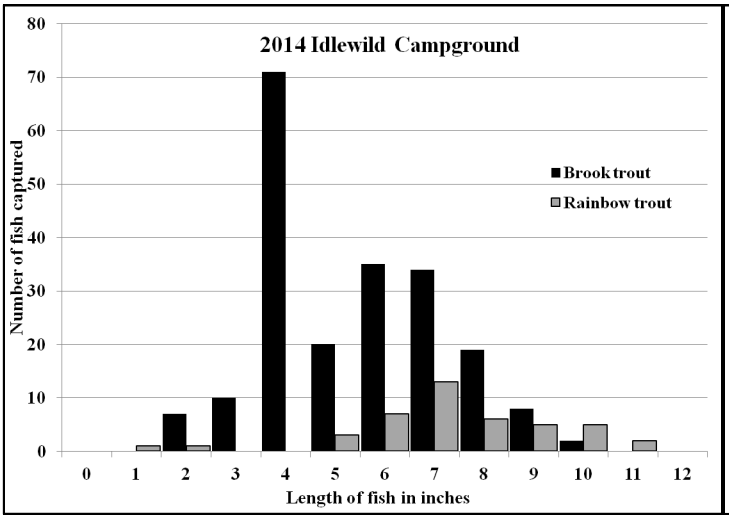
The nearest other site that we surveyed in 2016 is the Safeway station in the town of Fraser. We did not observe similar declines in any of these parameters at that station compared to previous years. In 2013, the Confluence Park site saw a decline in biomass similar to this one; however, the decline was among rainbow trout only (brook trout actually increased) and is easily explained by changes in our stocking strategy at that time. Such a decline across three species of trout is unprecedented in the history of our Fraser River monitoring.

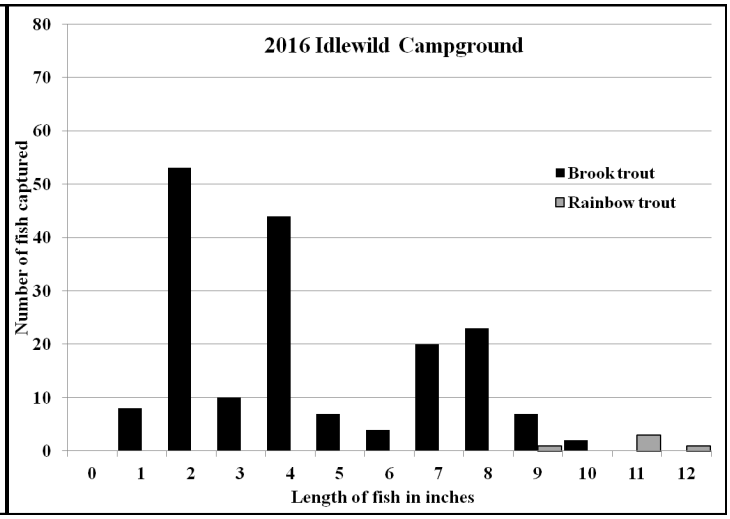
The figures below display the size structure of brook trout and rainbow trout captured at this station in 2014 and 2016. It is important to be aware that 2013 was the last year that we stocked rainbow trout fingerlings in the Fraser, and some of the decline in the rainbow trout population can be attributed to this change. The rainbows in the 5-10" range in 2014 are the result of past fingerling stocking. The two small rainbows we captured in 2014, 1-2" in length, are evidence of successful natural reproduction that year. The information collected in 2016 suggests that rainbows may not sustain themselves in this reach without the aid of future stocking.

The 2" brook trout captured in 2016 are young-of-the-year fish, and are evidence of a successful 2016 year class. We captured very few Age-0 fish in 2014. This is likely the result of a spring runoff that year that was far above normal. In some locations, unusually high spring runoff can either displace or kill an entire year class of juvenile brook or brown trout. This is likely what occurred here.

Because this station was a new location surveyed for the first time in 2014, it is impossible to know which of the two years is out of the ordinary. It is possible that the 2016 data reflects a return to "normal" fish densities for the site and that 2014 happened to be a particularly productive year. However, it is more common to observe a short-term suppression of fish populations in years with extremely high runoff such as 2014.

This reach has been the recipient of multiple discharge events in recent years that originate from the Moffat Tunnel. High levels of turbidity have occurred and CPW has received multiple reports from the public and other entities. While we have not observed a direct fish kill as a result of these events, this data appears to provide at least circumstantial evidence of some level of environmental stress or disturbance on the trout population here. We will continue to monitor this location in the future.





Colorado River near Parshall

FISH SURVEY AND MANAGEMENT INFORMATION

Jon Ewert - Aquatic Biologist (Hot Sulphur Springs)

General Information: The Colorado River offers approximately 4 miles of public access on the Kemp-Breeze, Lone Buck, and Paul Gilbert State Wildlife Areas and BLM Sunset property unit.
Location: Approximately 10 miles east of Kremmling, CO on US highway 40.
Recreational Management: Colorado Parks and Wildlife, Bureau of Land Management
Fishery Management: Gold medal river trout fishery

Amenities and General Info.

- 4 miles of public river access for wade or bank angling at multiple access points
- Picnic Areas
- Kids fishing pond
- Primitive restrooms
- Guide services available through several area businesses

Regulations

- All fishing is by flies and lures only, and all trout must be returned to the water immediately.

Previous Stocking

Rainbow trout of various sizes have been stocked through 2015 (see report), with the goal of reestablishing a wild, self-sustaining rainbow population.

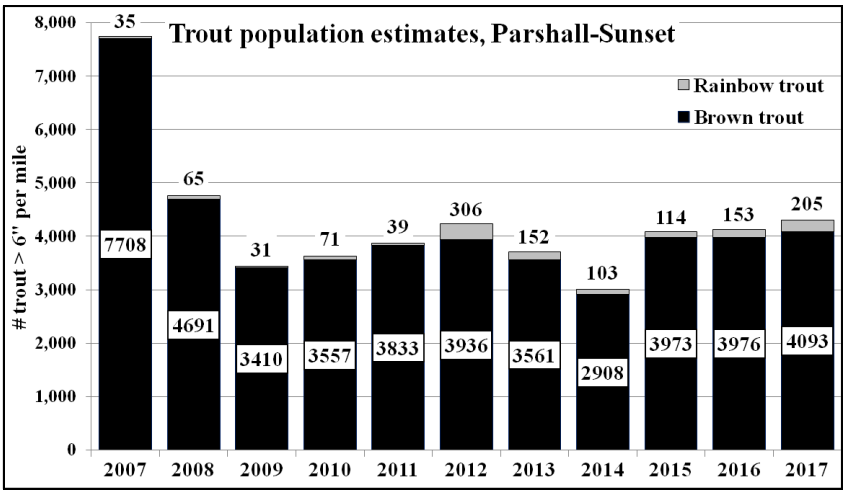
Sportfishing Notes

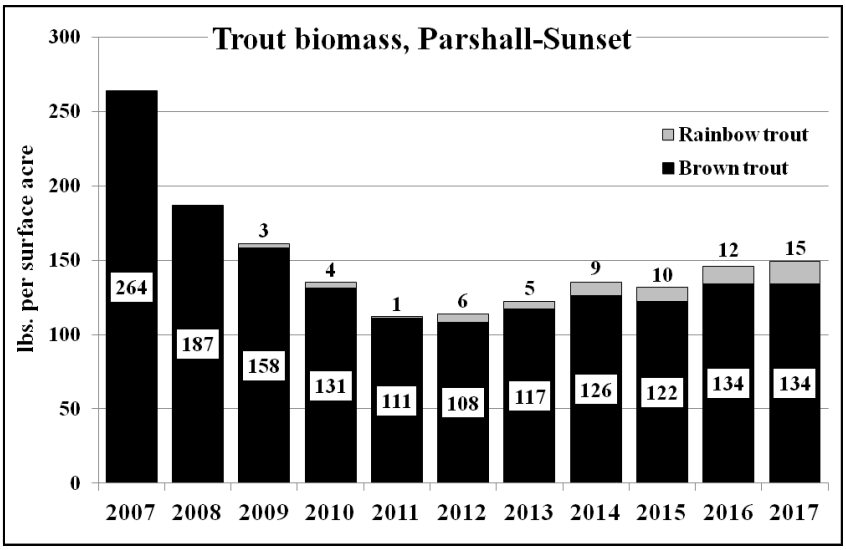
- This section of The Colorado River is one of the most well-known and heavily fished sections of river in the state.
- Despite heavy fishing pressure, trout populations are consistently excellent
- Fly fishing is the most common method of choice. There is a wide spectrum of aquatic insect varieties to imitate, from midges in the winter to various mayflies in the spring, stoneflies in early summer, caddis, terrestrials, and more mayflies later in the summer. Usually the biggest challenge for catching fish is figuring out what the trout happen to be focused on that particular day.
- These fish are well-educated and demand an accurate presentation.

