Consulting
Engineers and
Scientists

Substrate and Algae Assessment in the Colorado River and Fraser River Basins 2020

March 2021

Sediment and Algae Assessment in the Colorado River and Fraser River Basins 2020

GEI Consultants

Consulting Engineers and Scientists

Submitted to:
Grand County Learning By Doing
308 Byers Avenue
PO Box 264
Hot Sulphur Springs, CO 80451

Submitted by:
GEI Consultants, Inc.
4601 DTC Blvd., Ste. 900
Denver, CO 80237

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5/25/2021
Ashley Ficke, Project Manager

5/25/2021
Jeniffer Lynch, Reviewer

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1. Introduction

At the request of Grand County's Learning By Doing (LBD), GEI Consultants, Inc. (GEI) conducted assessments of the substrate and algae at multiple sampling locations in the Colorado River and Fraser River basins in Grand County in the fall of 2020. A total of nineteen sites were sampled from September 22, 2020 through October 1, 2020, with ten sites located on the Colorado River, seven sites located on the Fraser River, and two sites located on Ranch Creek. One site on the Colorado River was qualitatively assessed due to safety issues. The sites sampled by GEI for substrate and algae characteristics were previously established throughout LBD's Cooperative Effort Area .

At thirteen of the nineteen site locations, GEI performed pebble counts and measured percent fines, percent embeddedness, riffle stability index, and algal cover. At five site locations, GEI collected sediment with a McNeil sampler and collected suspended sediment samples. The data collected at each site location may be used to assess potential sediment transport issues in the basin and to address questions related to biological integrity such as the Sediment Tolerance Indicator Value (TIV_{SED}) for macroinvertebrates and a salmonid spawning habitat assessment.

2. Cooperative Effort Area

All sites sampled were located within LBD's Cooperative Effort Area (CEA) in Grand County. The sampling area stretches from the town of Winter Park, CO to approximately 1.7 miles upstream of the confluence with the Blue River (Figure 2-1; Table 2-1). The ten sites on the Colorado River extend from the town of Granby, CO to the town of Kremmling, CO. The seven sites on the Fraser River extend from the town of Winter Park, CO to upstream of the town of Granby, CO. The two sites established on Ranch Creek are located in the town of Tabernash, CO, upstream from the confluence with the Fraser River (Figure 2-1).

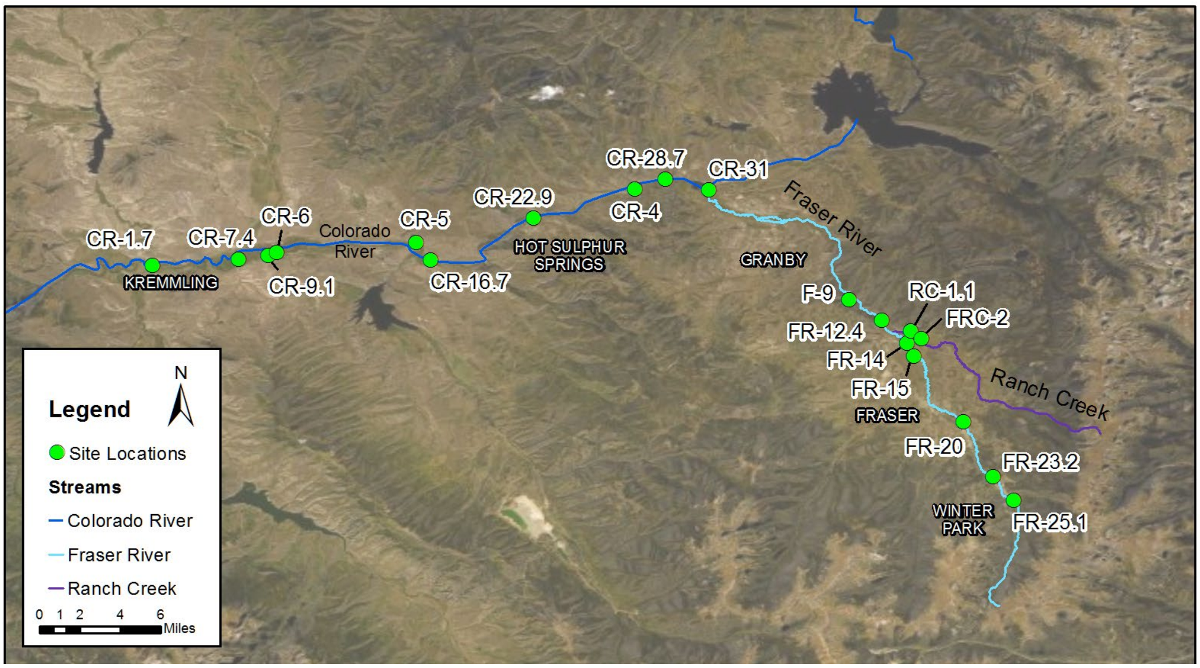


Figure 2-1: All site locations on the Colorado River, Fraser River, and Ranch Creek sampled in 2020.

Table 2-1: Names and locations for all 19 sites sampled in 2020.

Site Name	Station Description	Latitude	Longitude
CR-1.7	Colorado River upstream of Blue River	40.044	-106.374
CR-7.4	Colorado River downstream of Troublesome Creek	40.051	-106.311
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	40.054	-106.289
CR-6	Colorado River downstream of KB Ditch	40.056	-106.283
CR-16.7	Colorado River upstream of Williams Fork	40.050	-106.173
CR-5	Colorado River downstream of Williams Fork	40.063	-106.183
CR-22.9	Colorado River upstream of Hot Sulphur Springs	40.080	-106.099
CR-28.7	Colorado River just downstream of Windy Gap	40.108	-106.004
CR-4	Colorado River downstream of Windy Gap	40.101	-106.026
CR-31	Colorado River upstream of Fraser and Windy Gap	40.101	-105.973
F-9	Fraser River at Granby Ranch	40.079	-105.916
FR-12.4	Fraser River downstream of Ranch Creek confluence	40.007	-105.848
FR-14	Fraser River upstream of Tabernash	39.992	-105.830

Table 2-1 (cont.):

Site Name	Station Description	Latitude	Longitude
FR-15	Fraser River upstream of Fraser Flats restoration	39.983	-105.826
FR-20	Fraser River at Rendezvous Bridge	39.935	-105.791
FR-23.2	Fraser River upstream of Winter Park Sanitation	39.896	-105.769
RC-1.1	Ranch Creek downstream of Meadow Creek	39.999	-105.828
RC-2	Ranch Creek upstream of Meadow Creek	40.079	-105.916

3. Methods

3.1 Pebble Counts and Embeddedness

At each site location, pebble counts were performed utilizing the method outlined by Colorado Water Quality Control Division (WQCD) Policy 98-1, which describes the Modified Wolman Pebble Count Method (Colorado Department of Public Health and Environment [CDPHE] 2014). A total of ten transects were established at each site, evenly spacing each transect along a length of stream approximately twenty times the average bankfull width. At each of these ten transects, a 60 by 60-centimeter (cm) sampling frame was used to designate four substrate particles for measurement at ten evenly spaced points across the transect (Photos 3-1 and 3-2). This accounted for a total of 40 substrate particle measurements per transect, and a total of 400 measurements per sampling location. The 60 by 60 cm sampling frame consisted of 4 aluminum bars connected to form a square, with an inside width of 60 cm, and 4 elastic bands placed forming four cross sections with a width of 50 cm. The intermediate axis of each particle designated by the elastic band cross sections on the sampling frame was measured using a gravelometer or ruler (if the particle was too large to fit through the apertures in the gravelometer). Ocular estimates were used for substrate particles that could not be removed from the bed (i.e., due to size). The measured particles were analyzed to determine the D_{50} and the D_{84} of the sample. The notation D represents the particle size in millimeters (mm), and the subscript denotes the percentile; the D_{50} and D_{84} are the diameters (in mm) that are larger than 50% and 84% of the particles in the sample, respectively. The percentage of fine substrate (i.e., < 8 mm) was also calculated to determine the availability of clean substrate and interstitial spaces (i.e., the spaces between gravel and cobble particles used by macroinvertebrates and juvenile fishes).

A subset of the particles measured at each of the transects at each site location were used to determine percent embeddedness, or the extent to which larger particles are surrounded by or buried in fine substrate. A minimum of four or five large gravel or cobble-sized particles at each transect were measured for percent embeddedness, for a total of 40 to 50 embeddedness measurements per sampling location. Embeddedness percentages were determined by measuring the height that each particle was buried and dividing by the total particle height. This method allowed for a quantitative estimate of the total percent embeddedness at each site.

At three sites, CR-6, F-9, and RC-2, the pebble counts were specifically targeted towards locations where trout would spawn. These spawning bed surveys involved the use of a modified Wolman pebble count (Wolman 1954). This method requires that the surveyor walk across the spawning bed and periodically pick up a piece of substrate at their boot toe without looking (to avoid bias in selection). The number of steps between particle selection depended on the size of the spawning bed; the goal was to cover the entire bed in a “zig zag” pattern.

Embeddedness was not measured at these sites, but the D_{50} and the percentage of fine substrate (i.e., < 8 mm) were calculated to ensure appropriate substrate size for spawning fish was present and to ensure that an overabundance of fines was not present. Regulations established by CDPHE dictate that the percentage of fine substrate should not exceed 20% in spawning beds.

Photo 3-1: Substrate being measured with a gravelometer at Site CR-16.7 on the Colorado River.

Photo 3-2: Sampling frame with four cross sections for randomized substrate characterization.

3.2 Riffle Stability Index

The Riffle Stability Index (RSI) was determined at seven sites using the methods outlined by Kappesser (2002). The RSI value indicates the percentage of mobile bed material in the riffle. A point bar, lateral bar, or similar depositional feature at each site location was identified in close proximity to a riffle. A transect was established in a riffle across its bankfull width, and 200 substrate particles were selected. In smaller streams with insufficient width to allow selection of 200 particles, a second transect was established. The intermediate axis of each particle was measured. On the depositional feature, the intermediate axis of 10 to 30 of the largest recently deposited particles were measured, and the geometric mean of these particles was calculated. The geometric mean was then compared to the cumulative distribution of particle sizes from the 200-pebble count in the riffle. This determined the percentage of particles in the riffle that were smaller than the representative large mobile particles in the depositional feature at each site. The mobile fraction on the riffle can be estimated by comparing the relative abundance of various particle sizes present on the riffle with the dominant large particles on an adjacent bar (Kappesser 2002). A point bar, or the accumulation of gravel, cobble, and sand on the inside of a meander bend is a typical depositional feature in the CEA; point bars at two sampling sites on the Fraser River are shown in Photos 3-3 and 3-4.

Photo 3-3: An example of a depositional point bar, from Site FR-23.2 on the Fraser River.

Photo 3-4: An example of a lateral depositional bar, from Site FR--14 on the Fraser River.

