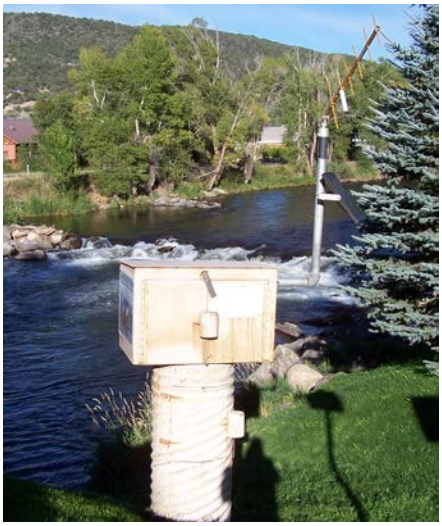
ROARING FORK WATERSHED STREAM GAGE NEEDS WORKSHOP

(April 20, 2012 Aspen)

SUMMARY REPORT

May 22, 2012



The Roaring Fork Watershed gaging initiative is a project of Friends of Rivers and Renewables (FORR). FORR is an initiative of Public Counsel of the Rockies and was formed to support continued community involvement in the development of regional smart water and clean energy projects. Please visit our website www.FORRaspen.com to learn more about all our emerging projects.

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NEXT STEPS

A draft report was provided to all participants in the April 20 meeting (identified in appendix 3), and other stakeholders. FORR requested that each recipient of the draft report review its contents (specifically notes pertaining to each priority reach) and provide any additional data to "fill in the blanks."

After comments were received and incorporated into this document, FORR and Roaring Fork Conservancy engaged technical experts to further analyze and refine stream gage placement, potential gage technology and data relay/transmission options for each location, including opportunities to co-locate additional data sensors to existing USGS, CDWR, CWCB and BOR gaging stations. They also assessed the potential cost (capital and maintenance) for proposed technologies.

During this same period, FORR worked to:

- Further investigate public and private funding opportunities,
- Evaluate examples of other gage networks in other watersheds, and
- Continue outreach to valley municipalities, water districts, and other interested stakeholders.

INTRODUCTION

Demands for water for municipal uses, irrigation, recreation (including snowmaking) and energy production put pressure on both the quantity and quality of water in the Roaring Fork watershed. These demands, coupled with growing population and climate change in the decades ahead, make it essential that we develop a comprehensive system of stream gages to inform the wise management and long-term conservation of local rivers and streams.

The Roaring Fork Watershed's operational and historic stream gages have been installed by different agencies for different purposes[1]. The oldest gage in the watershed, located on the lower Roaring Fork River, was installed in 1905. There is a need to review and assess the performance and value of existing gages, and identify new stream monitoring needs, to create an intelligent, interactive and useful gaging network that will support immediate and long-term water management and conservation goals. Federal and state agencies, local governments and conservation organizations in the Roaring Fork Watershed have expressed keen support for such an effort. Furthermore, the 2012 Roaring Fork Watershed Management Plan sponsored by the Ruedi Water and Power Authority and their lead consultant, Roaring Fork Conservancy, identified the creation and maintenance of an adequate network of stream gages in the watershed as a "high priority".[2]

A comprehensive stream gaging network provides hydrologic information needed to help define, use, and manage the region's water resources. An integrated gaging network provides a continuous, well documented, well-archived, unbiased, and broad-based source of reliable water data that may be used for a variety of purposes including the assessment of the health of these ecosystems, a basis for evaluating potential new diversions and impacts, and opportunities for wise restoration or mitigation. For more uses of stream flow data see Appendix 2.

Friends of Rivers and Renewables (FORR) has assumed the role of catalyzing, organizing and coordinating public and private involvement in an effort to design and implement a basin-wide system of stream gages. These gages will monitor flows and other indices of stream health in threatened or impaired reaches in the Roaring Fork Watershed. FORR will also coordinate the collection and distribution of real-time data

[1] Appendix 1 is the current list of operational and historic gages in the Roaring Fork Watershed maintained by Roaring Fork Conservancy.

[2] The plan identified the following: Highest priorities for stream gages in the watershed are: (1) Castle and Maroon creeks, (2) the Lower Crystal River (year-round), (3) the Upper Roaring Fork, and (4) tributaries in the Upper Fryingpan. Second order and higher streams in the watershed with significant diversions and no active stream gage or no gage located below the major diversion structures include: Brush, Fourmile, Threemile, Cattle, Woody, Sopris, Capitol, Maroon, Owl, Landis and Thompson creeks. Several creeks with by-pass flows associated with the Fry-Ark Project are not gaged. Gages at Cattle, Fourmile, Maroon, Thompson, Castle Lime, Cunningham, Middle Cunningham, Mormon, Carter, Granite, Sawyer, and Lily Pad creeks are no longer operating.

from this network of gages so that it is available and useful to all interested parties through the Colorado Data Sharing Network or on USGS and other agency websites. By identifying technological approaches that are cost-effective and efficient in streamlining and integrating the collection of stream data, FORR hopes to demonstrate that accurate, useful and defensible stream flow data can be acquired within a reasonable timeframe and budget. At the same time, FORR hopes this collaborative planning process will generate broad public support for efforts to understand and improve the management of scarce water resources.