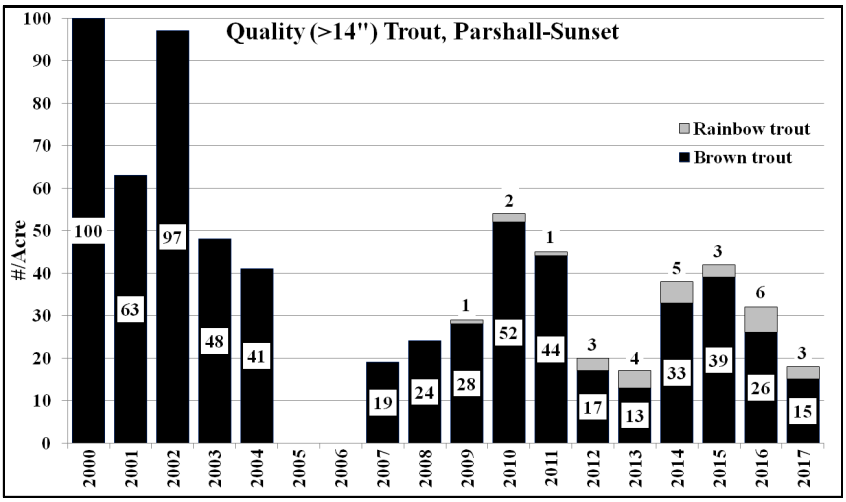
Colorado River at Parshall

Fish sampling information

Jon Ewert—aquatic biologist







This and all the following information reflects trout population data collected on the two-mile reach of river beginning just upstream of the "Parshall Hole" and extending downstream to the irrigation diversion on the BLM Sunset property. This survey is conducted in the third or fourth week of September annually. Population estimates are obtained by raft electrofishing using standard mark-recapture methodology .

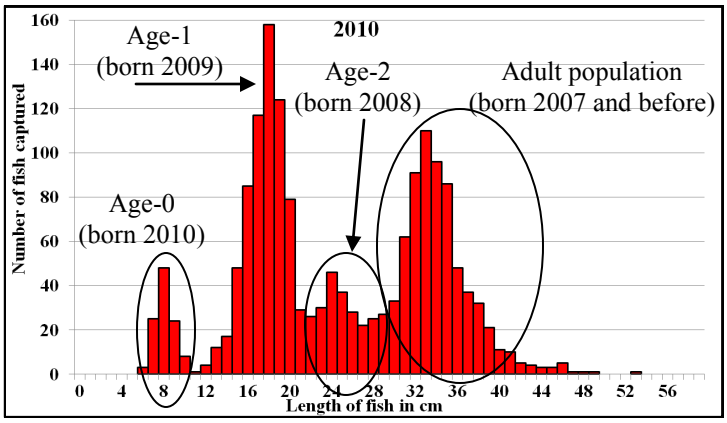
The figure at top left displays trout population estimates in fish per mile 6" or larger. The high brown trout estimate in 2007 is the result of multiple large year classes of young brown trout recruiting during the relatively low-water years leading up to that year. It is common to see high recruitment of juvenile brown trout during drought periods, simultaneous with declining numbers of large fish. The increase in rainbow trout estimates beginning in 2012 reflects the introduction of Whirling Disease resistant rainbows to this section of river (see following discussion).

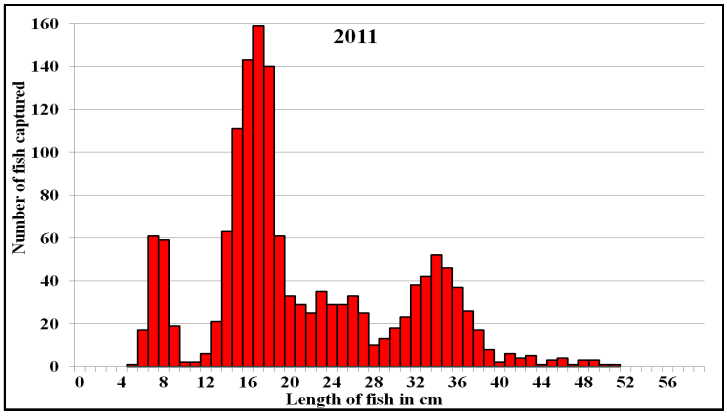
The middle figure at left displays estimates for trout biomass in pounds per surface acre over the 2-mile reach. The lower figure at left displays density estimates of trout greater than 14" per surface acre.

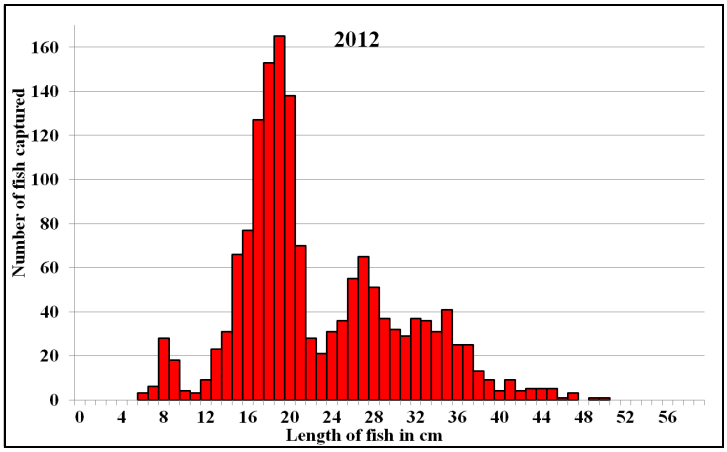
Biomass and density of quality trout are important parameters because these are the estimates used to confirm a river's status as a Gold Medal fishery. In order to maintain Gold Medal status, a fishery must produce at least 60 pounds per acre of total trout biomass AND at least 12 trout per acre greater than 14" in length. In recent years such as 2012 and 2013, this reach of the Colorado River has come uncomfortably close to failing to meet those standards.

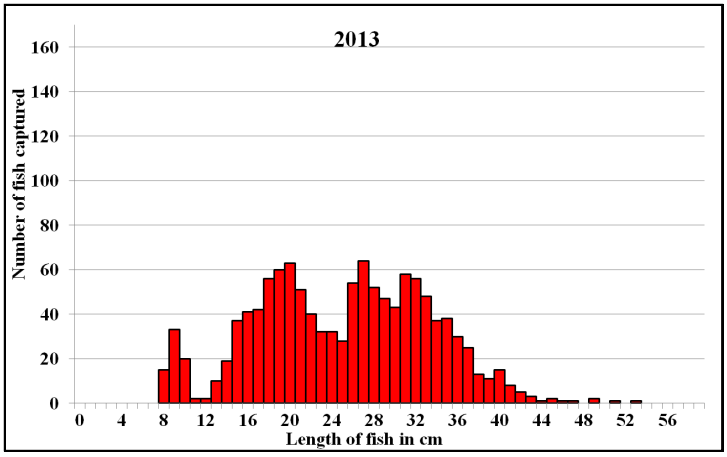
Each of these three graphs show a point in recent history when the particular parameter being measured has reached a historic low point. This information makes a strong case that this is a declining fishery. All the reasons for this are not known, but some of the most likely culprits are a long-term degradation in the quality of invertebrate forage, long-term degradation in the quality of physical habitat (particularly overwinter habitat), resulting in more frequent weak juvenile year classes and poor recruitment into the adult population. These declines are probably attributable to a combination of these factors, which are interrelated.

Brown trout population size structure









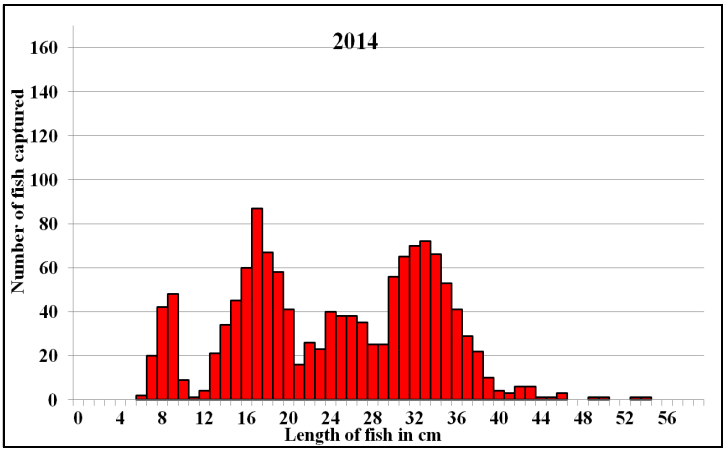
These figures (and the following page) display the size distributions for all brown trout captured in the Parshall-Sunset reach in September from 2010-2017. The vertical axis on all graphs is the same, enabling comparisons among years. The vertical bars represent the number of fish that were captured in each size class by centimeter (15 cm = 6”). Viewing the data in this way reveals a wealth of useful information including rough estimates of annual growth and survival rates. Fish less than 15 cm are not effectively captured during these surveys, so it is difficult to assess the abundance of the age-0 year class (fish that were born the year of the survey) from this data. However, the age-1 year class (born the year prior to the sample), in the 12-20 cm range, is represented more accurately.

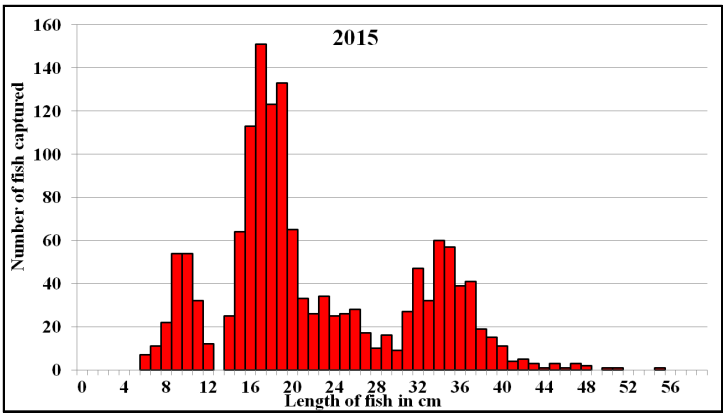
When studying this survey data, a question sometimes arises regarding movement of trout. The question is whether or not the data represents the “true” resident population of fish, or whether the fish move so much that it is more of a single snapshot in time of the trout that happen to be occupying the reach on that day. There are a few aspects of this data which at least partially answer that question. First, the survey is conducted as close to the same date as possible every year. If the results are heavily influenced by fish movements, those movements should at least be similar among years as long as the dates of the survey are consistent. Anecdotally, many fish are collected each year that have small scars in the tail where they were marked in previous years’ surveys, proving that those fish occupy the same reach across multiple years. Also, the analysis below demonstrates that year class strength is a strong predictor of the future adult population. If the population was heavily influenced by emigration or immigration, this would not necessarily be the case. There are examples of other reaches of the Colorado (such as the Radium survey reach) where the number of juvenile fish has never explained the high density of adult fish present, meaning that the reach “gains” fish from elsewhere.