3.3 Algae Presence, Percent Cover, and Thickness

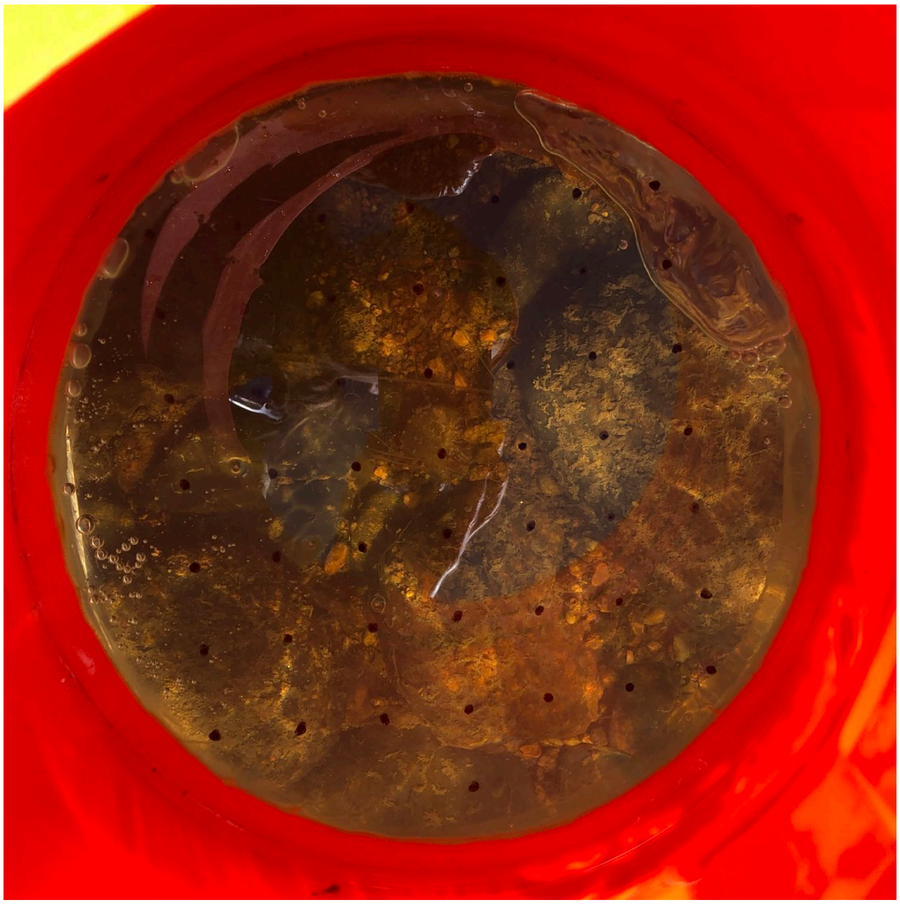
Algae presence (filamentous algae and diatoms), the percent filamentous algae cover, and diatom thickness data were recorded using a combined method that included protocols taken from the WQCD Standard Operating Procedures for the Collection of Stream Periphyton Samples (CDPHE, no year) combined with the grid-based pebble count method. Along each transect established for pebble counts, the presence of filamentous algae, the presence of diatoms, the percent filamentous algae cover, and diatom thickness were measured or visually estimated.

The algal communities were observed at three distances per transect: 25%, 50%, and 75% from the streambank, for a total of 30 points evaluated at each site. The algae viewing bucket consisted of a 5-gallon bucket with its bottom replaced with transparent plexiglass with 50 evenly spaced points marked with permanent marker (Photo 3-5). At each of the three transect positions, the presence of filamentous algae and/or diatoms was recorded. Filamentous algae was defined as algae that was green in color and formed strands or filaments. Diatoms are microscopic algae and tend not to form tall-growing colonies, with one exception. *Didymosphenia geminata* (Didymo), sometimes forms dense, brown or gray blooms that can cover much of the stream substrate. Low-growing algae and the readily identifiable Didymo were considered diatoms. For filamentous algae cover data, the viewing bucket was used twice at each of the three points along each transect. The total number of points where filamentous algae was growing was divided by 100 to calculate the percent filamentous algae cover at each of the three distances per transect. At each of the three distances the thickness of diatom growth was visually estimated in millimeters (mm) and categorized in accordance with Stevenson and Bahls 1999 (Table 3-1).

Table 3-1: Diatom thickness categories as defined by Stevenson and Bahls 1999.

Category	Categorical Description
0	Substrate rough with no visual evidence of microalgae
0.5	Substrate slimy, but no visual accumulation of microalgae evident
1	A thin layer of microalgae is visually evident
2	Accumulation of microalgal layer from 0.5 to 1 mm thick is evident
3	Accumulation of microalgal layer from 1 to 5 mm thick is evident
4	Accumulation of microalgal layer from 5mm to 2 cm thick is evident
5	Accumulation of microalgal layer greater than 2 cm thick is evident

Photo 3-5: The 5-gallon algae viewing bucket with transparent bottom and grid. The grid encompasses an area of roughly 100 in^2.



3.4 McNeil Substrate and Suspended Sediment

The amount of fine sediment and the composition of stream gravel were sampled using a McNeil sampler at three sites on the Colorado River, one site the Fraser River, and one site on Ranch Creek in 2020. This sediment data can be used to assess the spawning success of salmonids and other gravel-dependent spawners (McNeil and Ahnel 1964), and channel characteristic data have been used to monitor changes in channel morphology that ultimately affect fish habitat quality over time (Olson-Rutz and Marlow 1992). Six replicate samples were taken from pool tails or low-gradient riffles at each of the sampled site locations. Material was removed to the depth of the armor layer, or the layer of clean substrate that forms the top layer of stream substrate and would be moved by salmonids constructing redds, or nests. Substrate material was manually removed from the streambed using the McNeil sampler and brought to the GEI Ecological Laboratory for analyses.

Each sample was dried before analysis. Dried samples were shaken through a series of sieves, and the amount of sample retained on each sieve was weighed. The weight of the sample retained on each sieve was divided by the total sample weight to obtain the percent of the sample weight belonging to each size class. The D_{50} and D_{84} were calculated for each of the McNeil core samples. The percentage of fines, defined as the proportion of substrate with a diameter of 4.65 mm or smaller, was also calculated. The D_{50}, D_{84}, percent fines, and suspended solids values were compared between sample locations. Each sample was also compared to benchmarks established by Kondolf et al. (2008) to determine whether the grain size distribution could reduce the survival of salmonid eggs or the probability of successful emergence of salmonid fry from their redds.

The amount of suspended solids was determined by using the American Society for Testing Materials (ASTM) method D3977-97 (ASTM 2019). At each of the sampling locations a 470 milliliter (ml) sample of water was collected from the McNeil sampler after the substrate material was removed. The samples were kept on ice below 4°C until analysis by the GEI Laboratory. A total of six replicate aliquots were taken from each sample, and the average of the six replicates was used to characterize the suspended solids at each sample location.

4. Results

4.1 Pebble Counts and Embeddedness

A pebble count was performed at each site location from September 22, 2020 through October 1, 2020. A total of 10 transects were sampled at each site except for Site CR-6 on the Colorado River, Site F-9 on the Fraser River, and Site RC-2 on Ranch Creek, where the spawning bed surveys were performed. Site CR-1.7 was assessed qualitatively in 2020. The reach was not wadeable and dominated entirely by soft, fine substrate; it could not be surveyed safely. Most sites on the Colorado River and Fraser River were dominated by substrate sizes categorized as cobble and/or small cobble (Table 4-1). The substrate at the Ranch Creek sites were dominated by smaller substrate classes such as small cobble and gravel-sized substrate. Bedrock was only present in a small proportion at Site CR-16.7. Fine substrate, particles with an intermediate width less than 2 mm, was most common on the Colorado River at the farthest downstream sites, Site CR-7.4 and Site CR-1.7, at FR-23.3 on the Fraser River, and at Site RC-1.1 on Ranch Creek (Table 4-1).

All sites surveyed with the 400-rock count had percentages of fine sediment (i.e., < 2 mm) less than 29.3%, which is the threshold set in CDPHE Policy 98-1 for the protection of macroinvertebrates for sites in the CEA, with one exception. Qualitative surveys indicated that Site CR-1.7 was comprised almost entirely of fine sediment. Spawning beds were surveyed at three sites; the spawning beds at Site CR-6 and Site FR-9 met CDPHE Policy 98-1 standards for the protection of spawning salmonids. However, fines less than 8 mm constituted more than 20% of the sample in spawning beds at Site RC-2 (Table 4-1).

Average percent embeddedness was equal to or greater than 22.6 at all sites on all streams, with the largest average percent embeddedness observed at sites CR-7.4, CR-28.7, and RC-1.1 (Table 4-2). Average percent embeddedness values were in general lower in the upper portion of the Colorado River, and greatest at Site CR-7.4. This site also had the greatest percentage of fine substrate (<2 mm) of all of the quantitatively surveyed sites (Table 4-1).

Average percent embeddedness values on the Fraser River were all comparable between sites, ranging from a minimum of 34.7 to a maximum of 38.1 (Table 4-2). Among the Fraser River sites, Site FR-14 had the highest average percent embeddedness value observed (Table 4-2). Of note, Site FR-25.1 was dissimilar to all other sites on the Fraser River, Colorado River, and Ranch Creek. This site was dominated by very large boulders with a steep grade, and greatly influenced by surrounding human-made alterations to the riverbanks, portions of the river, and nearby roadways.

The percentage of substrate sizes observed in 2020 at sites on the Colorado River varied between sites. The substrate classes between <2 mm to ≤256 mm were observed at all sites. There was little to no substrate greater than the 256 mm at the two most downstream sites, Site CR-9.1 and Site CR-7.4. Site CR-7.4 had a noticeably greater percentage of smaller substrate, between <2 mm to ≤64 mm, than all other Colorado River sites sampled in 2020 (Figure 4-1). The Colorado River sites exhibited decreased average substrate size from upstream to downstream (Figure 4-1). Substrate types and proportions at Site RC-1.1 were similar to those in the lower portion of the Fraser River, at sites F-9 and FR-12.4. The most downstream site on Ranch Creek, Site RC-2, had much greater percentages of smaller substrate compared to Site RC-1.1(Figures 4-1 and 4-2).

Table 4-1: Percent average substrate size classes at all sites sampled in 2020.