GOALS

By introducing state-of-the-art technologies for real time river monitoring, local government agencies, elected leaders, conservation organizations, citizen advisory boards, and other concerned stakeholders will have information they need to better assess the health of our rivers and streams. With this knowledge will come the ability to manage and protect these resources far more effectively in the face of increasing and competing demands for water.

Some of the specific **GOALS** for developing such a stream gaging network include:

1) enhancing legal and administrative accountability;

2) capturing critical water quality data and linking flows to quality;

3) identifying water conservation and instream flow protection opportunities (drought mitigation);

4) demonstrating cost-effective technologies for data collection that can provide alternatives to traditional gaging approaches and can be replicated in other locations;

5) identifying gaging priorities among different agencies, municipalities and utilities, and understanding where they overlap;

6) demonstrating the feasibility and efficiency of 3rd party agreements, e.g., a qualified hydrographer in the Roaring Fork Watershed employed by Pitkin County Rivers Board or Roaring Fork Conservancy to maintain a net of additional gages using USGS or other protocols and ensuring broad access to these data; and

7) demonstrating regional responsibility for monitoring and improving instream flows “in our own backyard.”

BACKGROUND

On April 20, 2012 FORR convened experts from public agencies, private hydrology and consulting firms, and water management and conservation organizations to work together to identify the first tier of priority sites in the Roaring Fork Watershed (see Appendix 3 for a list of meeting participants).

Prior to this meeting FORR conducted individual meetings and/or phone consultations with meeting participants; relevant agencies, regional municipalities and water districts; and gaging and watershed experts to compile a broad list of 16 imperiled reaches in the Roaring Fork Watershed. See Appendix 4 for the complete list of pre-identified reaches.

A state-of-the-art watershed map was developed for the project, showing historic and existing gaging stations, land ownership, diversions, and responsibility for gage monitoring and maintenance. Using this map, the group discussed specific gaging needs and opportunities for the pre-identified reaches. The participants were asked to rank each reach in order of priority concern.

Based upon this ranking, FORR selected the eight highest ranked reaches to be the "first tier" of priority gages to be addressed. The purpose of this report is to provide further analysis of the stream gage development potential for these eight sites. Specifically, FORR will coordinate efforts of experts and stakeholders to understand:

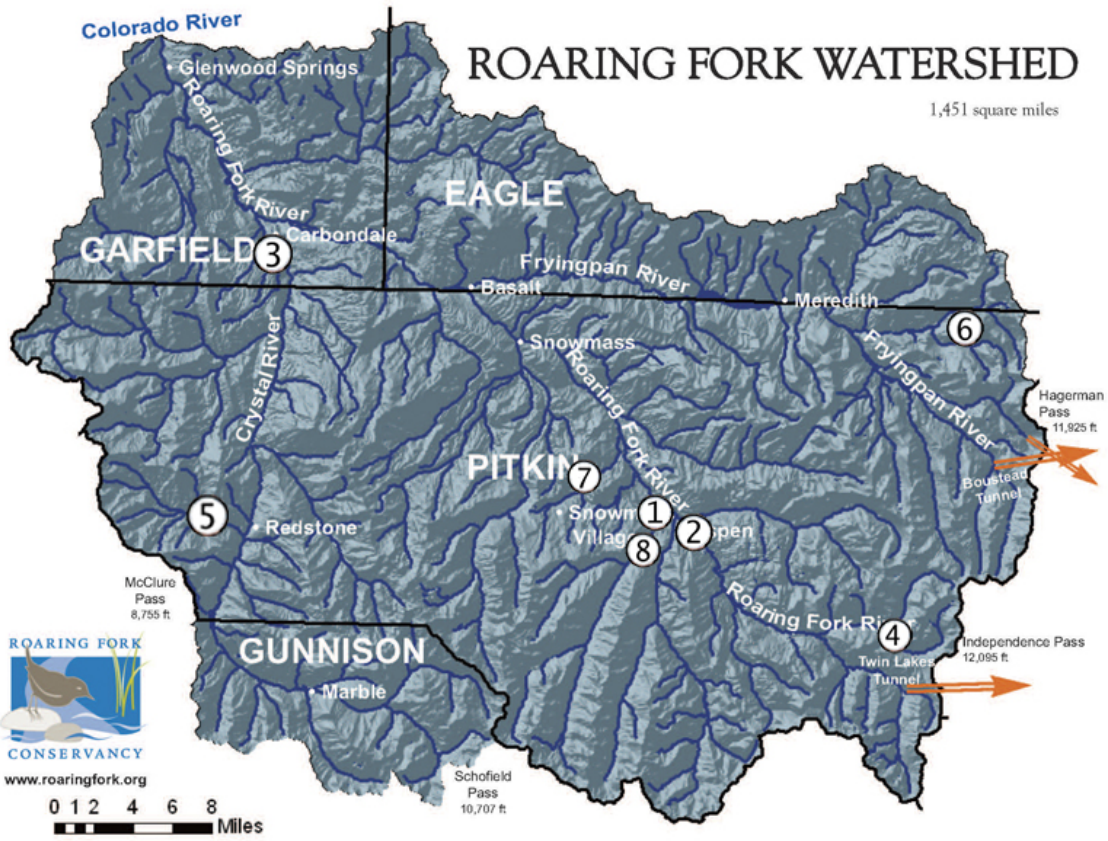
1) the data to be collected, as well as the timing and duration of monitoring, in each location based on potential uses of the data, e.g., water rights administration and accountability, water quality compliance, stream health, etc.,
2) technology options to accomplish data collection,
3) existing as well as potential funding sources for installation and maintenance of gages,
4) opportunities for public/private partnerships in implementing and funding this gaging net, and
5) data dissemination, including to water quality agencies such as Colorado Department of Public Health and the Environment and U.S. EPA if located on a State 303 (D) listed reach, and the Colorado River Water Conservation District.