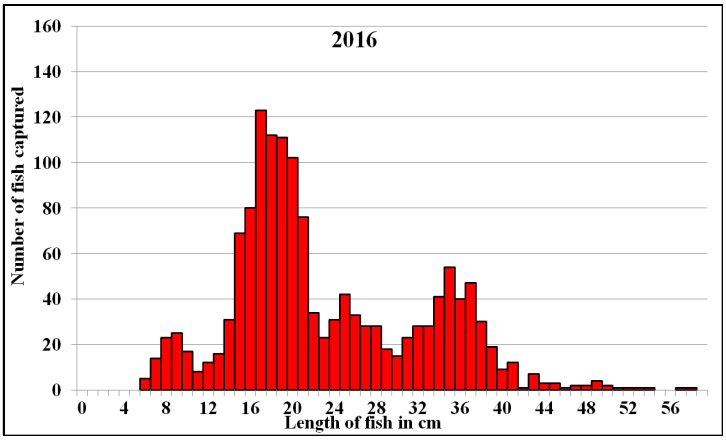
The strength of the age-1 year class in any given year is of great interest because of its ability to predict trends in the adult population in future years. Due to high mortality rates in small fish, strong age-1 year classes are necessary in order to maintain the adult population. We found strong age-1 classes in 2007, 2010, 2011, 2012, 2015, and 2016. Weak age-1 classes were observed in 2008, 2009, 2013, 2014, and 2017.

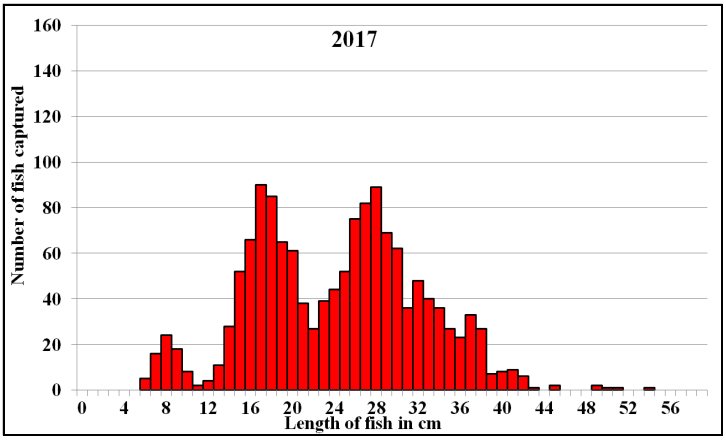
The result of weak age-1 recruitment in 2008 and 2009 can be seen in the weakening adult population in 2011 and 2012. That weakening of the adult population is evident on page 2 in the biomass and quality trout estimates for those years.

In 2012 the age-2 fish were poised to bolster the adult population, which took place in 2013 and 2014. This also appears on page 2 in the improving biomass estimates in those years and the increase in quality trout in 2014.









2013 revealed another strong age-2 year class; however the age-1 group was weak in both 2013 and 2014. The adult population in 2014 reflects the benefit of the strong age-1 groups of 2011 and 2012. This is also evident in the increased number of quality trout that we observed in 2014. However, the weak recruitment years of 2013 and 2014 resulted in moderate decreases in the adult population in 2015 and 2016, which was ultimately manifested in the lower quality fish estimate in 2016. Age-1 recruitment in 2015 and 2016 returned to strong levels, which should again bolster the adult population in 2017 and 2018. Age-0 capture in 2016 was low, resembling that of 2012 and 2013, suggesting that 2017 would reveal another weak Age-1 year class.

Quality trout density estimates in 2017 were among the lowest ever (page 2). However, the 2017 sample revealed a large, overlapping group of Age-2 and 3 fish (peaking at 28 cm) resulting from the strong age-1 groups in 2015 and 2016. These fish should recruit into larger size classes in 2018 and 2019 and improve the densities of 14"+ fish. Age-0 capture in 2017 mirrored that of 2016, predicting another weak Age-1 group for 2018.

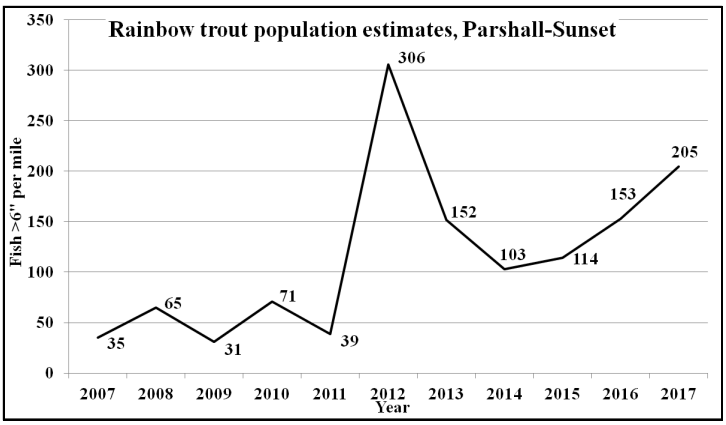
We do not have a strong understanding of factors that produce strong or weak year classes in any given year on this reach of the Colorado. In some rivers, above-average runoff results in high mortality of brown trout, thus forming poor year classes, while drought years see high survival of age-0 fish due to the lack of intense flows. However, we have seen counterexamples of that dynamic in the Colorado River in recent years. 2011 produced a peak runoff period that was far above average, yet a strong year class survived. Conversely, 2012 was a drought year that produced a weak age-1 group. Intensity of runoff probably plays a role in some years, but does not appear to be the chief factor determining year class strength on this reach.

Spawning habitat quality could act as a limiting factor in the formation of year classes. However, if there was a general lack of spawning habitat, there would be no reason for the variability in year class strength that we have observed. All year classes would be equally poor.

In some winters, anchor ice, frazil ice, and various formations of ice damming are common on this reach of the Colorado. It is possible that harsh winter conditions exacerbated by low flows lead to high mortality rates of brown trout eggs that are incubating in the gravel, which would result in poor year class formation. We do not currently have a way to quantify those conditions, and the degree to which they vary among winters. However, in-channel habitat improvements would address this issue by enhancing the quality of spawning riffles as well as overwintering habitat, making these areas less vulnerable to the harsh winter conditions that can take place during periods of cold weather and low flows.

Status of wild rainbow trout in the Parshall-Sunset reach

The Colorado River in Grand County historically supported one of the most productive wild rainbow trout fisheries in the world. In 1981, there were estimated to be 75 rainbow trout per acre over 14". These fish were all the product of wild reproduction and unsupported by stocking. Brown trout comprised 25% of the trout population in the river that year. Whirling disease appeared in the river in 1987. The proliferation of this parasite ended virtually all successful reproduction of rainbow trout. In the following years, the brown trout population exploded to fill the habitat that was vacated due to lack of reproduction in the rainbow population. It has always been the goal of CPW to restore some level of a wild rainbow trout fishery to this reach of the Colorado. Beginning in 1994, CPW began stocking fingerling rainbow trout to attempt to compensate for the lost natural reproduction. Research has shown that rainbow trout mortality from whirling disease drops dramatically when the fish have reached a length of 5". Based on this information, that is the size of fish that was stocked throughout the 2000's. Due to the timing of rainbow spawn in the hatchery, fish of that size were not available until the fall, usually October. 40,000 5" fish per year were stocked annually in October in this reach of river.