Sites	Substrate Size Categories							
	Fines	Small Gravel	Gravel	Small Cobble	Cobble	Small Boulder	Boulder	Bedrock
	<2 mm	2-8 mm	8-64 mm	64-128 mm	128-256 mm	256-512 mm	>512mm	
CR-7.4	22.9	9.0	49.9	15.0	3.0	0.2	0.0	0.0
CR-9.1	8.5	4.0	28.0	35.3	19.8	4.3	0.3	0.0
CR-6[1]	0	0	8.8	13.7	48	29.4	0.0	0.0
CR-16.7	11.2	5.7	12.0	19.0	32.9	15.5	3.5	0.2
CR-22.9	5.2	6.0	18.5	20.4	36.2	12.7	1.0	0.0
CR-28.7	7.8	3.5	18.0	12.0	46.8	12.0	0.0	0.0
CR-31	6.8	2.5	11.0	18.8	47.9	13.0	0.0	0.0
F-9[1]	5.0	9.0	20.0	37.0	27.0	2.0	0.0	0.0
FR-12.4	8.8	10.3	18.5	26.5	24.5	11.3	0.3	0.0
FR-14	3.8	7.5	11.5	20.3	34.3	22.5	0.3	0.0
FR-15	7.8	6.0	15.0	21.8	33.3	15.5	0.5	0.0
FR-20	8.3	3.0	15.4	25.0	28.0	18.7	1.5	0.0
FR-23.2	12.8	10.3	15.0	16.3	23.3	12.8	9.8	0.0
FR-25.1	10.3	3.0	6.5	5.3	10.0	22.3	42.8	0.0
RC-1.1	13.0	8.5	25.3	27.5	19.3	2.8	3.8	0.0
RC-2[1]	5.0	32.7	45.5	13.9	3.0	0.0	0.0	0.0

[1] Spawning bed pebble counts only (100 particles)

Table 4-2: Average embeddedness by site location.

Sites	Waterbody	Average Percent Embeddedness
CR-7.4	Colorado River	54.3
CR-9.1	Colorado River	40.5
CR-16.7	Colorado River	31.5
CR-22.9	Colorado River	39.8
CR-28.7	Colorado River	48.7
CR-31	Colorado River	22.6
FR-12.4	Fraser River	35.9
FR-14	Fraser River	38.1
FR-15	Fraser River	35.4
FR-20	Fraser River	37.9
FR-23.2	Fraser River	34.7
FR-25.1	Fraser River	37.3
RC-1.1	Ranch Creek	45.4

Substrate composition varied less between the Fraser River sites than observed on the Colorado River, with the exception of Site FR-25.1 (Figure 4-2). Site FR-25.1 was the most upstream site on the Fraser River, and the hydraulic and geomorphic properties of this site were substantially different from the other sites sampled on the Fraser River. Site FR25.1 had a strikingly greater percentage of larger substrate, with the majority being greater than 512 mm (Figure 4-2).

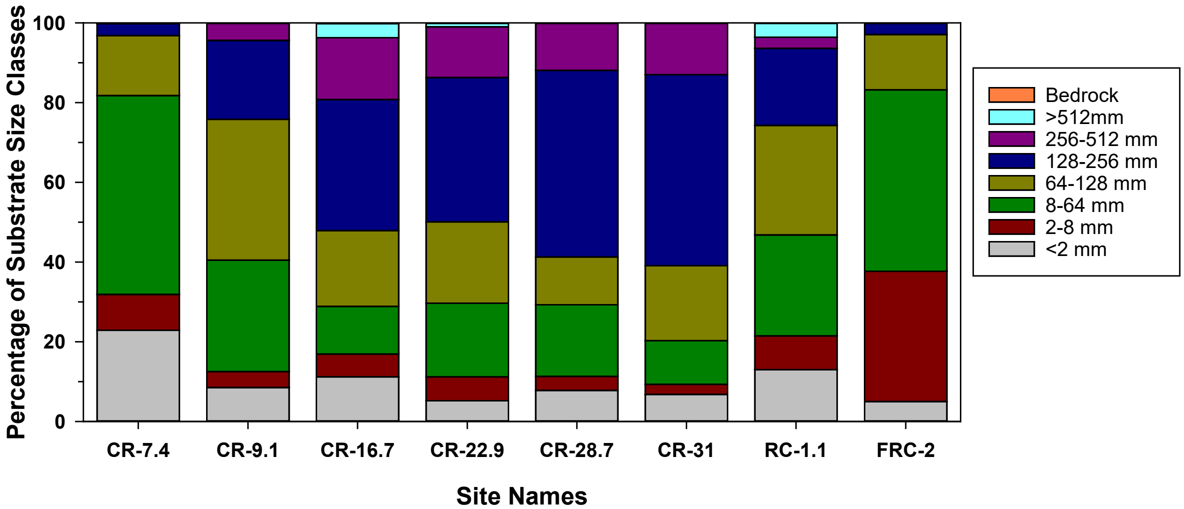


Figure 4-1: Percentage of substrate size classes for all sites on the Colorado River and Ranch Creek.

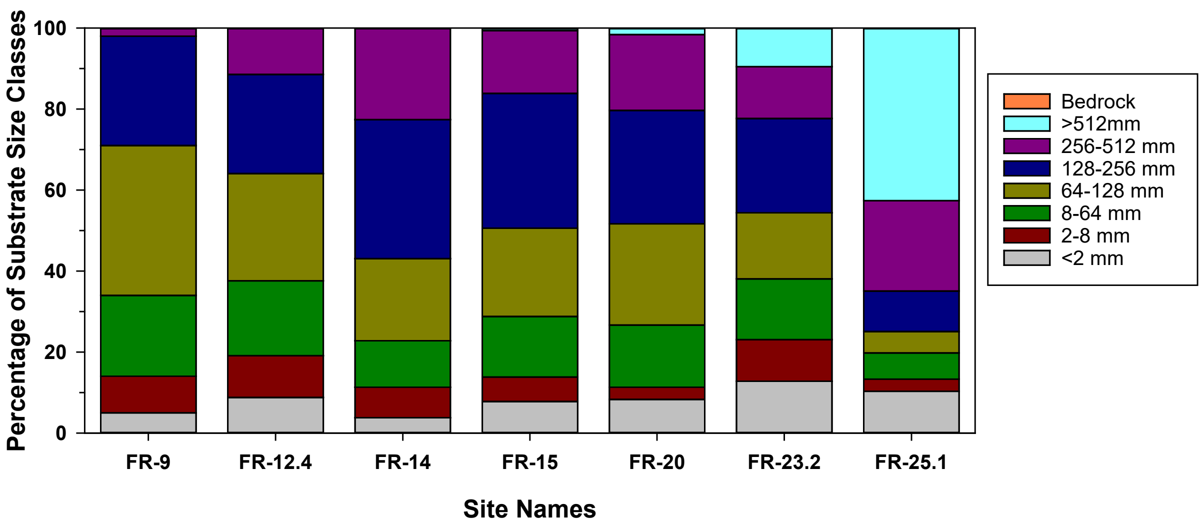


Figure 4-2: Percentage of substrate size classes for all sites on the Fraser River.

4.2 Riffle Stability Index

A 200-riffle pebble count and a 10 to 15 pebble count on a nearby depositional feature were performed at eight of the fifteen sites in 2020.

The RSI value indicates the cumulative percentage of riffle particles that are smaller than the dominant large particles on a depositional bar (Kappesser 2002). Values of the RSI range from 0 to 100, with higher numbers indicating sand and small gravel loading in the riffle. Reference, or unmanaged, streams in the Kappesser study (2002) had a median RSI value of 58, indicating that RSI values in the high 50s do not indicate an unexpected number of fines. The minimum RSI value observed occurred at Site FR-23.2 on the Fraser River and the maximum observed value was observed at Site RC-2 on Ranch Creek. In general, the RSI values were moderately high on the Colorado River and Fraser River, with an average RSI of

64 on the Colorado River, and 61 on the Fraser River. RSI values on Ranch Creek were higher than the averages on the Colorado River and Fraser River, with a notably larger RSI value at Site RC-2 (Table 4-3).

Table 4-3: Average Riffle Stability Index (RSI) by site location in 2020.

Sites	Waterbody	Riffle Stability Index
CR-7.4	Colorado River	--
CR-9.1	Colorado River	59
CR-16.7	Colorado River	57
CR-22.9	Colorado River	--
CR-28.7	Colorado River	75
CR-31	Colorado River	--
F-9	Fraser River	71
FR-12.4	Fraser River	--
FR-14	Fraser River	--
FR-15	Fraser River	57
FR-20	Fraser River	--
FR-23.2	Fraser River	54
FR-25.1	Fraser River	--
RC-1.1	Ranch Creek	74
RC-2	Ranch Creek	96

4.3 Algae Presence, Percent Cover, and Thickness

The algae community at a total of 30 points within each site reach was assessed in conjunction with pebble count surveys from September 22, 2020 through October 1, 2020. The percent average presence of filamentous algae across these 30 points per site varied considerably across all sampling locations. Values ranged from 0 percent filamentous algae presence at Site FR-25.1 on the Fraser River, to a maximum of 83 percent presence at Site CR-28.7 on the Colorado River.

The percent filamentous algae cover at each site also varied widely, and was generally low, with the exception of sites CR-7.4 and CR-9.1, and CR-28.7 on the Colorado River, and at Site FR-23.2 on the Fraser River (Table 4-4). When filamentous algae was present, it generally occurred in short strands and did not occur in large, extensive blooms.

Table 4-4: Filamentous algae and diatom data by site location.

Sites	Waterbody	Percent Average Filamentous Presence	Percent Average Filamentous Algae Cover	Percent Average Diatom Presence	Average Categorical Diatom Thickness
CR-7.4	Colorado River	66.7	33.6	83.3	2.1
CR-9.1	Colorado River	76.7	25.9	100	1.9
CR-16.7	Colorado River	50	9.8	86.7	2.7
CR-22.9	Colorado River	43.3	8.2	96.7	3.2
CR-28.7	Colorado River	83.3	38.9	93.3	1.1
CR-31	Colorado River	63.3	7.3	100	2.2
F-9	Fraser River	--	--	--	--
FR-12.4	Fraser River	30.0	4.2	93.3	1.6
FR-14	Fraser River	60.0	7.2	100	1.8
FR-15	Fraser River	36.7	4.2	90.0	1.7
FR-20	Fraser River	6.7	0.3	80.0	1.7
FR-23.2	Fraser River	63.3	15.5	86.7	0.7
FR-25.1	Fraser River	0.0	0.0	86.7	0.6
RC-1.1	Ranch Creek	23.3	2.2	93.3	1.5
RC-2	Ranch Creek	--	--	--	--

Diatom algae were present at each site sampled in 2020, and the percentage of diatom presence at each site was high, ranging from a minimum of 86.7 percent to 100 percent (Table 4-4). The diatom species *Didymosphenia geminata* (Didymo) is a stalked diatom that can form nuisance blooms in rivers in the western United States (Spaulding and Elwell 2007). Although Didymo was present at some sites, thick, extensive blooms of this species were not observed in 2020. Diatom thickness was categorized as less than 1 mm at sites FR-23.2, and FR-25.1 on the Fraser River. All other sites on every stream sampled in 2020 had thickness categories that exceeded a thickness of 1 mm (Table 4-4; Table 3-1).

4.4 Volumetric Substrate and Suspended Solids Analyses

Stream substrate was sampled with the McNeil sampler, and suspended solids samples were collected at sites CR-4, CR-5, and CR-6 on the Colorado River, Site F-9 on the Fraser River, and at Site RC-2 on Ranch Creek. These samples provided data to help assess fish spawning and benthic macroinvertebrate habitat.