FORR would like to thank all the individuals, agencies, and municipalities who contributed information and expert knowledge and to all the participants who were able to attend our April 20th meeting. A special thanks to Sharon Clarke and the Roaring Fork Conservancy for their expert involvement and enthusiasm throughout this project and in the preparation of this report.

This report will be distributed to all meeting attendees and interested stakeholders.

PRIORITY REACH DESCRIPTION

Assessment of Top Eight Priority Reaches[3]



1) Maroon Creek below Stapleton Ditch
2) Roaring Fork River near Aspen ("suite of gages")
3) Lower Crystal River (above fish hatchery)
4) Roaring Fork River near Lost Man
5) Coal Basin
6) Fryingpan-Arkansas Project Ungaged Bypass Flows
7) Brush Creek
8) Maroon Creek (below COA municipal diversion)

[3] See Appendix 4 for a complete listing of discussed stream reaches and meeting participants' priority ranking of those reaches.

Maroon Creek below Stapleton Ditch & Maroon Creek below COA municipal diversion

Middle Roaring Fork River Sub-watershed; Pitkin County

DESCRIPTION OF NEED:
Year round flow monitoring would allow the Colorado Division of Water Resources (CDWR) to administer a call placed by the Colorado Water Conservation Board (CWCB) to meet their instream flow (ISF) right. For this reason, stream flow gage technology must meet state standards. This site would also assist in the monitoring of the City of Aspen's (COA) municipal diversions.

DESCRIPTION OF REACH:
Pitkin County
From State of the Roaring Fork Watershed 2008:

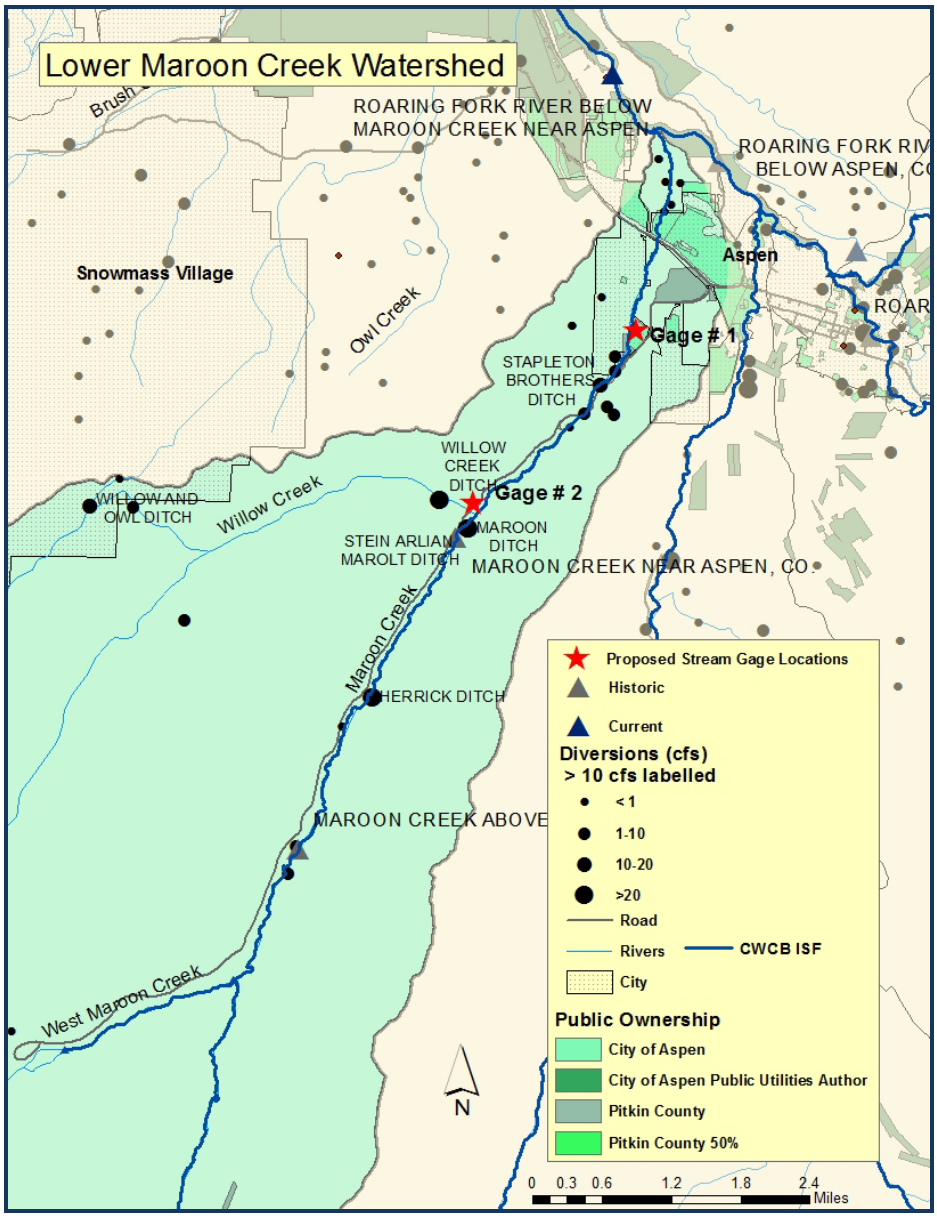
- Flows on Lower Maroon Creek (evaluated at lower historical gage site) has decreased 15-20 percent from October to April compared to pre-development flows.
- The greatest impacts on this reach are recreational activities/trails. Other contributors are weeds, development, and flow alteration.
- The riparian corridor is generally characterized as high quality.
- There is no heavily modified or severely degraded instream habitat. Of the sites surveyed, 14 percent was high quality, 49 percent slightly modified, and 31 percent moderately modified.
- There is no recent water quality data for Maroon Creek.
- Colorado Natural Heritage Program identified Lower Maroon-Castle Creek as a Potential Conservation Area and Maroon Creek was identified as a Conservation Area of Concern by Stream Health Initiative.
- The CWCB ISF right on Maroon Creek begins at the confluence of East and West Maroon Creeks and extends to the confluence with the Roaring Fork River. The ISF right was appropriated on January 14, 1976 for 14 cfs from Jan 1 to Dec 31.
- Maroon Creek had two historic USGS gages: Maroon Creek Near Aspen, CO.(9076000) that operated from 1/1/1911 to 5/31/1917 and Maroon Creek Above Aspen, CO. (9075700) that operated from 9/1/1969 to 9/30/1994 (locations are shown on the map). No gages are currently operating.

From other sources:

- In a Roaring Fork Watershed Water Quality Monitoring Plan prepared by David Brown, USGS (2012), a new water quality and water quantity site was identified on Maroon Creek (39 10 42.03 N, 106 51 41.35 W) to document water quality before significant urbanization. The data would be used for concentrations, trends, and loads. He recommended field physical and chemical properties, E. coli bacteria, low level nutrients, discharge, major ions, trace elements, and selenium be measured 6 times/year. There was no collection of continuous parameters recommended.
- There are no River Watch water quality monitoring sites on Maroon Creek.

- In 2009, Pitkin County entered into an agreement with CWCB to place 4.3 cfs in trust to contribute to instream flows in Maroon Creek. (http://www.aspendailynews.com/section/home/137663).
- Educational opportunities may exist in adjacent open space areas, partnering with the City of Aspen or Pitkin County Open Space and Trails.
- The City of Aspen is working with Colorado Department of Parks and Wildlife to conduct stream monitoring. The upper proposed gage site is below the Maroon Creek intake and should be located at or near the current stream monitoring site.

POTENTIAL FUNDING SOURCES:
CWCB, City of Aspen, Aspen Skiing Company, private



Roaring Fork River near Aspen ("suite of gages")

Upper Roaring Fork Sub-watershed; Pitkin County

DESCRIPTION OF NEED:

Workshop participants supported the idea of a "suite of gages" throughout this reach that extends through Aspen to Smith Way. These gages would monitor water quantity and quality.

Year round flow monitoring would allow the CDWR to administer a call placed by the CWCB to meet their instream flow right. For this reason, stream flow gage technology must meet state standards.

Because of the high visibility of this area, this suite of gages is ideally suited to provide education about water quantity and quality.

This suite of gages would allow the City of Aspen to monitor the effectiveness of their aggressive stormwater management activities.