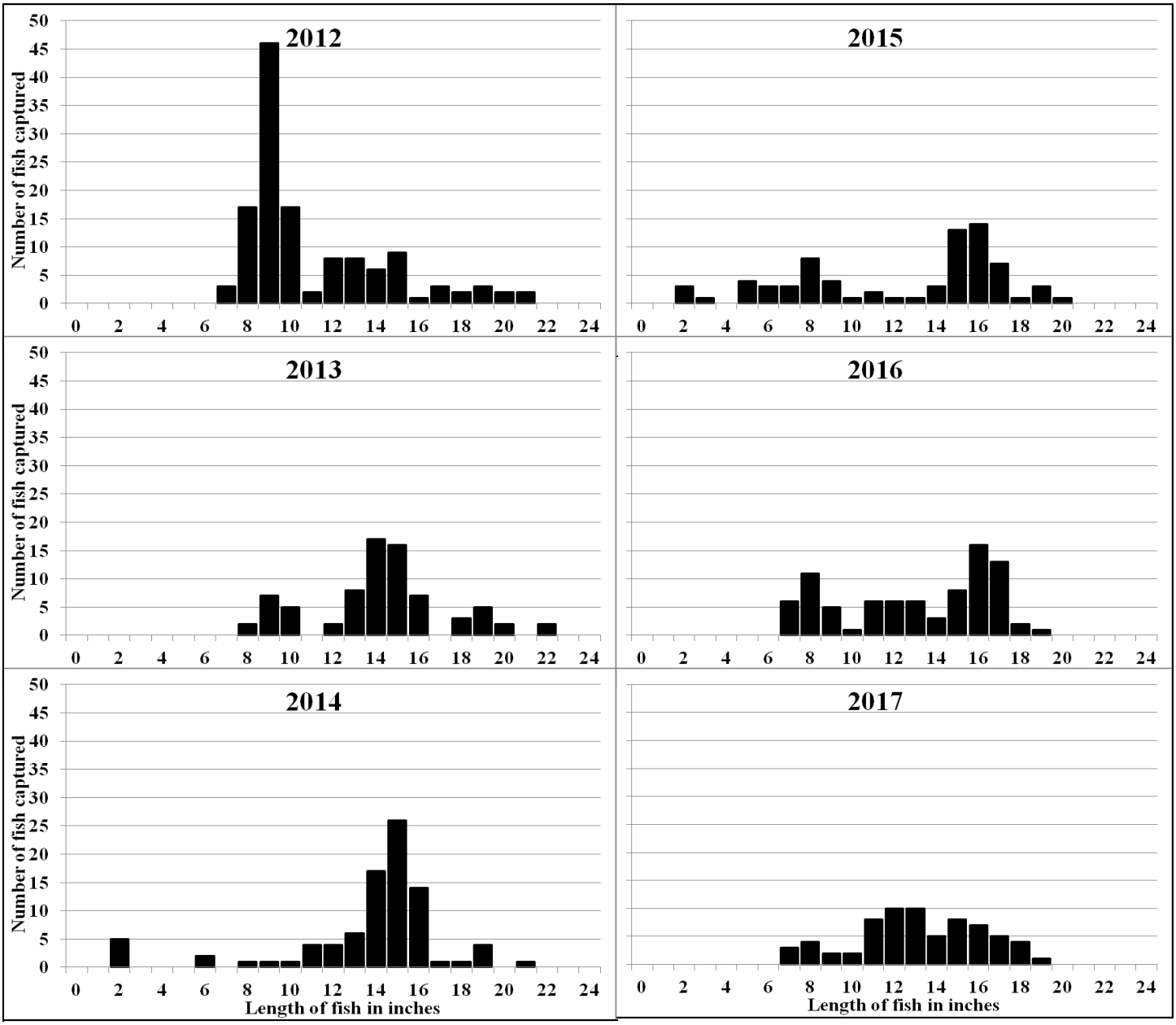


The figure to the left demonstrates the failure of the stocking strategy described above. Even though 5" fish should be able to survive in the presence of whirling disease, recruitment rates from stocking these fingerlings was abysmal, and rainbow trout continued to constitute a tiny fraction of the total trout population of this reach.

In 2008 and 2009, the fingerlings stocked were a hybrid strain of Colorado River rainbow trout (the historic strain that had been developed in the river over the previous 100+ years), crossed with German rainbow trout which have been found to be highly resistant to whirling disease. The fish were still 5" long, and stocked in October. We did not observe any evidence that this strain was any more successful at recruiting into the population when stocked at that size.

In 2010, we adopted a different stocking strategy based on the hypothesis that the limitation on recruitment in the 5" plants is timing rather than WD infection (if this was not the case we should have seen a positive response with the introduction of the WD-resistant strain in 2008). We stocked a larger number (60,000) of smaller (1.6 inches average) fish during the third week of July. We stocked these small fish out of a raft, only in the most ideal fry habitat. At this small size the fish are not habituated to being fed yet, and will hopefully quickly develop wild behaviors that are likely already lost in fish that have been raised to 5" in a hatchery environment. After encouraging results in 2010, in 2011 and 2012 we continued this stocking strategy and increased the number of fry stocked to 100,000. Pictures of the stocking operation are shown below.

Our 2012 survey detected the recruitment of these fish into the adult rainbow trout population for the first time (above). Subsequent surveys have not yielded population estimates as high as 2012, but they have remained above pre-2012 levels. We have documented successful natural reproduction, but it remains to be seen if it will be enough for the percentage of rainbows in the trout population to increase (see discussion following page).

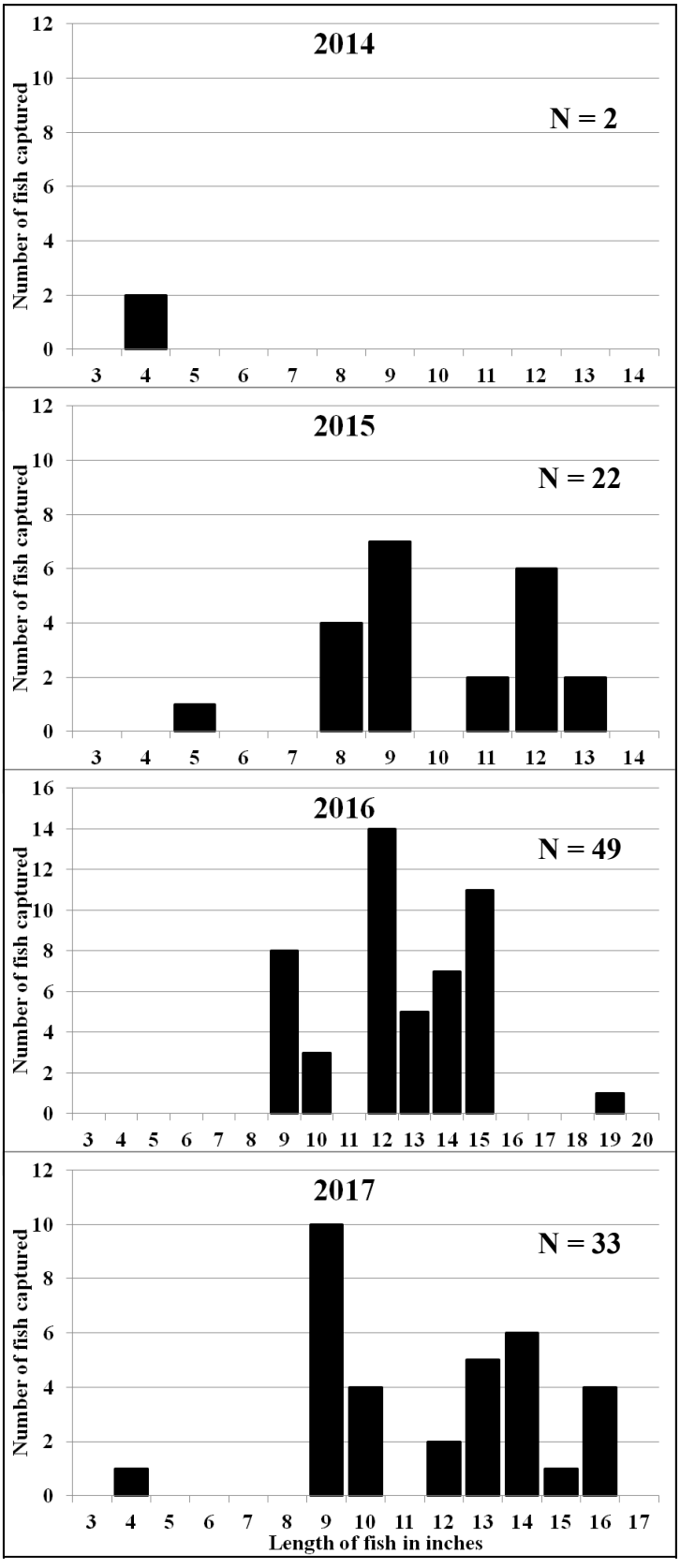


The figures above display the size distribution of all the rainbow trout captured over the past six years in this reach. In 2010 we captured rainbow trout smaller than 6" for the first time. These were the 2" fry that had been stocked two months previously. In 2011, we found that the fry stocked in 2010 had grown to an average of 8 inches in length, which was an excellent growth rate, and were present in good numbers.

2012 saw the largest age-1 year class to date, and the 2010 year class was now in the 12-15" range. We did not capture age-0 fish in 2012 during the raft survey. 2013 revealed the continued development of a more robust adult population in the 12-16" range. We also observed another age-1 year class, although much weaker than 2012's age-1 group, which explained why we did not find them in 2012.

In 2014, we found the most fully developed adult rainbow population to date. The density estimate for rainbows larger than 14" was 5 fish per acre, which was the highest estimate in the post-WD era, until 2016 yielded an estimate of 6 per acre. We also did not detect an age-1 year class in 2014 for the first time since fry stocking began, for unknown reasons. However, we did collect some age-0 (fry stocked in 2014) fish. 2015 and 2016 saw the return of moderate age-1 groups.

Due to a disease issue in our hatchery system, 2015 was the last year that we stocked rainbow trout fry. The 8" age-1 year class seen in 2016, and the 12" Age-2 group in 2017, represent the last stocked rainbow fry. This strain of rainbows will not be available until approximately 2019, and thus we are in a new period of no rainbow stocking and observation to determine if there are enough adult rainbows in the river now to sustain and increase their numbers through natural reproduction. The 7-9" group in 2017 are wild fish, and through fry monitoring we have observed some successful natural reproduction. We are hopeful that this trend will continue.



Mountain Whitefish Invasion

In 2013, we collected four juvenile mountain whitefish on this reach for the first time. This species had never been captured on this reach of river in a history of biological survey work that extends back to 1981. There are no historical records of mountain whitefish occurring anywhere in Middle Park upstream of Gore Canyon. This species is native to the White and Yampa river drainages but not to the Colorado. There is an established population in the Colorado downstream of Gore Canyon.

The graphs at left display the size distribution of whitefish that we have captured since 2014. That year, we captured two juvenile whitefish. By 2015, we captured 22 whitefish representing three age-classes, which corresponded to the juveniles we had caught the two previous years. In 2016 our catch increased to 49 mountain whitefish representing four year-classes and ranging up to 19" in length. We captured fewer in 2017, but still found at least three year-classes.

In other surveys, in 2016 we also captured single adult whitefish as far upstream as Windy Gap dam. These findings suggest that we are witnessing the beginning of a significant invasion of the species into the upper Colorado. The reasons that this is occurring now are unknown. 2011 saw the highest flows on the Colorado River since the early 1980's, and our current theory is that the prolonged high flows during that summer allowed adult whitefish to find their way through Gore Canyon for the first time.

Impacts of mountain whitefish on the trout fishery are unknown at this time. There are ways in which they might benefit the fishery (for example, providing an additional prey source for large, predatory brown trout), but they may also present new competition with trout for food and habitat. Catch-and-release regulations on this reach apply to trout only, so these fish are available for angler harvest. We will closely monitor this invasion over the coming years and continually assess whether or not any management changes are warranted.