All sites on the three streams had low proportions of fine sediment, and very similar average D_{50} and D_{84} substrate sizes (Table 4-5). Both the D_{50} and D_{84} for each site are within the 8 mm to 64 mm range and categorized as gravel. These values exhibit that the majority of streambed substrate in areas where trout may preferentially spawn are composed of gravel substrate that is conducive to spawning.

Average suspended sediment varied among the three streams with the lowest values present at the Colorado River site locations. Site RC-2 on Ranch Creek had a notably greater concentration of suspended sediment than at the Colorado River sites, and Site F-9 had a notably greater value than at any site location on the Colorado River or Fraser River (Table 4-5). Suspended sediment values increased in a downstream direction on the Colorado River, indicating that there is an increase in fine sediment moving downstream. The D_{50} at all sites sampled in the CEA fell within the range of 5.8 mm to 50 mm. This range of values was observed in redds constructed by Brown Trout (*Salmo trutta*) in a 1993 study by Kondolf and Wolman.

Table 4-5: Averages of McNeil sample data, percent fines, and suspended sediment.

Sites	Waterbody	McNeil Samples		Average Percent Fines	Average Suspended Sediment (ppm)
		Average D_{50} (mm)	Average D_{84} (mm)		
CR-4	Colorado River	16.0	40.6	12.4	558.6
CR-5	Colorado River	16.3	41.1	13.1	747.9
CR-6	Colorado River	18.2	42.7	8.5	827.2
F-9	Fraser River	15.4	40.5	12.0	3,058.9
RC-2	Ranch Creek	15.3	40.2	9.9	1,793.1

5. Discussion

The substrate, suspended solids, and algae community data gathered in the fall of 2020 at multiple sites along representative stretches of the Colorado River, Fraser River, and Ranch Creek have enabled a basin-wide assessment of substrate size, substrate mobility, substrate deposition, and algae population data. This in turn allows inference about the effects of current substrate conditions on fish and macroinvertebrate habitat quality.

5.1 Pebble Counts and Embeddedness

5.1.1 Colorado River

Based on observed changes between sites, sediment composition in the CEA is likely affected by large-scale factors such as reservoirs, tributary inputs, magnitude of flow, and by local-scale factors such as hillslope erosion and stream diversion infrastructure.

Windy Gap Reservoir is located near the upstream end of the CEA on the Colorado River, just below the Colorado River and Fraser River confluence and between Site CR-31 and Site CR-28.7. This reservoir began operating in 1985 and is a relatively small flow-through system that extends about 0.4 miles from the inlet to the outlet. A large proportion of the sediment transported into the reservoir is retained behind the dam. Windy Gap Reservoir was partially drained in September 2020 in preparation for the modification of the dam and construction of the connectivity channel in the Colorado River. In 2020, the substrate sizes were more comparable between Sites CR-31 and CR-28.7 than in 2019. The percentage of fine substrate and small gravel at Site CR-28.7 increased between 2019 and 2020. The draining of Windy Gap Reservoir may have introduced new fine sediments and gravel into the Colorado River.

Substrate less than 64 mm did not increase in percentage from Site CR-28 moving downstream until the river passed through areas that receive sediment input. Diagonal cobble bars and mid-channel cobble bars, both of which indicate a lack of sediment mobility (Rosgen 2006), were observed downstream of Windy Gap Reservoir. Substantial additions of new substrate material into the Colorado River likely do not occur until the river reaches Byers Canyon, downstream of the town of Hot Sulphur Springs, below Site CR-22.9.

Byers Canyon and Little Muddy and Beaver creeks are both located between Site CR-22.9 and Site CR-16.7 on the Colorado River. Byers Canyon is characterized by escarpments adjacent to the stream along with a steep stream corridor composed of mainly large boulder substrate. This section of the river extends approximately 1.9 miles just downstream of Hot Sulphur Springs. The river in the canyon is narrow and has a higher slope than adjacent reaches, resulting in greater water velocities than the sections of river just upstream and just downstream of the canyon. This creates a higher potential for sediment transport and a lower potential for sediment storage. The steep canyon walls also provide material ranging from silt to boulders to the river, largely through natural processes. Muddy Creek is downstream of Byers Canyon; this small, unregulated system likely also serves as a source of new material to the Colorado River. The proportion of fine sediment (<2 mm) increased between Site CR-22.9 and Site CR-16.7 and is likely attributable to the addition of sediment from Byers Canyon.

There are two relatively large tributaries to the Colorado River in the downstream portion of the study reach that influence substrate characteristics in the river. The Williams Fork of the Colorado River (Williams Fork) flows into the Colorado River just downstream of Site CR-16.7 in the town of Parshall, CO, and Troublesome Creek flows into the Colorado River between Site CR-9.1 and Site CR-7.4. The Williams Fork downstream of Williams Fork Reservoir is a short section of river about 2.0 miles in length before the confluence. This reservoir disrupts the continuity of sediment transport in the Williams Fork and likely diminishes the amount of substrate historically provided to the Colorado River. The Williams Fork adds a relatively large amount of volume to the flow in the Colorado River, which assists with transporting sediment downstream.

Site CR-9.1, the first sampling site downstream of the Williams Fork confluence, had greater proportions of gravel substrate in 2020 than observed at the next upstream site, Site CR-16.7. This increase in gravel between the two sites may be attributable to restoration work on the Williams Fork River in 2019 that enabled some smaller substrate material to be transported into the Colorado River. The KB Ditch is located approximately 0.4 miles upstream of Site CR-9.1 on the Colorado River and diverts flow from the Colorado River for agricultural use (Photo 5-1). The diversion runs the width of the river at the ditch inlet, with the exception of a small bypass on river right (looking in a downstream direction). This structure also has the potential to trap sediment. The KB Ditch and Williams Fork confluence with the Colorado River are both upstream of Site CR-9.1; there is no monitoring site between them . An additional site located between Williams Fork and KB Ditch might determine their relative influences on the sediment characteristics at Site CR-9.1.

Photo 5-1: Aerial image of the KB Ditch diversion and inlet (Google Earth, earth.google.com/web/). The Colorado River flows towards the left of the photo.

Troublesome Creek is a moderately sized tributary to the Colorado River, and the confluence is located between Site CR-9.1 and CR-7.4, approximately 0.4 miles upstream from Site CR-7.4. This creek is low-gradient, sinuous (i.e., meandering), and runs adjacent to agricultural fields for much of its length. The confluence of Troublesome Creek and the Colorado River is located just upstream of where the sinuosity of the Colorado River increases dramatically, the slope decreases, and the water velocity decreases in comparison to the upstream reaches. The highly sinuous section of the Colorado River extends approximately 12 miles before entering Gore Canyon just downstream of the town of Kremmling. Substantial bank erosion also occurs in portions of this reach (Jon Ewert, Colorado Parks and Wildlife, personal communication).

Due to higher sinuosity, lower slope, reduced water velocity, and the addition of sediment from Troublesome Creek, the Colorado River transitions from being dominated by small cobble and cobble substrate to being dominated by smaller substrate size classes. Site CR-7.4 was dominated by gravel substrate with a large proportion of fine substrate, and there was a notable increase in the amount of gravel and fines between sites CR-9.1 and CR-7.4 in 2019 and 2020.

Based on observed changes between sites, sediment composition throughout the CEA is likely affected by a combination of natural and man-made factors. Troublesome Creek, Muddy Creek, and Byers Canyon likely act as sources of sand and gravel in an otherwise sediment-limited system; bank erosion in the lower section of the Colorado River, between CR-9.1 and CR-1.7 may also introduce a significant amount of fine sediment into the system. While the Williams Fork provides additional flow, it is also sediment-limited and probably does not provide substantial amounts of gravel to the system. The predominance of fine substrate at Site CR-1.7 is likely due to transport capacity being limited by low gradient and high sinuosity. The changes between the Colorado River sites in 2019 and 2020 and the changes within these sites between 2019 and 2020 suggest that the Colorado River can transport gravel sediment, even in years with average spring flows.

Embeddedness values generally increased in a downstream direction on the Colorado River in 2020. Embeddedness was lowest at the most upstream site and then increased notably at the next downstream site, Site CR-28.7. This greater embeddedness value at Site CR-28.7 may be related to its proximity to the dam. While flushing flows from Windy Gap occur annually during spring runoff, fines that were carried in suspension over the dam could have been deposited at this site on the descending limb of the hydrograph or after the drawdown of Windy Gap Reservoir. Embeddedness values then decreased between Site CR-28.7 and Site CR-22.9, and further decreased at Site CR-16.7. The decreases between these sites implies that flows were sufficient to flush some fines from the substrate at these locations in 2020. Embeddedness values increased at Site CR-9.1 and again at Site CR-7.4. This is due to the addition of substrate from tributaries, a notable decrease in the slope of the river, and an increase in sinuosity. These factors all decrease water velocity and facilitate deposition of fine substrate.

The percentages of substrate sizes did not change considerably among most of the Colorado River sites sampled between 2019 and 2020 (Appendix C). Notable changes occurred at the two most downstream site locations sampled in 2020, sites CR-7.4 and CR-9.1. At both of these sites there was in increase in the percentage of gravel observed between 2019 and 2020, and this increase may be attributable to additional substrate input from Williams Fork and Troublesome Creek in 2020. The 2020 data at sites CR-7.4 and CR-9.1 will provide important information in subsequent years, as they were collected before the East Troublesome Fire occurred. Although the effects of the fire on sediment input to Troublesome Creek and the Colorado River are highly dependent on runoff and precipitation, it is likely that these sites will receive substantial amounts of additional sediment in subsequent years. The remaining differences in substrate percentages between sites in 2019 and 2020 on the Colorado River are minor and probably due to a combination of natural variability and sampling variability.

5.1.2 Fraser River and Ranch Creek

As with the Colorado River, sediment composition on the Fraser River is affected by large-scale and local-scale factors. The primary large-scale factor is flow management, but local features such as unpaved roads, erodible hillslopes, beaver ponds, and man-made ponds appear to have a larger effect on the proportion of fine sediment in the watershed, as opposed to the cumulative proportion of sediment less than 128 mm in diameter.

Site FR-25.1 has markedly different substrate characteristics than the remaining Fraser River sites. This site is steeper and straighter than the remaining sites; the streambed contains a step-pool system instead of the riffle-pool morphology observed at the other sites. The differences in stream morphology between this site and the others on the Fraser River best explain the differences in substrate characteristics.

The Fraser River in the CEA has four relatively large tributaries: Vasquez Creek, which enters the Fraser River between sites FR-23.2 and FR-20, Elk Creek and St. Louis Creek, both of which enter the Fraser River between sites FR-20 and FR-15, and Ranch Creek, which enters the Fraser River downstream of Site FR-14. Even though sites FR-25.1, FR 23.2, FR-20, and FR-15 had a greater percentage of large substrate (> 512 mm) than the three most downstream sites on the Fraser River, the substrate composition changed less than expected from the upstream-most to downstream-most sampling site in 2020. The individual influences of tributaries like Vasquez Creek and St. Louis Creek on Fraser River sediment dynamics were not pronounced in 2020, perhaps because the tributaries are highly regulated by diversions. Similar results were found in 2019.