DESCRIPTION OF REACH:

From the State of the Roaring Fork Watershed 2008:

- The upper Roaring Fork River's hydrologic regime has been dramatically altered with an average of 37 percent of the sub-watershed's yield diverted to the East Slope annually.
- Below the Roaring Fork near Aspen stream gage the combined impact of the Independence Pass Transmountain Diversion System (IPTDS) and inbasin diversions (including the senior 1904 Salvation Ditch diversions and several smaller in-basin diversions) create low flows in the late summer and early fall.
- A CWCB ISF right on the Roaring Fork River extends from the confluence with Difficult Creek to the confluence with Maroon Creek. The ISF right was appropriated on January 14, 1976 for 32 cfs from Jan 1 to Dec 31. Downstream a CWCB ISF right on the Roaring Fork River extends from the confluence with Maroon Creek to the confluence with the Fryingpan River. The ISF right was appropriated on November 8, 1985 for 55 cfs from April 1 to Sept 30 and 30 cfs from Oct 1 to March 31.

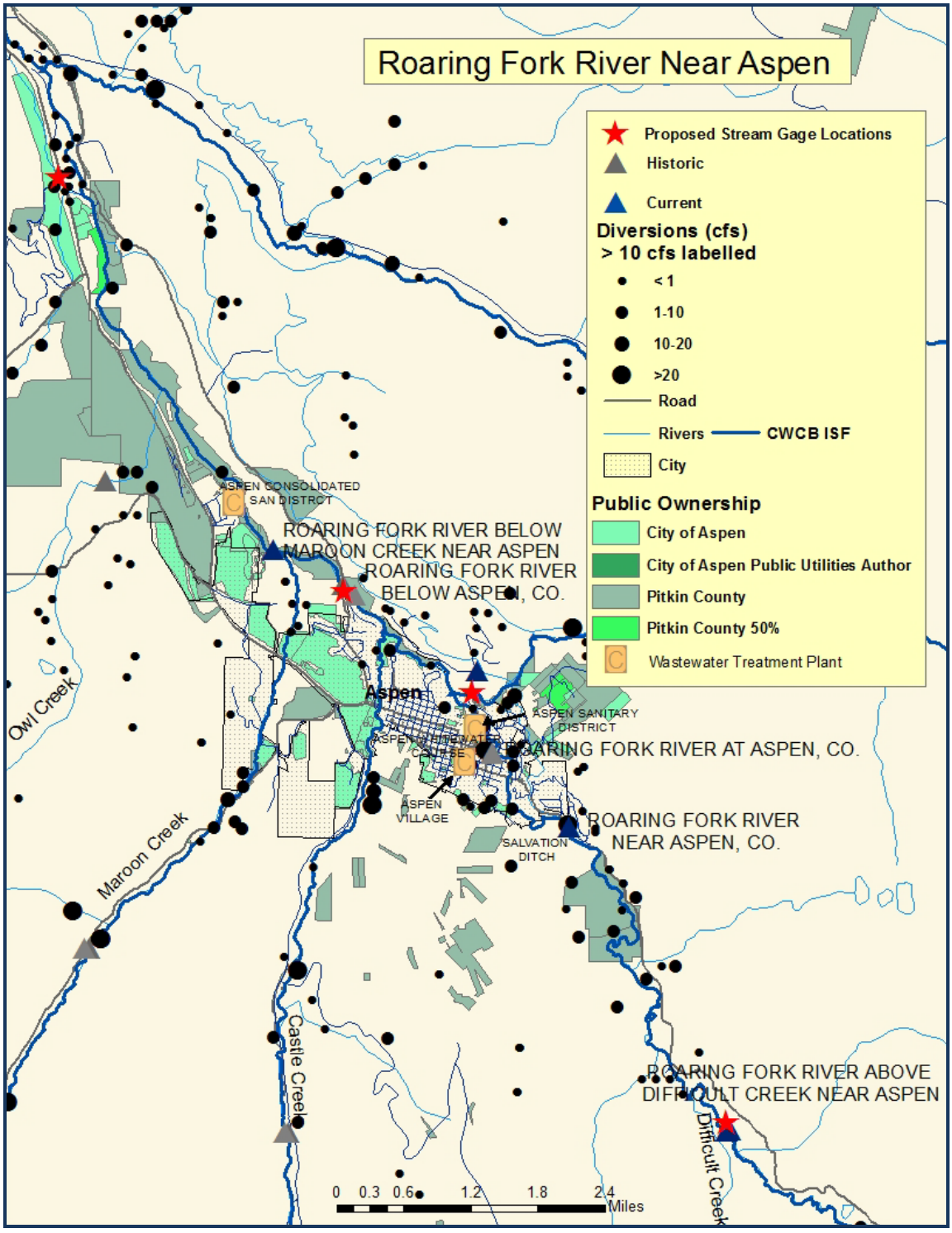
From other sources:

- The Roaring Fork River from the confluence with Hunter Creek to below the Brush Creek confluence is provisionally listed for aquatic life on the state's Section 303(D) list for impaired waters (CDPHE, 2012).
- In Roaring Fork Watershed Water Quality Monitoring Plan prepared by David Brown, USGS (2012) two water quality and stream gage sites were identified. One on the Roaring Fork River at Smith Way Road (39 15 31 N, 106 52 52.00 W; Below Aspen Metro Plaza) to evaluate urbanization and the upper portion of the Roaring Fork Watershed and also for regional assessment refinement. The data would be used for concentrations, trends, loads, water quantity, sediment loading, and surrogate development. He recommended field physical and chemical

properties, E. coli bacteria, low level nutrients, and discharge be measured 8/times year and major ions, trace elements, selenium, and suspended sediment be measured 6 times/year. The plan recommended installing a new streamflow gage that would collect continuous measurements of temperature, specific conductance, and sediment concentration. The other was located on the Roaring Fork above Difficult Creek at the USGS gage (09073300). The location is upstream of most human influences; and can be used to monitor the national forest and document water quality before significant urbanization. The data would be used for concentrations, trends, loads, and water quantity. He recommended field physical and chemical properties, E. coli bacteria, low level nutrients, discharge, major ions, trace elements, selenium, and discharge be measured 4 times/year. Continuous streamflow monitoring was recommended at this site.

- River Watch monitors water quality at three sites in this area: Roaring Fork River at Difficult Creek Campground (#769), at Mill Street Bridge (#770), and Slaughterhouse Bridge (#68). The first two are monitored 4 times a year and the last site is monitored every month. One gage is co-located with Site # 769 and proposed gages could be co-located with these monitoring sites.
- The closest operating stream gages are at the Roaring Fork River Near Aspen, CO above Aspen and the Salvation Ditch and the Roaring Fork River below Maroon Creek near Aspen. The location of these gages does not capture the lowest flow conditions seen in Aspen.
- RFC sampled Site # 68 and #770 for macroinvertebrates in the fall of 2011 and will partner with the City of Aspen's stormwater department to sample 4 sites in 2012.
- Educational opportunities may exist with the City of Aspen, Pitkin County and RFC.

POTENTIAL FUNDING SOURCES:
Pitkin County, Colorado River Water Conservation District, City of Aspen, Aspen Sanitation District.


Roaring Fork River Near Aspen
Proposed Stream Gage Locations
Historic
Current
Diversions (cfs)
> 10 cfs labelled
< 1
1-10
10-20
>20
Road
Rivers
CWCB ISF
City
Public Ownership
City of Aspen
City of Aspen Public Utilities Author
Pitkin County
Pitkin County 50%
Wastewater Treatment Plant
ASPEN CONSOLIDATED SAN DISTRICT
ROARING FORK RIVER BELOW MAROON CREEK NEAR ASPEN
ROARING FORK RIVER BELOW ASPEN, CO.
Aspen
ASPEN SANITARY DISTRICT
ASPEN WASTEWATER TREATMENT PLANT
ROARING FORK RIVER AT ASPEN, CO.
ASPEN VILLAGE
SALVATION DITCH
ROARING FORK RIVER NEAR ASPEN, CO.
Owl Creek
Maroon Creek
Castle Creek
ROARING FORK RIVER ABOVE DIFFICULT CREEK NEAR ASPEN
Difficult Creek
0 0.3 0.6 1.2 1.8 2.4
Miles

Lower Crystal River

Crystal River Sub-watershed; Garfield County

DESCRIPTION OF NEED:
Water quality and quantity need to be monitored throughout the year in the Lower Crystal. Currently, water quantity is measured seasonally and water quality is measured year-round downstream of the stream flow gage. The collection of water quantity and quality data in the Lower Crystal needs to be coordinated to maximize the utility of these data.

DESCRIPTION OF REACH:
From State of the Roaring Fork Watershed 2008:

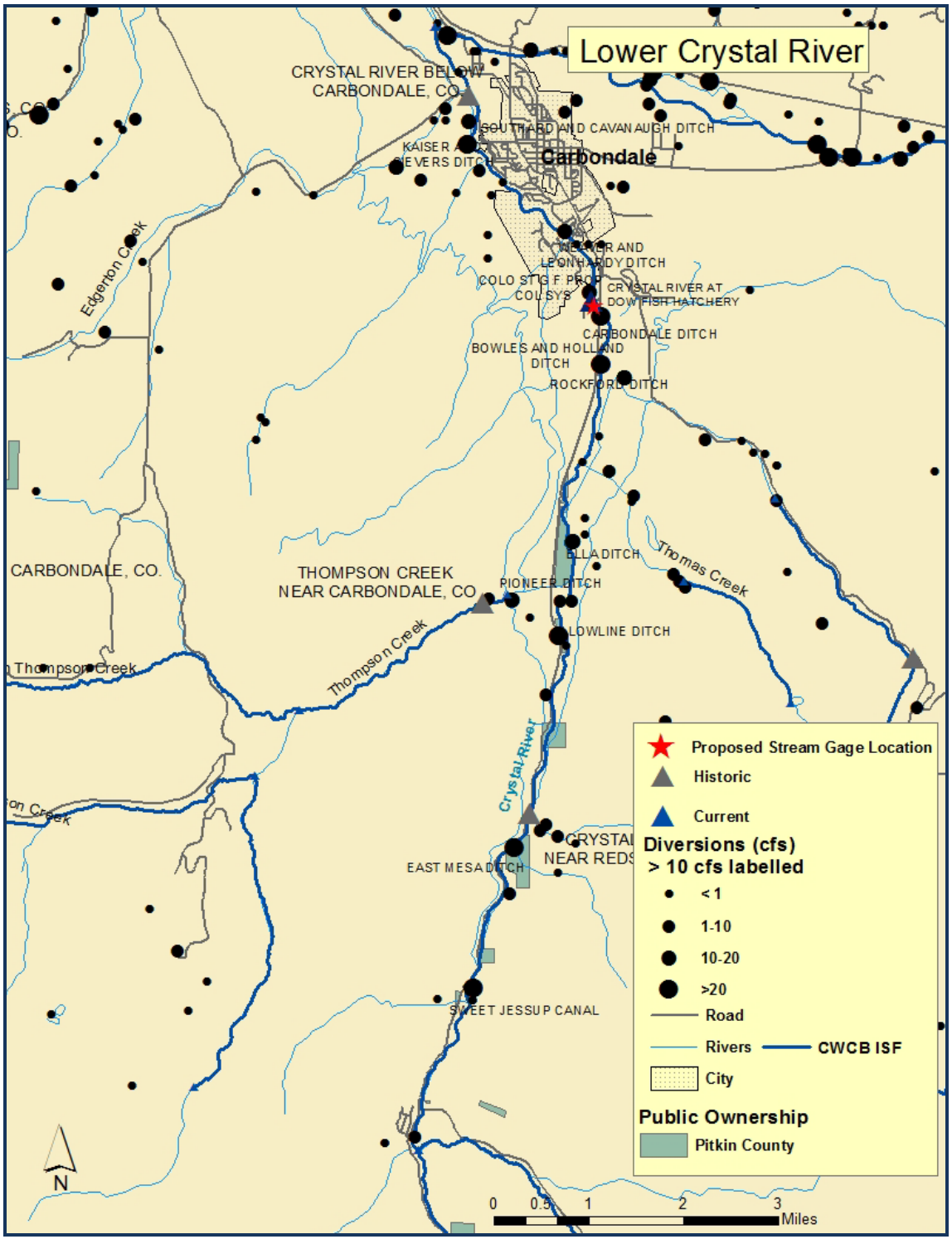
- Agricultural diversions decrease flow on the Crystal River in the late summer and fall.
- Grand River Consulting found there has been an irrigation shortage on the Crystal 27 percent of years from 1955 to 2000, with 22 percent of the years having shortages in September and 18 percent of the years having shortages in October.
- Grand River Consulting found instream flows below the CWCB ISF rights in 66 percent of years from 1955-2000. There were instream flow shortages in September 75 percent of those years and 44 percent of years in October.
- The stream gage was installed in 2006 by CDWR and CWCB. This gage allows the CWCB to better administer the lower Crystal River, including placing calls to meet CWCB ISF rights. The CWCB ISF right on the Lower Crystal River begins at Avalanche Creek and extends to the confluence with the Roaring Fork River. The ISF right was appropriated on May 1, 1975 for 100 cfs from May 1 to September 30 and 60 cfs from October 1 to April 30.

From other sources:

- In a Roaring Fork Watershed Water Quality Monitoring Plan prepared by David Brown, USGS (2012), a water quality and stream gage site was identified on the Lower Crystal River on CR 118. This site would be used to help identify potential agricultural influences on the Crystal River and refine the ability to bracket urban impacts. It would provide baseline information and integrate water quality impacts upstream of the Colorado Parks and Wildlife Fish Hatchery. The data would be used for concentrations, trends, loads, and water quantity. He recommended field physical and chemical properties, E. coli bacteria, low level nutrients, discharge, major ions, trace elements, and selenium be measured 4 times/year. Year round gaging was recommended.
- The current CDWR gage began operation in 2006 and operates seasonally (Apr-Sept). A USGS gage at the CRMS Bridge operated from 5/18/2000 to September 30, 2010.
- River Watch (Colorado Rocky Mountain School-CRMS) monitors water quality monthly at one site on the Lower Crystal River at the CRMS Bridge (#78). Another site at the Fish Hatchery (#75) was discontinued.
- RFC sampled Sites # 78 and #75 for macroinvertebrates in the fall of 2011 and is seeking a grant to resample these sites in 2012.