Mountain whitefish captured in the Parshall Hole.

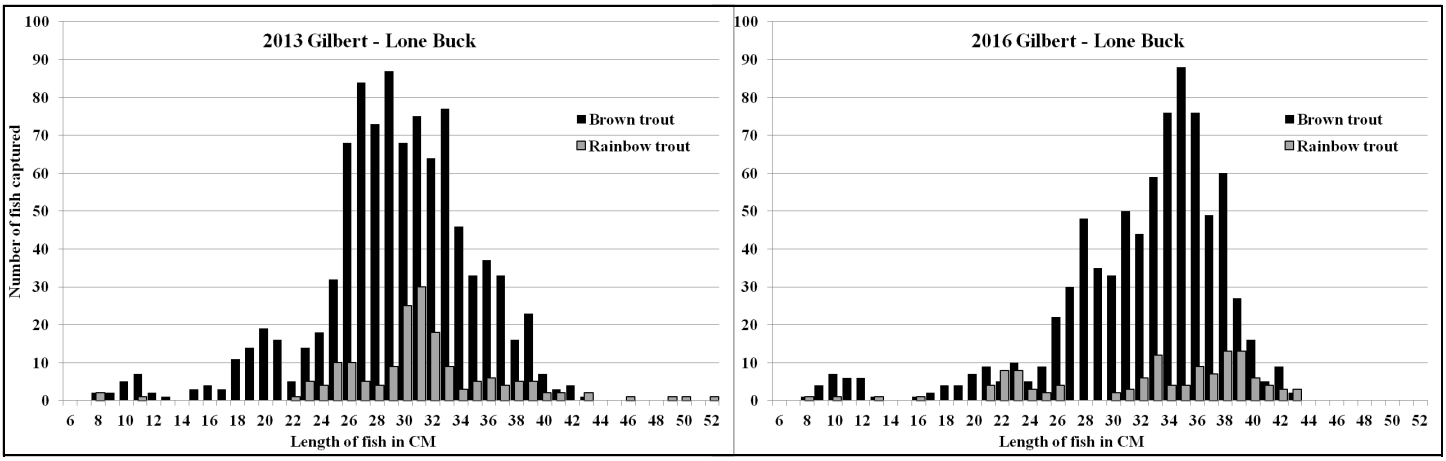
Spring 2016 survey of Paul Gilbert—Lone Buck reach

On April 19 & 21, 2016, we conducted a raft electrofishing survey of the Colorado River beginning just downstream of the Byers Canyon bridge and extending to the downstream border of the Lone Buck State Wildlife Area. This encompassed a river reach of approximately 7,000 feet in length. The main reason for this survey was to determine the number of spawning rainbow trout in this reach, which contains locations where rainbows regularly spawned historically. This was the first time since 2013 that we had surveyed this section. These are the only two occasions in recent history that the reach has been surveyed in the spring.

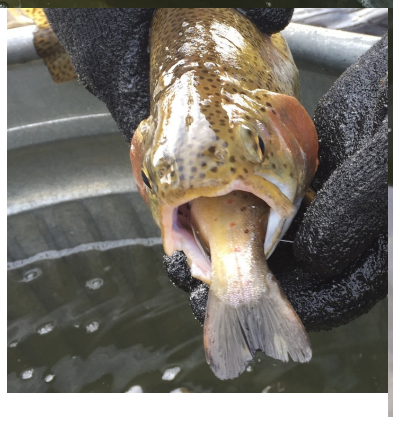
Results of the 2013 and 2016 surveys are contained in the table at right. Rainbow estimates remained essentially the same across the two occasions, while the number of large brown trout increased dramatically. This resulted in a greatly increased estimate of brown trout biomass. The size distribution of both species is shown in the graphs below.

Colorado River, Paul Gilbert—Lone Buck		
	2013	**2016**
Date of survey	5/6 & 8	4/19 & 21
Rainbows: #> 6”/mile	214	182
#>14”/surface acre	5	6
Biomass (lbs./acre)	13	13
Browns: #> 6”/mile	1,537	1,178
#>14”/acre	11	28
Biomass (lbs./acre)	74	132

In the 2016 survey, we also captured one mountain whitefish measuring 16”. At that time this was the farthest-upstream location that we had captured a whitefish; however, the following month we captured two more whitefish upstream of the town of Hot Sulphur Springs, indicating that they are present in the river up to Windy Gap dam.

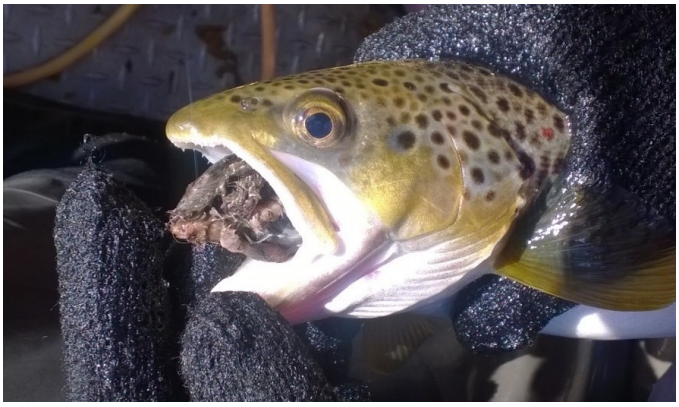


A Whirling Disease-resistant rainbow from the Lone Buck reach.

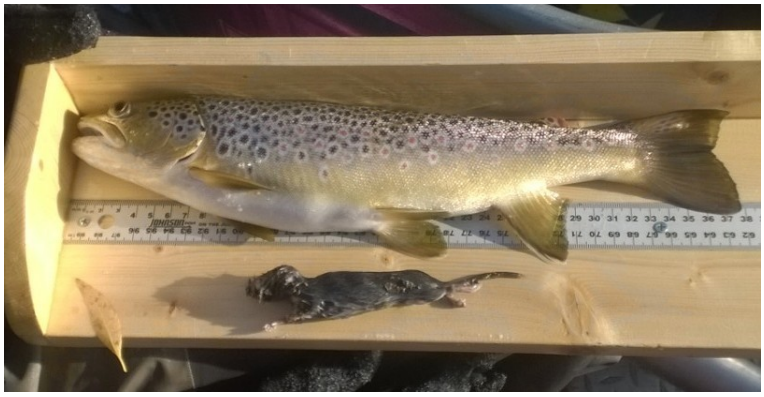


This handsome Parshall Hole rainbow in 2015 had recently enjoyed a meal of a 10” brown.

The largest brown captured in 2014. 21 inches, 4.6 pounds



This 15” brown had recently eaten some kind of rodent.



APPENDIX D.1

Core Sample Location Maps, GPS, and Photo Logs

Location Map: Fraser River. F2, coordinates represent downstream limits of ocular survey. N39°52'01.1", W105°44'58.5"

No photos: ocular survey at F2 was not conducted in 2017

Location Map: Core Sample Site, Ranch Creek, F-RC2
N39°59' 57.96", W105°49'48.36"

Core Sample Site: Ranch Creek, F-RC2.
Sample Date: September 6, 2017

Ranch Creek, F-RC2, looking upstream.

Ranch Creek, F-RC2, looking downstream.

Location Map: Core Sample Site, Fraser River, FR9
N40°04'43.74", W105°54'15.32"

Core Sample Site: Fraser River, FR9.
Sample Date: September 7, 2017

Fraser River, FR9, looking upstream.

Fraser River, FR9, looking downstream.

Location Map: Core Sample Site, Colorado River CR4 (Chimney Rock Ranch)
N40°06' 2.16", W106°01'36.36"

No photos; sampling at Chimney Rock was not conducted in 2017 due to lack of spawning gravels.

Location Map: Core Sample Site, Colorado River, CR4 (CDPW Paul Gilbert Public Access)
N40°06'03.8", W106°01'33.1"

No photos; sampling at CR4 (CDPW Paul Gilbert Public Access) was not conducted in 2017 due to lack of spawning gravels.

Location Map: Core Sample Site, Colorado River, CR4-(Pioneer Park)
N40°04'20.35", W106°06' 41.60"

Core Sample Site: Colorado River, CR4-PP
Sample Date: September 7, 2017

Colorado River, CR4-PP looking upstream.

Colorado River, CR4-PP looking downstream.

Location Map: Core Sample Site, Colorado River, CR5
N40°03'46.08", W106°11'02.16"

Core Sample Site: Colorado River, CR5.
Sample Date: October 27, 2017

Colorado River, CR5, looking upstream.

Colorado River, CR5, on island looking downstream.

Location Map: Core Sample Site, Colorado River, CR6
N40°03'20.98", W106°17'06.77"

Core Sample Site: Colorado River, CR6.
Sample Date: September 8, 2017

Colorado River, CR6, looking upstream.

Colorado River, CR6, looking downstream.

Location Map: Core Sample Site, Colorado River, CR7
N39°58'41.51", W106°30'56.45"

Core Sample Site: Colorado River, CR7.
Sample date: October 27, 2017

Colorado River, CR7, looking upstream.

Colorado River, CR7, looking downstream.