The local factors in the Fraser River Drainage include stream diversions, beaver dams, and unpaved roads. The proportion of fine sediment was similar at the two most upstream sites on the Fraser River, sites FR-25.1 and FR-23.2, and then generally decreases in a downstream direction before increasing again at Sites FR-12.4 and F-9. Hillslope inputs at sites FR-25.1

and upstream of F-9 (i.e., in Fraser Canyon) likely provide fine sediment to both sites, whereas Site FR-12.4 receives sediment from the beaver dams located immediately upstream. It is possible that there are multiple beaver dams in the Fraser River that were not observed but could affect sediment dynamics.

Mid-channel and diagonal bars were also observed in the Fraser River drainage and are evidence of its highly managed status. These depositional bars form when powerful, rapid flows recede and leave behind sediment deposits that cannot be moved by subsequent, lower flows; additional high flow events are required to move these features. These bars were likely created during the last significant flow event on the river. Almost all of the mid-channel and diagonal bars observed on the Fraser River did not show signs of recent formation and are likely not a result of recent flows.

On Ranch Creek, the percentage of substrate <2 mm was greater at Site RC-1.1 than at Site RC-2 and all sites on the Fraser River. The higher proportion of fine sediment may be due to a combination of low flows from multiple diversions in the Ranch Creek Watershed, multiple beaver dams between the two site locations, and the high availability of sediment from unpaved roads and hillslopes in the watershed. Site RC-1.1 on Ranch Creek was observed to have similar sinuosity, slope, and habitat types as the lower and middle sites on the Fraser River, suggesting that similarities in substrate characteristics could be attributable to similar stream morphologies at these sites. Site RC-2 had the highest proportion of sediment < 8 mm of any of the surveyed sites. This is likely attributable to its location immediately downstream of an extensive beaver dam complex.

Embeddedness values were comparable between sites on the Fraser River in 2020 with only small changes between subsequent sites. There was an observed increase in the embeddedness and substrate <2 mm at Site FR-14, the next site downstream from Site FR-15, and a decrease in the percentage of small gravel at Site FR-14. This is an indication that the stretch of river between these two sites is likely enabling the transport of smaller substrate material downstream past Site FR-14, and likely has a greater average water velocity than the portion of the river upstream of Site FR-15. The section of river between Site FR-15 and Site FR-14 was the focus of restoration efforts, and the narrowing of the river coupled with an increase in stream velocity has allowed this section of river to transport sediment more successfully than the other sections of the Fraser River below Site FR-25.1.

Similar to the Colorado River, the pebble count percentages for the locations on the Fraser River and Ranch Creek sampled in 2019 and 2020 differed little between the two years (Appendix C). A notable change was an increase in the fine substrate and small gravel percentages at Site FR-23.2, that is likely a result of sediment released from beaver dams between Site FR-23.2 and Site FR-25.1 in 2020. Another notable difference between 2019 and 2020 was a decrease in the percentage of gravel at Site FR-14 in 2020. This site location is within an area of the river that was recently restored and may have been accumulating gravel substrate previous to restoration efforts. This restored reach may now be more capable of transporting sediment, which would reduce the amount of gravel at Site FR-14 in 2020.

5.2 Riffle Stability Index

The mobile percentile of particles in a riffle, or RSI, is a useful estimate of the degree of increased sediment supply to riffles in mountain streams (Kappesser 2002). A stable stream reach in dynamic equilibrium has similar sediment size and sediment transport rates at the beginning of a reach compared to the end of a reach, so that there is no net gain or loss of sediment (Kappesser 2002).

In the Kappesser (2002) study in north Idaho, reference streams had a median RSI value of 58 and managed watersheds had a median RSI value of 80. The median RSI value was 64 for the sites on the Colorado River, 61 on the Fraser River, and 85 on Ranch Creek in 2020. A higher RSI value shows that a higher proportion of the material in a riffle is smaller than the larger materials on depositional features. This indicates that a riffle is storing a higher proportion of fine materials such as sand.

The RSI values from the 2020 sampling sites suggest that stream flows in the Colorado River and Fraser River have a relatively limited capacity to flush sand and gravel from riffles. The RSI values at the Ranch Creek sites indicate a very limited capacity to transport substrate material, as was also indicated by large proportions of sand and small gravel at both sites on Ranch Creek.

The RSI decreased on the Colorado River in a downstream direction from Site CR-28.7 to sites CR-16.7 and CR-9.1. This decrease indicates that substrate transport increases between the upper portion of the CEA and the lower portion on the Colorado River. The opposite was observed on the Fraser River in 2020, with comparable values at sites FR-23.2 and FR-15, and a noticeably larger value at Site F-9, the most downstream site. This decrease between the upper portion and lower portions of the Fraser River is attributable to inputs from beaver dams and from Fraser Canyon that were not flushed from Site F-9 in 2020. Riffles with a lower RSI value (i.e., those with a lower proportion of fine material) provide more interstitial spaces, or small spaces between clean substrate particles. These interstitial spaces provide high-quality habitat for macroinvertebrates, some species of juvenile fishes, and benthic, or bottom-dwelling, fishes.

Compaction of the substrate, or the packing of embedded substrate such that it is difficult to remove from the streambed was common in the Fraser River and in Ranch Creek, but less predominant at most sites on the Colorado River. Compaction occurs when interstitial spaces become filled with too much fine substrate, which is transported as suspended load in the water column, as opposed to an unconsolidated mix of fines and gravels that move along the streambed (Babbitt and Bidelspach, personal communication, 10/29/2019). The gravels that move as bedload tend to become trapped behind diversions in highly managed streams systems such as the Fraser and Colorado rivers. Substrate compaction negatively affects aquatic organisms by clogging interstitial spaces, as discussed above, and it limits spawning habitat by preventing fish from moving substrate to make nests or redds.

5.3 Algae Presence, Percent Cover, and Thickness

Diatoms were present at all sites unless the substrate was occluded by green algae. Didymo was present in the CEA but did not form extensive blooms in 2020. This species tends to create blooms in stable, low velocity flow regimes (Kirkwood et al. 2007; Miller at al. 2009). Didymo did not occur at nuisance levels in 2020; it is possible that runoff in the spring of 2020 or the draining of Windy Gap flushed much of the Didymo from the CEA. The percent average diatom presence varied little among all sites in the CEA between 2019 and 2020, but the average diatom thickness either stayed consistent or decreased in 2020 from 2019 values at all but one site on the Colorado River and Fraser River (GEI 2020).

Green filamentous algae coverage was low at all sites on the Fraser River and Ranch Creek, but extensive at sites CR-28.7, CR-9.1, and CR-7.4 on the Colorado River. The abundance of filamentous algae at these sites is likely partially due to nutrient inputs from agricultural run-off. These sites are also relatively wide and low-gradient, creating shallow and low-velocity conditions preferable to filamentous algae. There were likely low flows for an extended period at these sites that was insufficient to scour algae during the summer and fall.

The differences in the diatom and filamentous algae communities between 2019 and 2020 at each sampling location are likely attributable to natural variation. Blooms of diatoms and filamentous algae within each drainage are dependent on climatic conditions, peak and magnitude flows, and variations in nutrient availability.

5.4 Volumetric Substrate and Suspended Solids

Volumetric substrate data was collected using a McNeil sampler at three sites on the Colorado River, and at one site each on the Fraser River and Ranch Creek. Calculated values for the D_{50} and D_{84} were all very similar among all sites in the CEA. The D_{50} and D_{84} values at each site were generally lower than the corresponding values calculated from the pebble counts at each site. This is unsurprising and attributable to differences in sampling equipment and the areas targeted for data collection (i.e., spawning beds) between the two methods. The McNeil sample data and the suspended sediment data show that the substrate composition in trout spawning habitat is comparable among the sampled site locations.

An excess of fine sediment can be detrimental to trout reproduction. Incubating eggs and alevins must obtain oxygen and dispose of metabolic wastes while they inhabit the gravel, which requires that subsurface and surface water flow freely through the redd (Kondolf et al. 2008). Higher permeability of redds generally results in an increase in juvenile trout survival. The mean maximum levels of different grain sizes that allow for 50 percent salmonid emergence are: <0.85 mm, 13.6 percent; <2.00 mm, 15 percent; <3.35 mm, 29.5 percent; and

<6.35 mm, 30.3 percent (Kondolf et al. 2008). Preferred substrate size for spawning trout varies with fish length, with a general increase in spawning substrate size correlated with an increase in fish length. Volumetric substrate sampling indicated that substrate sizes in spawning beds in the CEA are near the lower end of the range for spawning trout, slightly lower than the Brown Trout average, and likely not a limiting factor for trout reproduction.

Average concentrations of suspended sediment were low at the Colorado River site locations and increased in a downstream direction. Fine sediment likely accumulates in a downstream direction due to the addition of sediment from tributaries between each site location and a decreased ability of the river to flush fine sediment due to a decrease in slope and an increase in stream width. The average concentrations of suspended sediment at Site RC-2 on Ranch Creek and F-9 on the Fraser River were notably higher than on the Colorado River. Also, the average concentration of suspended sediment at Site RC-2 was much greater than at Site F-9. The greater concentrations of suspended sediment at sites RC-2 and F-9 are due to their locations downstream of significant sediment sources. Site RC-2 is located immediately downstream of a large beaver complex, and Site F-9 is located downstream of the beaver complexes and Fraser Canyon.

6. Conclusion

The sediment conditions in the CEA in the Colorado and Fraser River drainages are typical of managed systems, and a combination of natural and man-made features influence the river's sediment dynamics. The 2020 annual daily flows observed in Grand County, CO during spring run-off and during the remainder of the year in the Colorado River, Fraser River, and Ranch Creek were nominally less than in 2019, and comparable to observed values in 2017 or in 2018 at each gage location (Appendix B). On a local scale, ditches/dams and beaver ponds trap gravels, and unpaved roads, unregulated tributaries, and erodible hillslopes provide sources of sand and gravel. Although the proportion of sand and silt at all sites was typical for rivers in this region, gravel was limited at most sampling sites. Embeddedness was over 30 percent at every site except for the most upstream site on the Colorado River, and the sediment was compacted at most of the sampling locations in the Fraser River. Spatial changes in substrate composition in 2019 and 2020 and temporal changes in substrate composition were not pronounced but imply that the streams in the CEA can transport gravel when it is available. However, flows in the CEA are likely not sufficient to transport larger substrate, such as cobble in most years.

Didymo was present but not extensive at several sites, and green filamentous algae blooms were present at a small number of sites, but nuisance blooms were generally absent in 2020. The sediment and algae conditions in the CEA have some implications for aquatic habitat quality, as discussed briefly below.