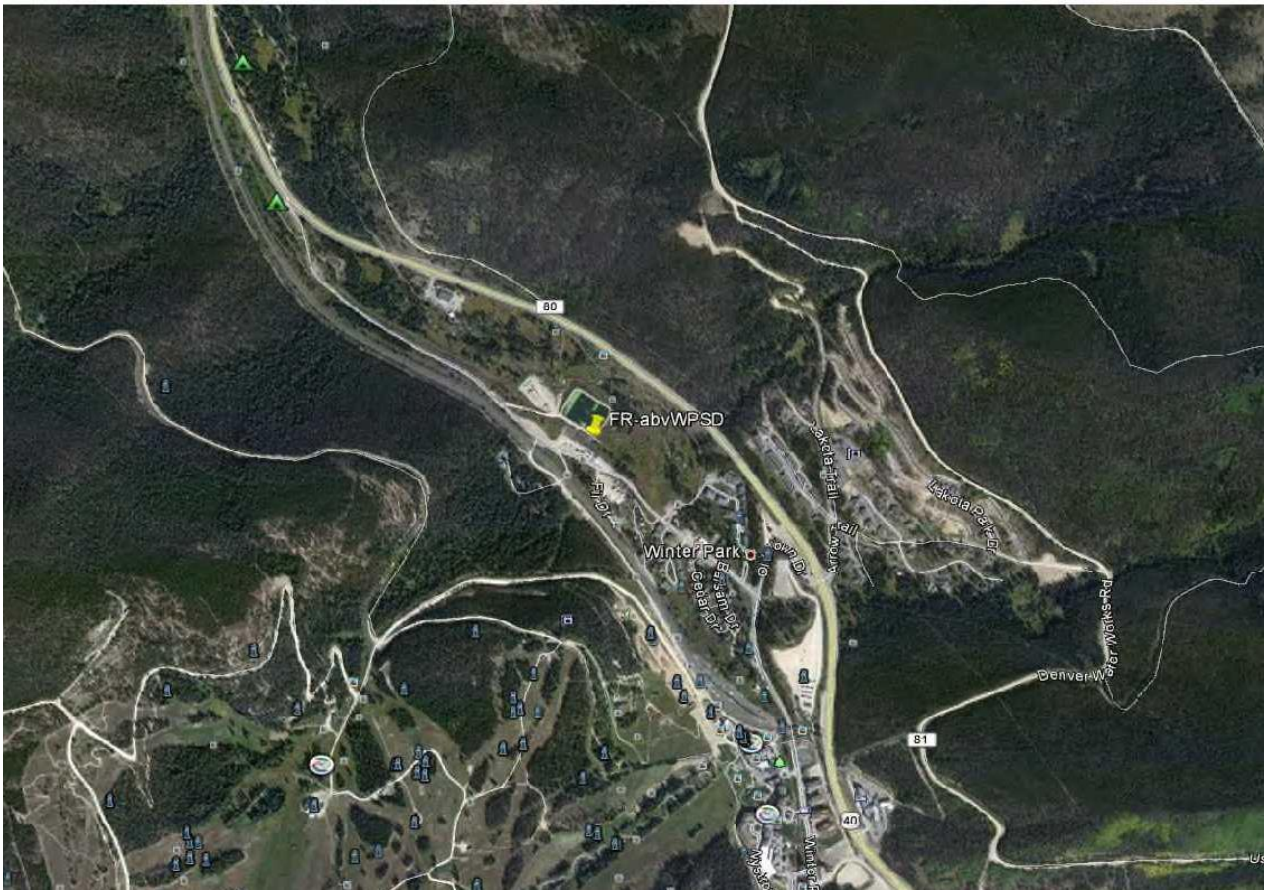
Core Sample Site: Colorado River, CR7.
Sample date: October 27, 2017

Colorado River, CR7, looking at bar for pebble count.

APPENDIX D.2

Pebble Counts at Macroinvertebrate Sites: Location Maps, GPS, and Photo Logs

Location Map: Pebble Count at Macroinvertebrate Site, Fraser River, FR-abvWPSD
N39° 53’ 40.02”, W105° 46’ 5.58”



Location Map: Pebble Count at Macroinvertebrate Site, Fraser River, FR-abvWPSD.
Date: September 6, 2017

Fraser River, FR-abvWPSD, looking upstream.

Fraser River, FR-abvWPSD, looking downstream.

Location Map: Pebble Count at Macroinvertebrate Site, Fraser River, FR-Rendezvous
N39° 56’ 02.832”, W105° 47’ 22.56”

Pebble Count at Macroinvertebrate Site: Fraser River, FR-Rendezvous.
Date: September 6, 2017

Fraser River, FR-Rendezvous, looking upstream.

Fraser River, FR-Rendezvous, looking downstream.

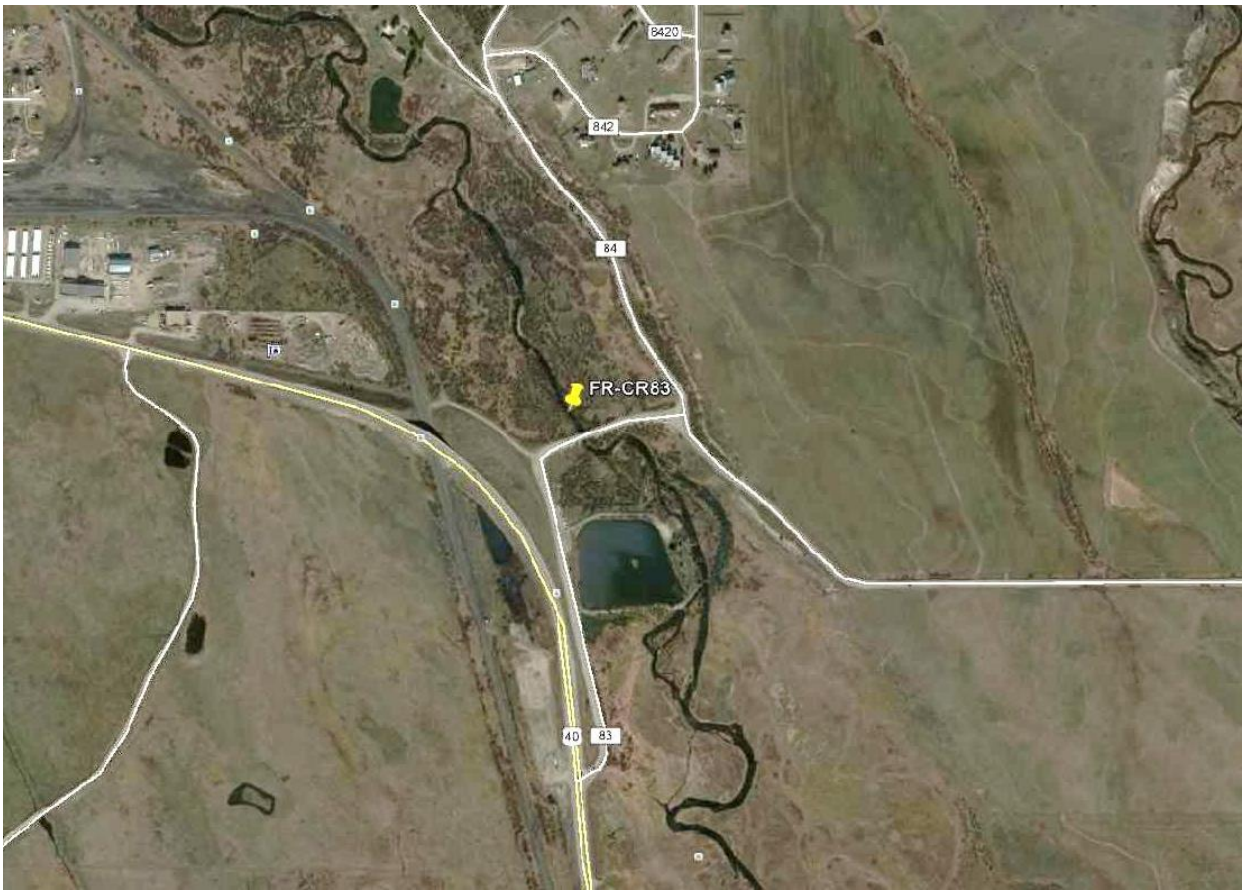
Location Map: Pebble Count at Macroinvertebrate Site, Fraser River, FR-FrSpProj
N39° 58’ 54.11”, W105° 49’ 49.50”

Pebble Count at Macroinvertebrate Site: Fraser River, FR-FrSpProj.
Sample Date: September 6, 2017

Fraser River, FR-FrSpProj, looking upstream at site.

Fraser River, FR-FrSpProj, looking downstream at site.

Location Map: Pebble Count at Macroinvertebrate Site, Fraser River, FR-CR83
N39° 59’ 25.99”, W105° 49’ 45.83”



Pebble Count at Macroinvertebrate Site: Fraser River, FR-CR83.
Sample Date: September 6, 2017

Fraser River, FR-CR83, looking upstream

Fraser River, FR-CR83, looking downstream.

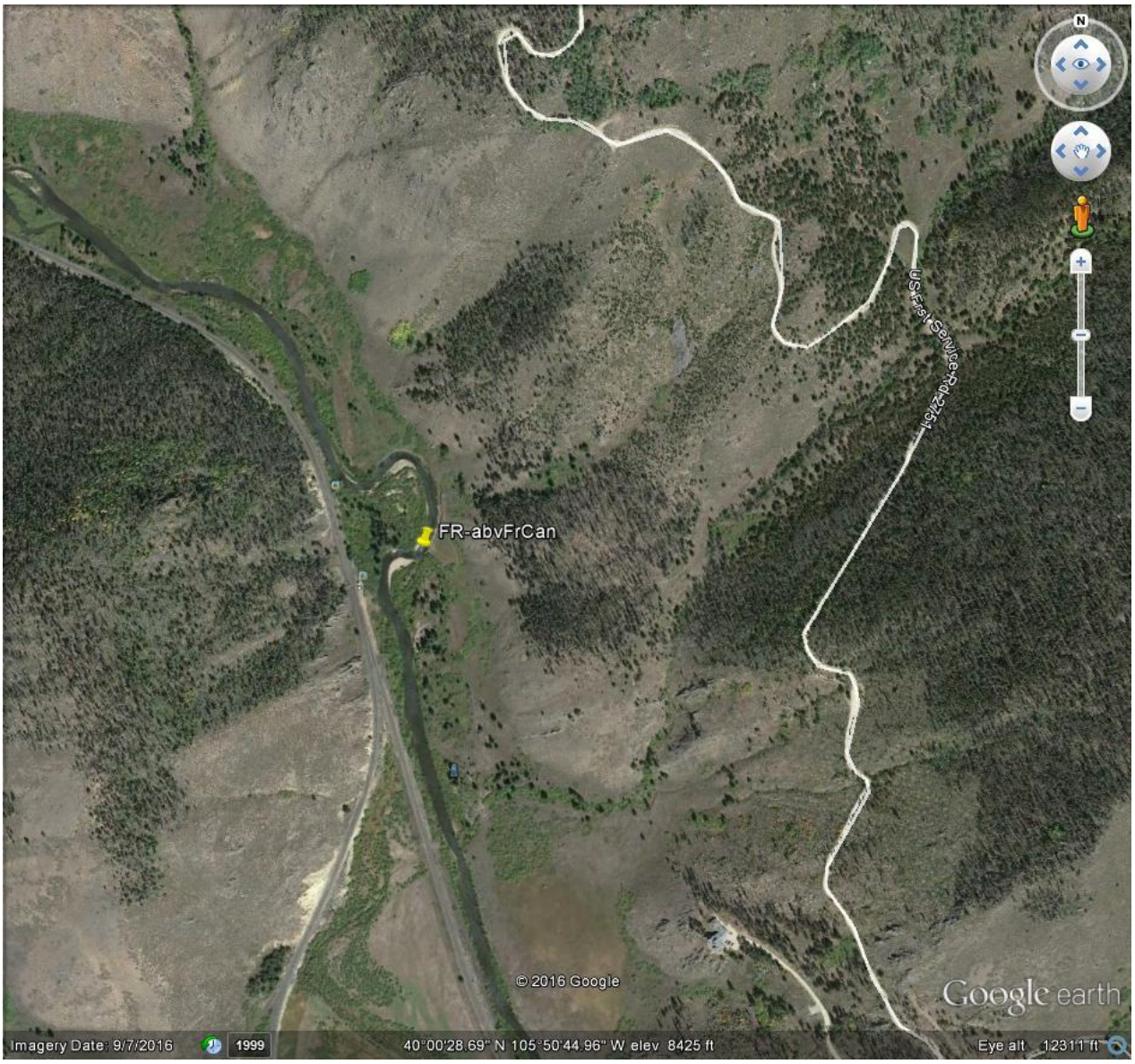
Location Map: Pebble Count at Macroinvertebrate Site, Ranch Creek below Meadow Creek, RC-blwMC (labeled RC-CR84 in 2015)
N39° 59’ 56.57”, W105° 49’ 39.11”

Pebble Count at Macroinvertebrate Site: Ranch Creek, RC-blwMC
Date: September 6, 2017

Ranch Creek, RC-CR84, looking upstream.

Ranch Creek, RC-blwMC, looking downstream.

Location Map: Pebble Count at Macroinvertebrate Site, FR-abvFrCan
N 40º 00’ 0.46”, W 105° 50’ 52.80”



Pebble Count at Macroinvertebrate Site: Fraser River, FR-abvFrCan
Sample Date: September 6, 2017

Fraser River, FR-abvFrCan, looking upstream

Fraser River, FR-abvFrCan, looking downstream

Location Map: Pebble Count at Macroinvertebrate Site, FR-abvGSD
N 40º 05’ 06.936”, W 105° 57’ 16.704”

Pebble Count at Macroinvertebrate Site: FR-abvGSD.
Date: September 7, 2017

Fraser River, FR-abvGSD, looking upstream.

Fraser River, FR-abvGSD, looking downstream.

Location Map: Pebble Count at Macroinvertebrate Site, COR-blwWG
N 40º 06’ 30.64”, W 106° 00’ 10.80”

Pebble Count at Macroinvertebrate Site: COR-blwWG
Date: September 7, 2017

Colorado River, COR-blwWG, looking upstream

Colorado River, COR-blwWG, looking downstream

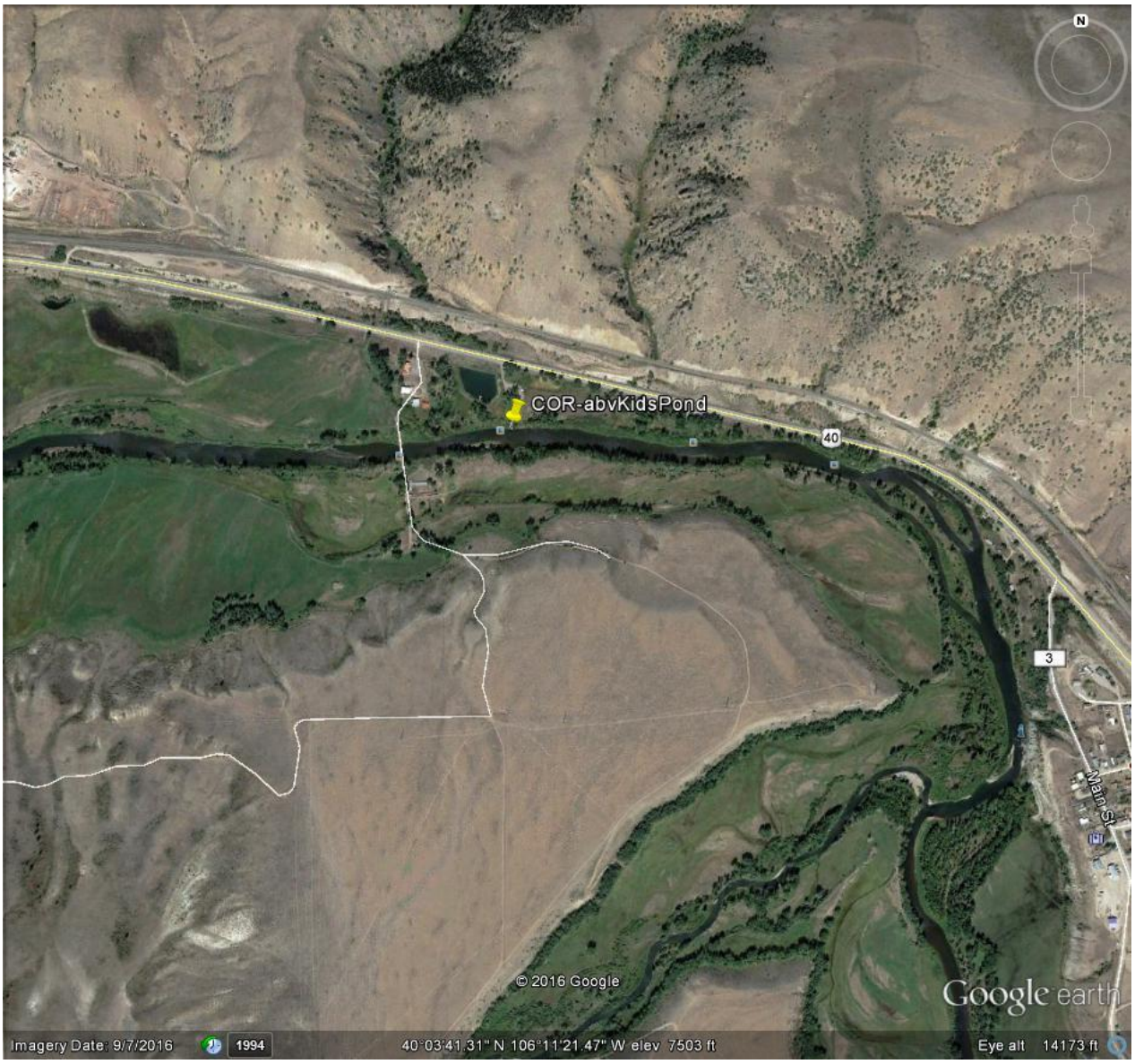
Location Map: Pebble Count at Macroinvertebrate Site, COR-abvHSR
N 40º 04’ 25.60”, W 106° 06’ 36.00”

Pebble Count at Macroinvertebrate Site: COR-abvHSR
Date: September 7, 2017

Colorado River, COR-abvHSR, looking upstream

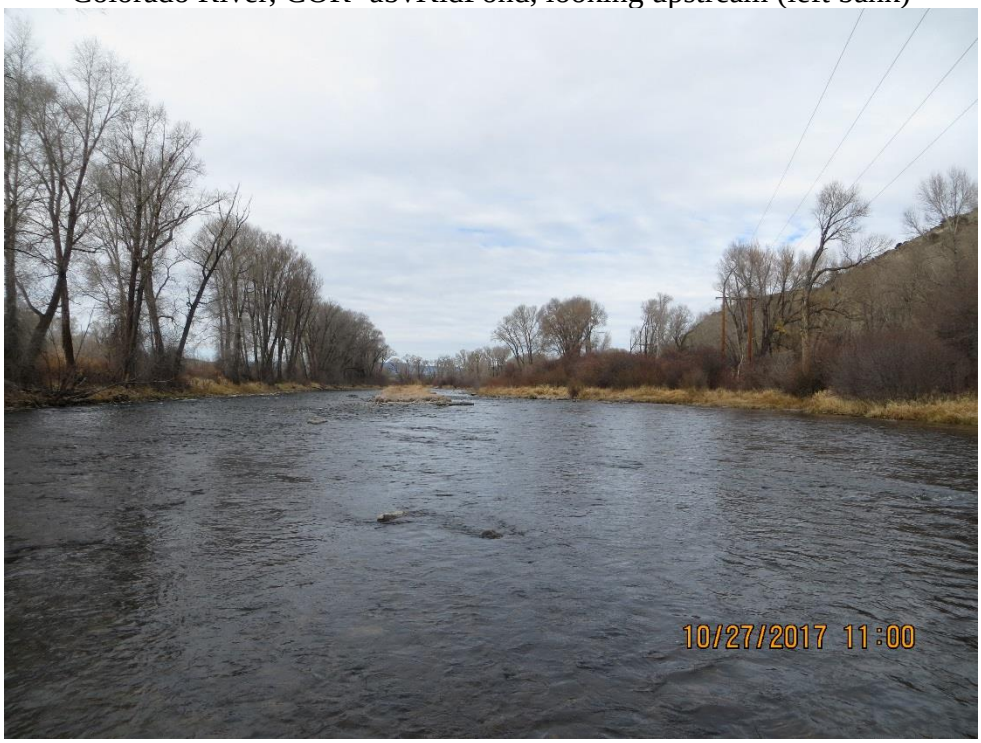
Colorado River, COR-abvHSR, looking downstream