The substrate sizes present in the volumetric substrate samples are favorable sizes for trout spawning and for certain benthic macroinvertebrate groups. This implies that trout can spawn successfully at the selected sampling sites. However, gravel is limited at many of the sampling sites, which would limit the availability of spawning sites in the CEA, and substrate compaction would also limit spawning success, especially in the Fraser River. Compacted sediment limits trout spawning success because trout cannot move the gravels to construct redds.

The availability of clean substrate and interstitial spaces is limited at many sites within the CEA due to high embeddedness by fine sediment and periodic blooms of algae. A low proportion of gravels and embeddedness of cobbles limit habitat for macroinvertebrates and small fishes (Waters 1995). A limited number of studies indicate that the effects of Didymo and green algae on macroinvertebrate communities is variable (Patrick 1983; Dodds and Gudder 1992; Ellsworth 2000; Spaulding and Elwell 2007; Tonkin et al. 2014), but reduction of sensitive taxa like mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) have been documented in some studies (Kilroy et al. 2009). Historic flows in the CEA were substantially greater in magnitude and duration during spring run-off than they are in modern times, multiple instream structures disrupt sediment transport, and human land use has altered the nutrient dynamics of the Colorado and Fraser rivers. Aquatic habitat conditions are somewhat limited within the CEA. However, this is unsurprising, given that the Colorado and the Fraser are both working rivers. It is highly likely that restoration efforts such as the Windy Gap Connectivity project and the Kemp-Breeze/Colorado River channel rehabilitation will result in increased sediment continuity and the associated benefits to aquatic habitat.

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Appendix A 2020 Sediment and Algae Data

Site: CR-7.4
Date: 9/28/2020
Notes:

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1	4	3	22	9	2			
2	11	3	20	5	1			
3	14	1	24	1				
4	12	9	19					
5	4	2	30	4				
6	5	3	16	12	4			
7	13	2	19	5	1			
8	12	3	13	8	3	1		
9	7	6	21	6				
10	10	4	16	10	1			
Total	92	36	200	60	12	1	0	0
% of Total	22.9	9	49.9	15	3	0.2	0	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5
1	20	30	50	70	50
2	80	50	50	30	80
3	100	50	50	60	50
4	50	60	70	50	60
5	50	70	60	40	40
6	20	30	40	30	30
7	50	50	60	60	50
8	30	40	50	100	100
9	60	65	60	50	70
10	50	60	40	50	100

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	0	4	0	28	4	4	16	0.5	3
2	8	1	2	10	0.5	3	0	1	0
3	0	0	0	10	0.5	2	50	0.5	3
4	0	1	0	0	5	0	0	3	0
5	0	1	0	0	5	0	0	3	0
6	50	4	3	90	0	5	30	3	4
7	100	0	5	6	3	4	90	0	4
8	60	3	3	60	2	3	100	0	4
9	90	4	4	80	3	3	60	2	3
10	50	3	3	20	3	3	0	3	0
Average	35.8	2.1	2	30.4	2.6	2.7	34.6	1.6	2.1

Site: CR-9.1
Date: 9/28/2020
Notes: High algae coverage is short colonies on individual rocks

Transect Substrate Count

	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	3	3	15	10	6	3		
2	2	1	6	13	16	2		
3	6	2	7	9	16			
4	8	1	7	7	9	8		
5	7	1	9	15	3	4	1	
6			2	21	17			
7	4	1	18	13	4			
8	2	2	26	9	1			
9		1	13	21	5			
10	2	4	9	23	2			
Total	34	16	112	141	79	17	1	0
% of Total	8.5	4	28	35.3	19.8	4.3	0.3	0

Spawning Bed	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Count			9	14	49	30		
% of Total	0	0	8.8	13.7	48	29.4	0	0

200 Riffle	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Count	13	10	56	47	67	7		
% of Total	6.5	5	28	23.5	33.5	3.5	0	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5
1	50	50	60	40	40
2	40	50	50	40	30
3	50	40	40	60	50
4	50	30	30	40	40
5	70	50	50	40	50
6	30	20	15	20	30
7	40	50	40	50	60
8	40	50	60	50	30
9	30	20	30	20	40
10	30	30	50	30	20

Site: CR-9.1
Date: 9/28/2020

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	70	3	4	14	0.5	3	2	0.5	3
2	0	2	0	40	0.5	3	10	0.5	3
3	60	2	4	30	1	2	0	2	0
4	15	4	4	30	2	4	25	0.5	3
5	0	5	0	0	5	0	70	1	3
6	0	0.5	0	10	2	2	20	3	3
7	40	3	3	0	0.5	0	50	1	2
8	60	2	3	30	3	2	20	3	2
9	20	4	2	30	0.5	3	20	0.5	2
10	60	1	3	0	2	0	50	0.5	3
Average	32.5	2.7	2.3	18.4	1.7	1.9	26.7	1.3	2.4

Site: CR-16.7
Date: 9/30/2020
Notes: Transect 4 located near beaver lodge

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1		2	10	11	15	2		
2	3	5	4	10	11	7		
3	9	5	6	11	8	1		
4	19		1	4	12	4		
5		2	2	9	10	16	2	
6	3	7	7	7	11	5		
7	1	1	5	3	7	15	7	1
8		1	8	10	14	4	3	
9	8		1	5	19	5	2	
10	2		4	6	25	3		
Total	45	23	48	76	132	62	14	1
% of Total	11.2	5.7	12	19	32.9	15.5	3.5	0.2

200 Riffle Count	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
	5	12	37	36	86	25		
% of Total	2.5	6	18.4	17.9	42.8	12.4	0	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5
1	25	30	20	10	15
2	15	15	20	25	60
3	20	60	50	50	20
4	60	100	70	40	50
5	20	50	30	40	20
6	15	45	30	30	15
7	0	25	30	20	30
8	20	30	20	15	15
9	50	30	35	20	30
10	40	30	25	30	30

Site: CR-16.7
Date: 9/30/2020

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	0	2	0	10	4	2	15	4	2
2	0	5	0	0	5	0	0	5	0
3	0	0	0	30	1	3	15	3	3
4	0	0	0	10	4	2	0	0	0
5	0	5	0	0	5	0	0	5	0
6	25	2	3	15	4	2	0	2	0
7	15	1	2	60	0.5	3	30	3	3
8	0	4	0	0	1	0	25	3	2
9	0	0	0	5	2	2	15	3	2
10	0	5	0	5	1	2	20	1	2
Average	4	2.4	0.5	13.5	2.8	1.6	12	2.9	1.4

Site: CR-28.2
Date: 9/28/2020
Notes:

Transect Substrate Count

Transect	**Fines <2mm**	**Sm. Gravel 2-8mm**	**Gravel 8-64mm**	**Sm. Cobble 64-128mm**	**Cobble 128-256mm**	**Sm. Boulder 256-512mm**	**Boulder >512mm**	**Bedrock Bedrock**
1			7	3	24	6		
2	1		11	3	22	3		
3		3	14		18	5		
4		3	9		21	7		
5	3	2	6		22	7		
6	2		5	7	23	3		
7	4		5	10	15	6		
8	10	2	4	9	12	3		
9	3	2	9	9	15	2		
10	8	2	2	7	15	6		
Total	31	14	72	48	187	48	0	0
% of Total	7.8	3.5	18	12	46.8	12	0	0

200 Riffle	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Count	4	9	39	49	63	35	1	
% of Total	2	4.5	19.5	24.5	31.5	17.5	0.5	0

Embeddedness

Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**
1	55	40	40	40	30
2	60	70	60	70	60
3	70	50	40	50	50
4	50	30	60	40	40
5	60	50	60	60	30
6	50	40	60	40	50
7	50	50	40	50	50
8	50	40	50	50	50
9	40	50	40	30	30
10	40	70	50	50	50

Site: CR-28.2
Date: 9/28/2020

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	20	0.5	2	0	0	0	0	0	0
2	20	1	2	70	0.5	3	90	0.5	4
3	30	0.5	2	0	3	0	40	0.5	3
4	10	0.5	1	15	0.5	2	0	0.5	0
5	30	0.5	2	80	0.5	3	15	0.5	1
6	80	0.5	2	50	0.5	2	90	0.5	4
7	40	0.5	2	25	0.5	2	25	0.5	3
8	90	0.5	5	90	1	4	50	0.5	4
9	35	0.5	3	2	5	1	70	4	4
10	0	5	0	80	0.5	4	20	4	4
Average	35.5	1	2.1	41.2	1.2	2.1	40	1.2	2.7

Site: CR-31
Date: 9/29/2020
Notes:

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1	2	1	9	15	11	2		
2	3	2	4	5	23	3		
3	2		2	6	24	6		
4			2	4	25	8		
5	3	2	6	9	19	1		
6	4	1	4	4	20	7		
7	4		4	8	18	6		
8	5	1	9	12	10	3		
9	1		2	7	17	13		
10	3	3	2	5	24	3		
Total	27	10	44	75	191	52	0	0
% of Total	6.8	2.5	11	18.8	47.9	13	0	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	20	20	10	15	15	16.0
2	20	35	15	20	20	22.0
3	15	15	20	20	20	18.0
4	10	15	10	25	15	15.0
5	20	20	30	20	25	23.0
6	20	20	20	20	40	24.0
7	30	15	20	20	15	20.0
8	30	30	20	15	25	24.0
9	15	30	45	20	20	26.0
10	40	20	30	30	70	38.0

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	15	0.5	2	0	5	0	0	5	0
2	0	0.5	0	0	0.5	0	0	0.5	0
3	0	0.5	5	0	0.5	0	0	0.5	0
4	0	0.5	5	0	0.5	5	0	0.5	4
5	0	2	0	10	2	2	20	3	4
6	15	4	4	10	3	4	10	3	4
7	20	2	3	15	4	3	30	3	3
8	0	3	0	15	4	2	5	4	2
9	5	3	1	20	3	4	0	3	0
10	0	1	0	10	2	3	20	3	3
Average	5.5	1.7	2	8	2.5	2.3	8.5	2.6	2

Site: F-9

Date: 9/25/2020

Notes:

Spawning Bed Count	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
	5	9	20	37	27	2		
% of Total	2.5	4.5	10	18.5	13.5	1	0	0

200 Riffle Count	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
	6	7	43	58	80	6		
% of Total	3	3.5	21.5	29	40	3	0	0

Site: FR-12.4
Date: 9/29/2020
Notes: Substrate somewhat compacted

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1		3	8	18	10	1		
2		4	5	12	15	4		
3	2	12	7	13	6			
4	1	11	9	15	4			
5	10	2	7	15	4	2		
6	2	1	7	12	14	4		
7	3	1	8	8	14	6		
8	5	1	7	6	11	10		
9	4	5	9	3	8	10	1	
10	8	1	7	4	12	8		
Total	35	41	74	106	98	45	1	0
% of Total	8.8	10.3	18.5	26.5	24.5	11.3	0.3	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	20	10	15	25	25	19.0
2	30	40	40	30	30	34.0
3	30	30	30	40	40	34.0
4	30	30	40	40	35	35.0
5	30	60	50	50	60	50.0
6	35	50	30	50	60	45.0
7	30	40	20	30	30	30.0
8	50	30	40	30	20	34.0
9	30	30	25	30	25	28.0
10	50	50	50	40	60	50.0