Location Map: Pebble Count at Macroinvertebrate Site, COR-abvKidPond
N 40º 03’ 48.31”, W 106° 11’ 27.60”



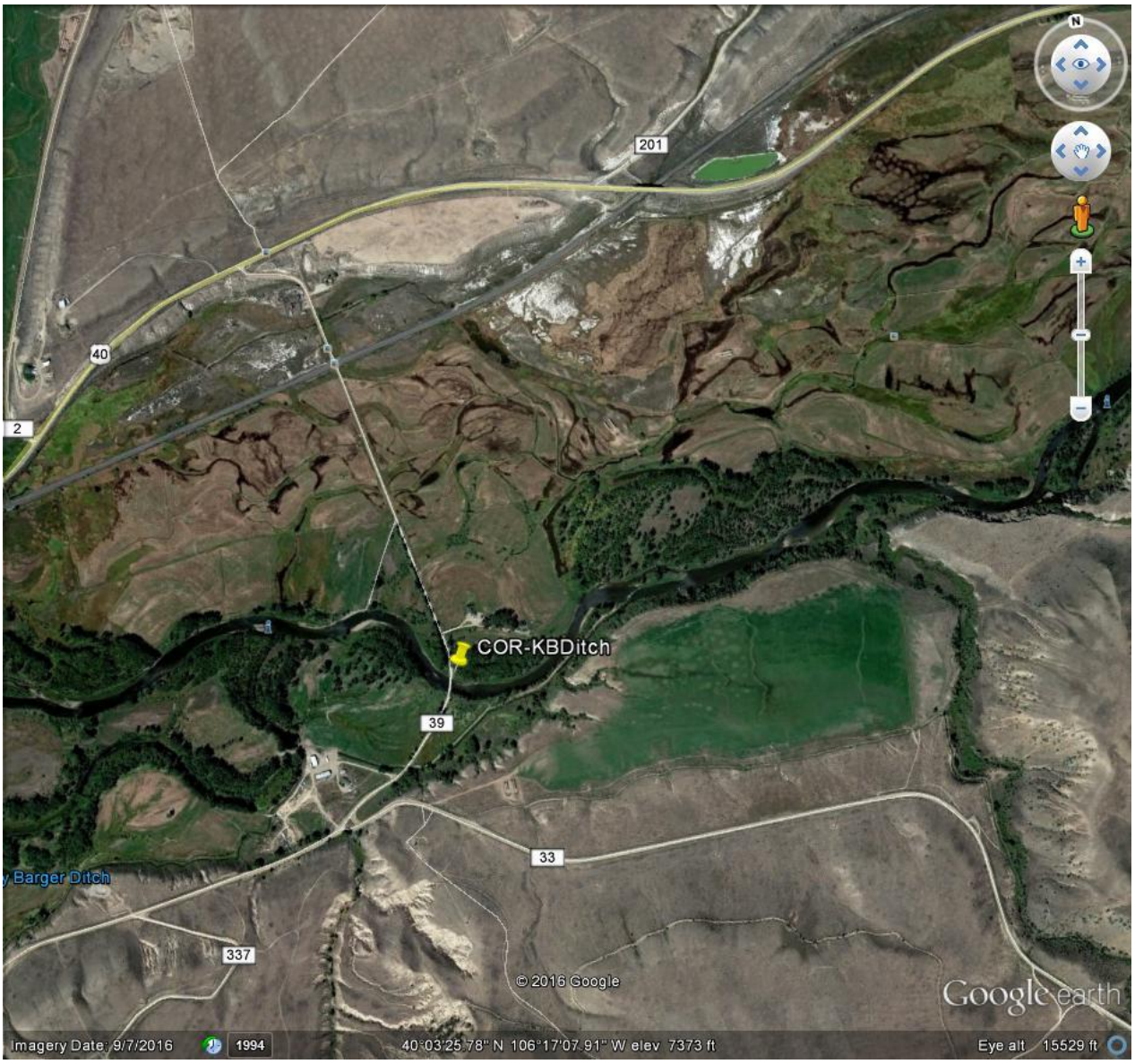
Pebble Count at Macroinvertebrate Site: COR-abvKidPond
Date: October 27, 2017

Colorado River, COR- abvKidPond, looking upstream (left bank)



Colorado River, COR- abvKidPond, looking downstream (left bank)

Location Map: Pebble Count at Macroinvertebrate Site, COR-KBDitch
N 40º 03’ 13.57”, W 106° 17’ 22.20”

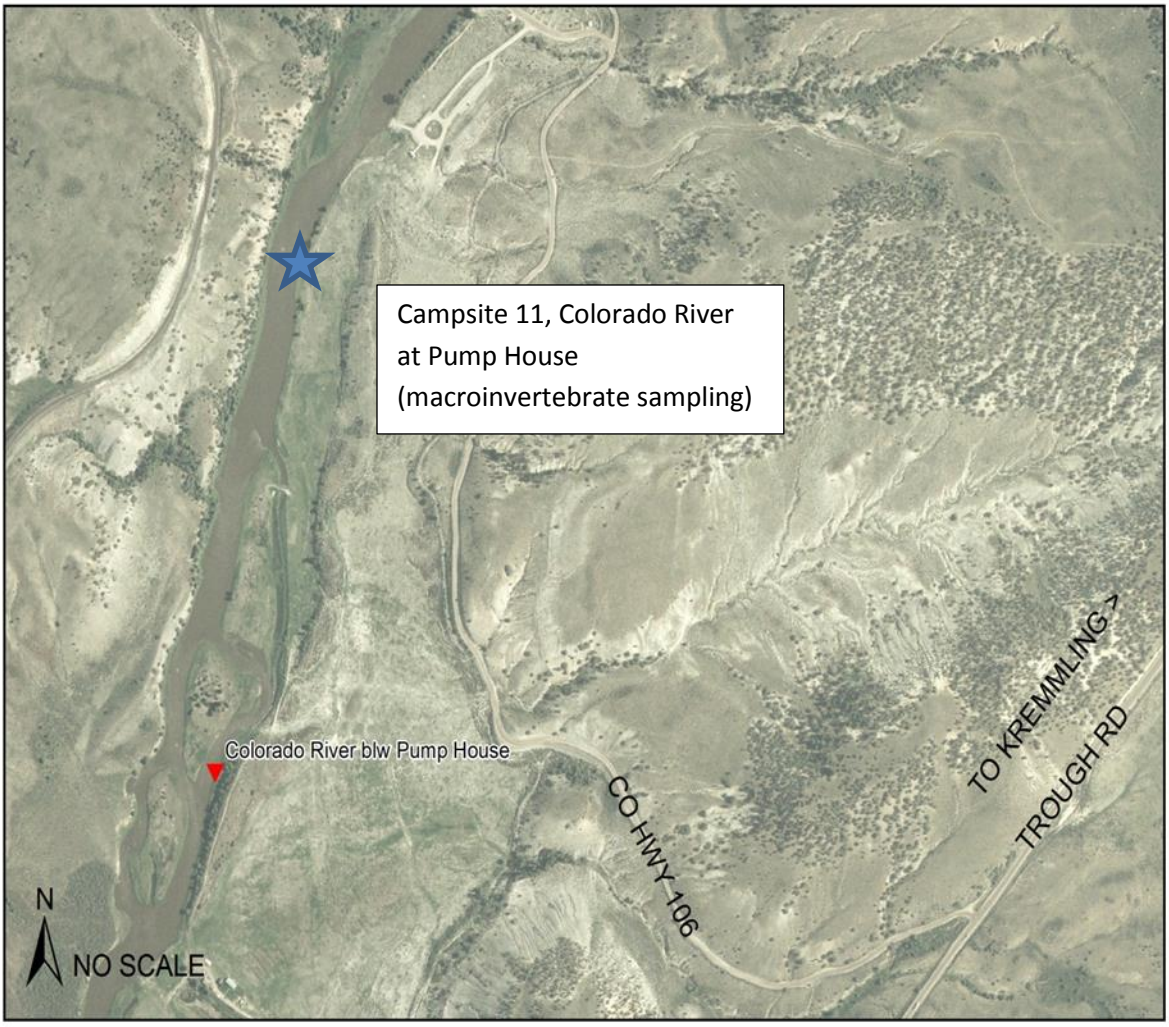


Pebble Count at Macroinvertebrate Site: COR-KBDitch
Date: September 8, 2017

Colorado River, COR- KBDitch, looking upstream

Colorado River, COR- KBDitch, looking downstream

Location Map: Pebble Count at Macroinvertebrate Site, COR-Pumphouse
N 39º 59’ 04.68”, W 106° 30’ 51.55”



Pebble Count at Macroinvertebrate Site: COR-Pumphouse.
Date: October 27, 2017

Colorado River, COR-Pumphouse, looking upstream

Colorado River, COR-Pumphouse, looking downstream