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	0	4	0	40	0.5	3	10	0.5	2
2	0	2	0	0	2	0	0	1	0
3	0	1	0	5	2	2	10	2	1
4	0	0.5	0	0	2	0	0	3	0
5	0	0	0	0	0	3	0	2	0
6	10	2	2	20	0.5	4	15	0.5	1
7	0	1	0	15	2	2	0	2	0
8	0	2	0	0	3	0	0	3	0
9	0	2	0	0	2	0	0	1	0
10	0	1	0	0	1	0	0	1	0
Average	1	1.6	0.2	8	1.5	1.4	3.5	1.6	0.4

Site: FR-14
Date: 9/29/2020
Notes: While some movement of rocks on surface, deeper rocks are very embedded and armored

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1	1	4	8	10	9	8		
2		2	5	10	14	8	1	
3		3	4	11	14	8		
4	1	6	5	10	12	6		
5		3	7	6	14	10		
6	4	3	1	6	16	10		
7	3	2	3	5	12	15		
8	2	3	5	8	11	11		
9	2	1	4	7	17	9		
10	2	3	4	8	18	5		
Total	15	30	46	81	137	90	1	0
% of Total	3.8	7.5	11.5	20.3	34.3	22.5	0.3	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	70	20	25	30	20	33.0
2	20	20	20	20	20	20.0
3	30	30	35	30	20	29.0
4	45	60	50	50	40	49.0
5	40	30	40	30	30	34.0
6	40	50	50	50	40	46.0
7	40	30	40	50	40	40.0
8	30	40	50	50	60	46.0
9	60	50	40	60	30	48.0
10	30	30	40	50	30	36.0

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	15	2	3	30	4	2	20	2	2
2	10	0.5	2	20	2	2	0	0.5	0
3	10	3	1	10	1	1	10	1	1
4	0	3	0	10	2	1	15	1	2
5	0	3	0	0	2	0	15	3	2
6	5	2	3	0	2	0	10	1	2
7	0	1	0	15	1	2	0	1	0
8	5	2	2	0	2	0	0	2	0
9	0	2	0	0	2	0	0	2	0
10	10	1	2	5	0.5	2	2	1	1
Average	5.5	2	1.3	9	1.9	1	7.2	1.5	1

Site: FR-15
Date: 9/29/2020
Notes: Possibly a redd at T7

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1		6	7	10	12	4		
2	2	4	6	7	12	9		
3	2	3	5	7	18	5		
4	2	2	5	10	16	5		
5		3	10	14	11	2		
6	2	1	2	7	18	9	1	
7			7	10	14	9		
8	14	1	7	8	8	1	1	
9	9	3	7	6	11	4		
10		1	4	8	13	14		
Total	31	24	60	87	133	62	2	0
% of Total	7.8	6	15	21.8	33.3	15.5	0.5	0

200 Riffle Count	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
	7	13	37	41	67	35		
% of Total	3.5	6.5	18.5	20.5	33.5	17.5	0	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	15	15	15	20	15	16.0
2	20	15	20	15	30	20.0
3	20	20	20	30	20	22.0
4	30	20	20	25	20	23.0
5	15	20	15	15	20	17.0
6	30	40	30	50	50	40.0
7	20	25	30	30		26.3
8	70	100	100	100	100	94.0
9	100	20	30	80	100	66.0
10	30	20	30	30	30	28.0

Site: FR-15
Date: 9/29/2020

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	15	0.5	2	0	3	0	20	2	3
2	20	3	2	0	2	0	5	1	2
3	0	2	0	10	2	2	0	2	0
4	0	2	0	0	1	0	0	1	0
5	2	1	2	5	0.5	2	0	2	0
6	15	2	2	0	3	0	0	2	0
7	0	3	0	0	2	0	0	2	0
8	15	2	2	15	2	2	0	0	0
9	0	0	0	5	2	2	0	0	0
10	0	1	0	0	2	0	0	2	0
Average	6.7	1.7	1	3.5	2	0.8	2.5	1.4	0.5

Site: FR-20
Date: 9/30/2020
Notes: Beaver pond between T5 and T6, lots of silt

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1			7	13	10	10		
2	3	4	1	11	9	8		
3	2		5	13	8	11	1	
4			9	15	11	5		
5	2		1	9	16	12		
6	3	4	14	6	7	5	1	
7	5		6	5	10	11	3	
8	10	2	3	5	13	7		
9	6	2	5	8	18	1		
10	2		10	14	9	4	1	
Total	33	12	61	99	111	74	6	0
% of Total	8.3	3	15.4	25	28	18.7	1.5	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	30	25	40	35	30	32.0
2	30	40	20	40	45	35.0
3	20	30	20	20	20	22.0
4	40	50	40	40	30	40.0
5	30	40	40	30	40	36.0
6	30	60	30	50	30	40.0
7	30	40	70	40	30	42.0
8	30	70	40	40	30	42.0
9	50	70	80	70	50	64.0
10	30	20	40	20	20	26.0

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	0	3	0	0	3	0	5	3	2
2	0	0	0	0	1	0	0	2	0
3	0	2	0	0	2	0	5	2	2
4	0	2	0	0	2	0	0	2	0
5	0	2	0	0	2	0	0	2	0
6	0	3	0	0	0	0	0	2	0
7	0	2	0	0	1	0	0	0	0
8	0	0	0	0	3	0	0	3	0
9	0	0.5	0	0	0	0	0	0	0
10	0	1	0	0	3	0	0	1	0
Average	0	1.6	0	0	1.7	0	1	1.7	0.4

Site: FR-23.2
Date: 9/30/2020
Notes: Beaver dam at top

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1	5	6	4	14	7	4		
2	1	7	4	6	10	5	7	
3	5	4	6	6	5	5	9	
4	4	8	14	6	6	1	1	
5	10	1	5	4	11	4	5	
6	11	1	5	7	10	5	1	
7	6	2	4	8	15	3	2	
8	6	1	5	5	6	9	8	
9	2	5	5	4	14	6	4	
10	1	6	8	5	9	9	2	
Total	51	41	60	65	93	51	39	0
% of Total	12.8	10.3	15	16.3	23.3	12.8	9.8	0

200 Riffle Count	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
	3	4	26	44	71	41	13	
% of Total	1.5	2	12.9	21.8	35.1	20.3	6.4	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	20	30	15	20	30	23.0
2	20	20	35	40	45	32.0
3	60	30	40	50	50	46.0
4	20	15	20	30	20	21.0
5	30	30	30	40	20	30.0
6	50	50	60	40	40	48.0
7	40	35	60	30	20	37.0
8	30	30	20	60	30	34.0
9	20	30	30	45	40	33.0
10	40	50	50	30	45	43.0

Site: FR-23.2
Date: 9/30/2020

Algae Data

Transect	**25% Fil. Cover**	**25% Diatom Thickness**	**25% Fil. Thickness**	**50% Fil. Cover**	**50% Diatom Thickness**	**50% Fil. Thickness**	**75% Fil. Cover**	**75% Diatom Thickness**	**75% Fil. Thickness**
1	5	0.5	2	5	0.5	2	0	0.5	0
2	5	0.5	2	0	0.5	0	0	3	0
3	0	1	0	5	2	2	20	0.5	2
4	0	0	0	0	0.5	0	0	0	0
5	5	0	2	10	1	2	0	0.5	0
6	10	0.5	2	5	0.5	2	30	0.5	4
7	15	0	2	100	0.5	4	90	0.5	4
8	10	0.5	4	30	0.5	3	0	0.5	0
9	30	1	4	0	1	0	0	1	0
10	60	0.5	4	20	1	4	10	0.5	3
Average	14	0.5	2.2	17.5	0.8	1.9	15	0.8	1.3

Site: FR-25.1
Date: 9/30/2020
Notes: Site shortened due to culvert

Transect Substrate Count

Transect	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
1	1	3	1		1	9	25	
2	14	5	5	3	8	4	1	
3			1	1	4	12	22	
4	6	2	4	2	4	15	7	
5	6	1	3	2	2	5	21	
6			4	4	8	7	17	
7	1	1	3	5	5	9	16	
8	6		2		1	6	25	
9	3		2	2	5	13	15	
10	4		1	2	2	9	22	
Total	41	12	26	21	40	89	171	0
% of Total	10.3	3	6.5	5.3	10	22.3	42.8	0

Embeddedness

Transect	Emb. 1	Emb. 2	Emb. 3	Emb. 4	Emb. 5	Avg.
1	30	40	40	40	40	38.0
2	30	45	50	50	70	49.0
3	60	20	40	30	40	38.0
4	30	45	30	20	30	31.0
5	20	40	30	40	30	32.0
6	40	40	30	40	30	36.0
7	50	30	30	40	40	38.0
8	30	40	40	30	40	36.0
9	50	30	30	40	40	38.0
10	30	55	40	30	30	37.0

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	0	0.5	0	0	0.5	0	0	0.5	0
2	0	0.5	0	0	1	0	0	0.5	0
3	0	0	0	0	0.5	0	0	0.5	0
4	0	0.5	0	0	1	0	0	0.5	0
5	0	1	0	0	1	0	0	1	0
6	0	0	0	0	1	0	0	1	0
7	0	1	0	0	2	0	0	0.5	0
8	0	0	0	0	0.5	0	0	0.5	0
9	0	0.5	0	0	0	0	0	0.5	0
10	0	0.5	0	0	0.5	0	0	1	0
Average	0	0.5	0	0	0.8	0	0	0.7	0

Site: RC-1.1
Date: 9/30/2020
Notes:

Transect Substrate Count

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	4	2	10	15	7	2		
2	1	6	11	11	6	4	1	
3	3	4	12	18	3			
4	4	10	14	7	3	2		
5	9	1	9	14	4	3		
6	5	2	4	7	16		6	
7	7	2	10	4	15		2	
8	6	1	7	8	12		6	
9	10	2	9	14	5			
10	3	4	15	12	6			
Total	52	34	101	110	77	11	15	0
% of Total	13	8.5	25.3	27.5	19.3	2.8	3.8	0

200 Riffle Count	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
	11	18	58	69	39	4	1	
% of Total	5.5	9	29	34.5	19.5	2	0.5	0

Embeddedness

Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	40	40	30	35	30	35.0
2	20	40	20	20	50	30.0
3	30	30	20	50	40	34.0
4	30	80	60	20	60	50.0
5	40	30	60	50	50	46.0
6	60	70	70	60	40	60.0
7	80	80	90	60	50	72.0
8	30	40	25	70	80	49.0
9	40	50	40	40	30	40.0
10	40	30	40	40	40	38.0

Site: RC-1.1
Date: 9/30/2020

Algae Data

Transect	25% Fil. Cover	25% Diatom Thickness	25% Fil. Thickness	50% Fil. Cover	50% Diatom Thickness	50% Fil. Thickness	75% Fil. Cover	75% Diatom Thickness	75% Fil. Thickness
1	0	2	0	0	2	0	0	1	0
2	0	1	0	0	0.5	0	0	0.5	0
3	0	1	0	0	2	0	0	2	0
4	0	0	0	0	0	0	10	0.5	2
5	0	0.5	0	0	0.5	0	0	1	0
6	0	0.5	0	0	3	0	0	3	0
7	0	2	0	5	2	3	10	3	2
8	0	2	0	15	1	2	10	1	1
9	5	2	1	0	2	0	0	3	0
10	0	0.5	0	0	3	0	10	1	1
Average	0.5	1.2	0.1	2	1.6	0.5	4	1.6	0.6

Site: RC-2
Date: 10/1/2020
Notes:

Spawning Bed Count	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
	5	33	46	14	3			
% of Total	5	32.7	45.5	13.9	3	0	0	0

200 Riffle Count	Fines <2mm	Sm. Gravel 2-8mm	Gravel 8-64mm	Sm. Cobble 64-128mm	Cobble 128-256mm	Sm. Boulder 256-512mm	Boulder >512mm	Bedrock Bedrock
	32	23	90	50	5			
% of Total	16	11.5	45	25	2.5	0	0	0

Appendix B   Long-term Flow Data

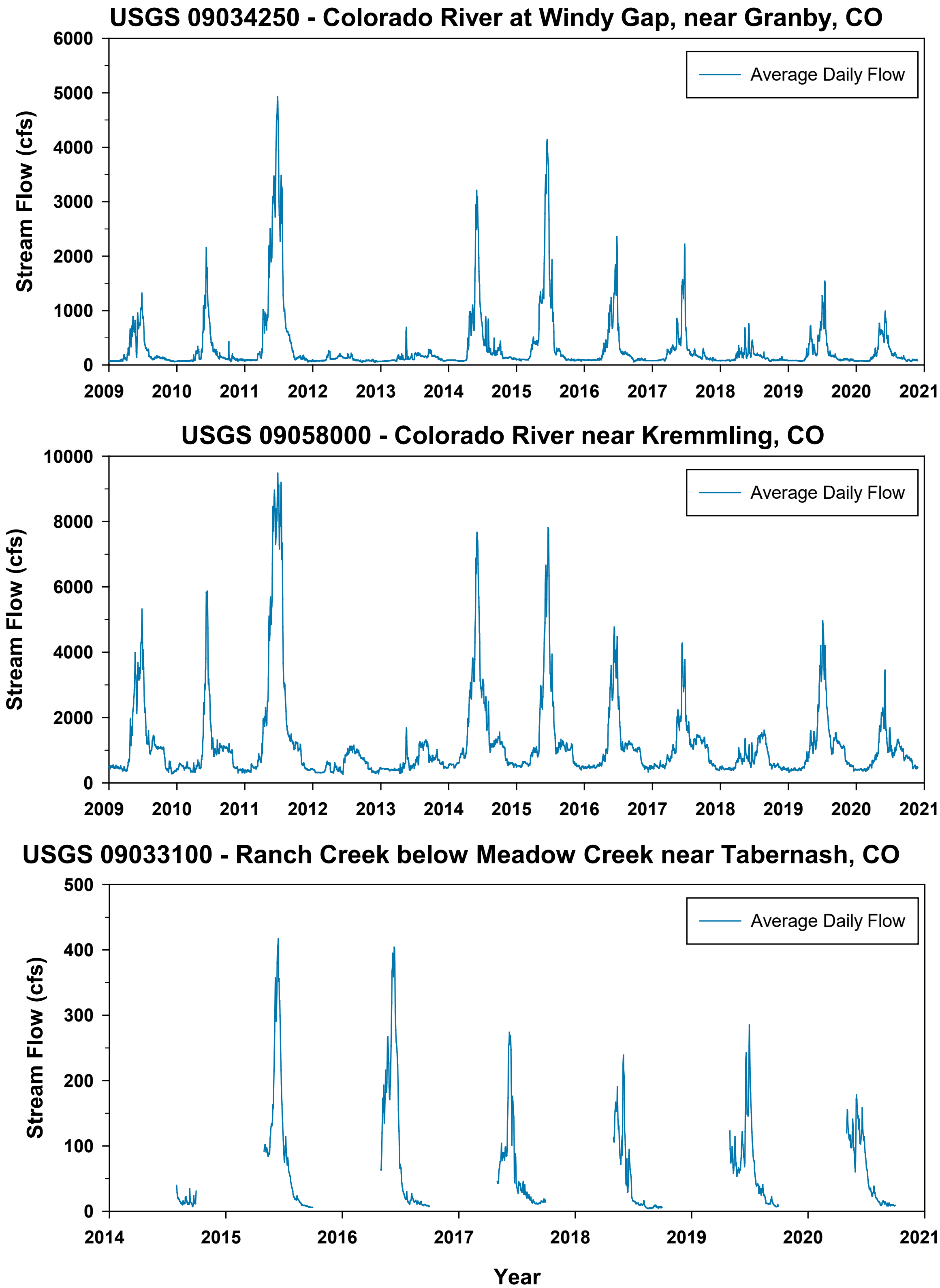

Figure 7-1: Average daily flow data for USGS stream gages on the Colorado River and Ranch Creek in Grand County, CO.

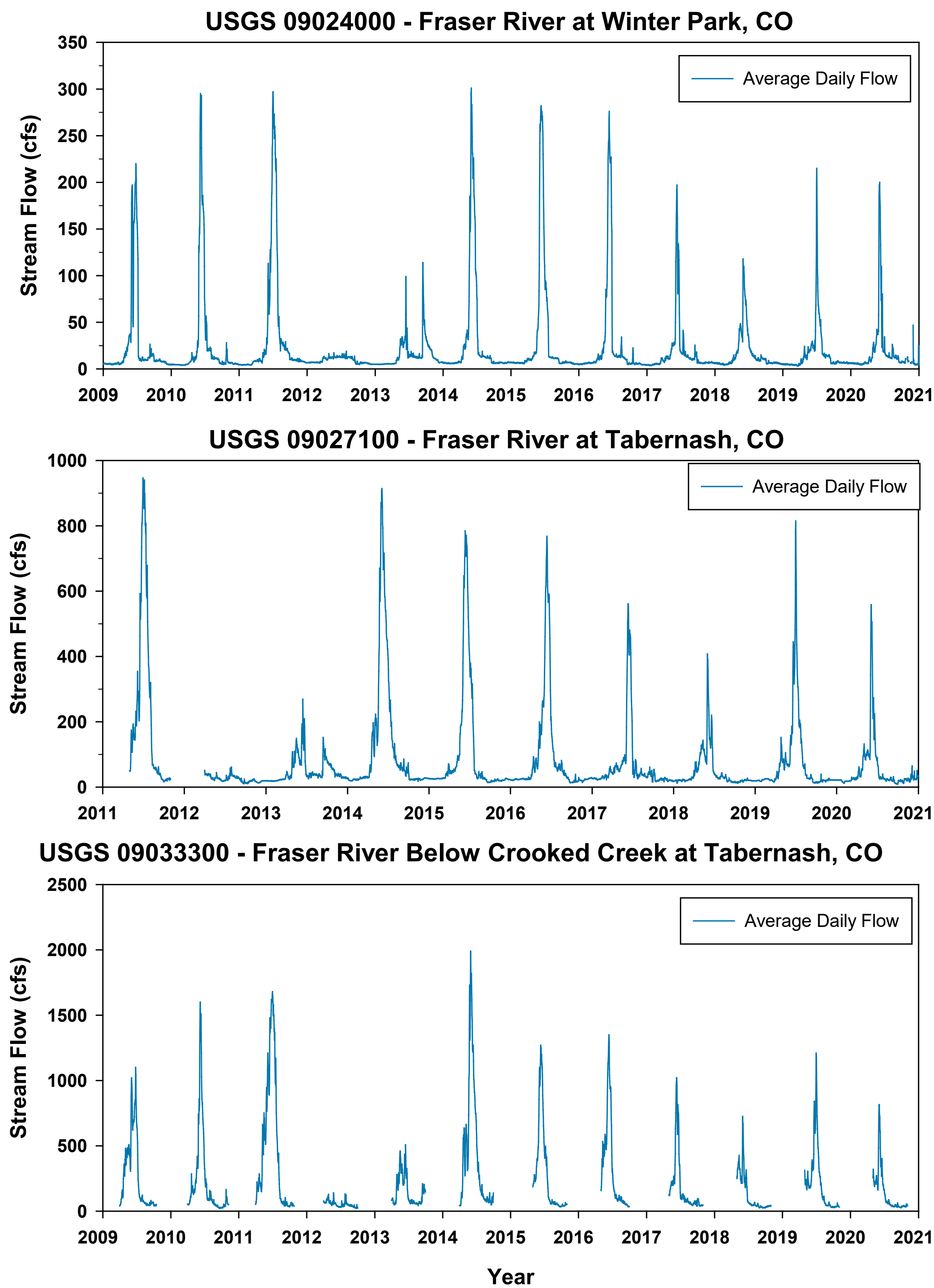

Figure 7-2: **Average daily flow data for USGS stream gages on the Fraser River in Grand County, CO.**

Appendix C 2019 Pebble Count Data

Table 7-1: Percent average substrate size classes at all sites sampled in 2019.

Sites	Substrate Size Categories							
	Fines	Small Gravel	Gravel	Small Cobble	Cobble	Small Boulder	Boulder	Bedrock
	<2 mm	2-8 mm	8-64 mm	64-128 mm	128-256 mm	256-512 mm	>512mm	
CR-1.7	65.8	13.8	6.5	5.8	7.0	1.3	0.0	0.0
CR-7.4	25.7	5.5	33.9	27.7	7.2	0.0	0.0	0.0
CR-9.1	12.0	1.7	17.7	27.2	38.7	2.7	0.0	0.0
CR-16.7	12.3	3.8	23.5	27.0	26.0	4.0	2	1.5
CR-22.9	4.1	2.7	15.2	20.7	46.0	10.6	0.7	0.0
CR-28.7	5.8	3.5	16.1	27.9	36.4	10.3	0.0	0.0
CR-31	5.5	3.3	18.8	32.0	29.0	11.5	0.0	0.0
FR-1.9	8.8	3.8	22.8	35.8	22.3	6.5	0.0	0.0
FR-14	5.9	5.1	23.3	26.2	30.9	8.1	0.5	0.0
FR-15	13.4	2.5	21.3	24.3	22.3	13.6	2.5	0.0
FR-20	15.5	4.0	18.0	28.8	17.3	11.8	4.8	0.0
FR-23.2	4.7	2.5	24.6	35.2	28.3	3.5	1.2	0.0
FR-25.1	8.5	3.0	7.2	8.2	8.0	14.7	50.4	0.0
RC-1.1	21.0	4.5	24.0	27.0	17.5	2.5	3.5	0.0