- Site # 78 is currently used as an educational River Watch site, with potential to further develop educational programs.

POTENTIAL FUNDING SOURCES:
Private, CWCB, CDWR, Town of Carbondale, Garfield County, CRMS

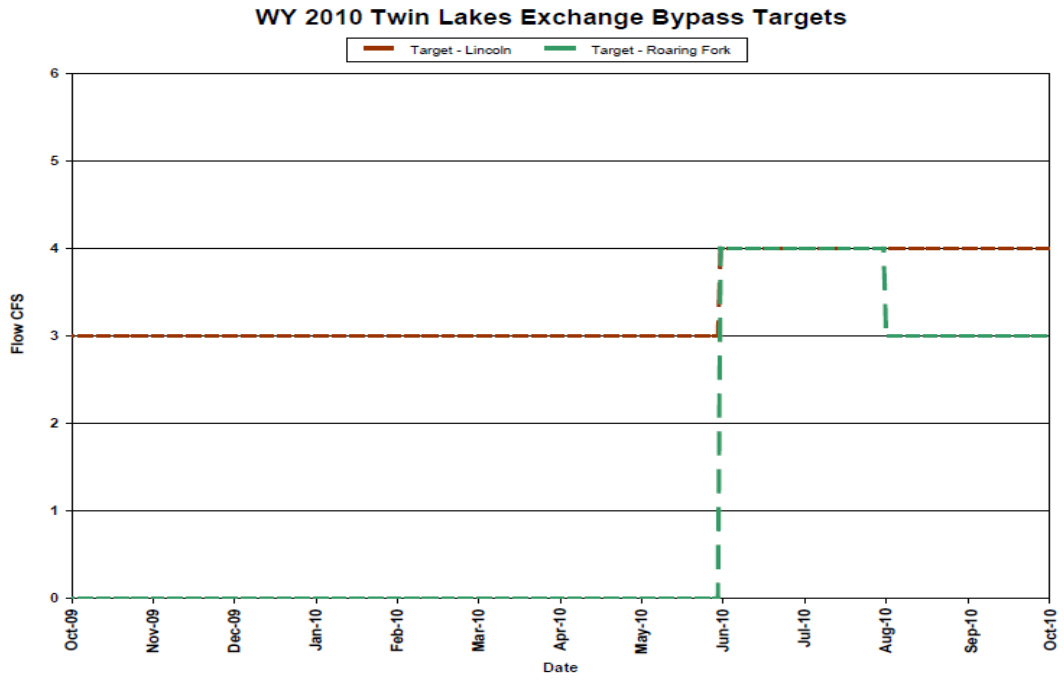


Roaring Fork River near Lost Man

Upper Roaring Fork Sub-watershed; Pitkin County

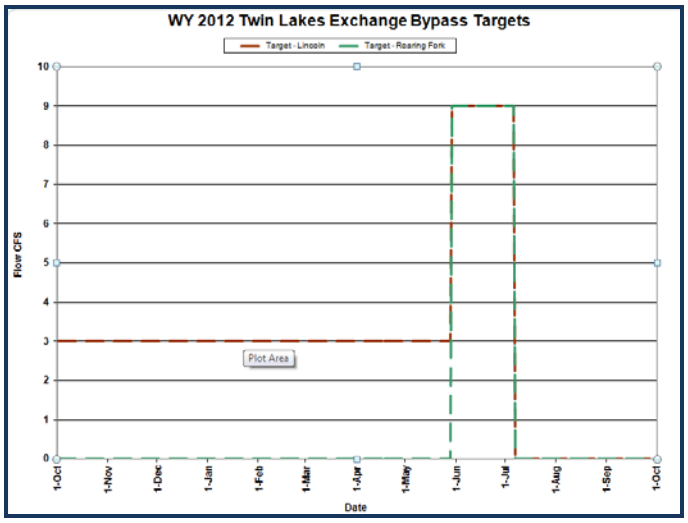
DESCRIPTION OF NEED:

The 3,000 acre foot Twin Lakes Exchange governs the need for a year-round stream gage in this section of the Roaring Fork. Currently, the bypass flows are set with input from the Colorado River Water Conservation District, Pitkin County, City of Aspen, USFS, Twin Lakes Reservoir and Canal Company, Colorado Springs Utilities, and RFC. The current bypass regime, shown below, allocated no bypass flows for the Roaring Fork River from Oct through June 10th. No water is bypassed to the Roaring Fork River for two reasons: 1) there is a limited amount of water available to allocate between the Upper Roaring Fork River and Lincoln Creek throughout the year and 2) there is no ability to measure bypass flows in the Upper Roaring Fork in the winter. An improved gage at this location or relocation of the gage closer to the diversion would be needed if the bypass flow regime called for a winter bypass flow to the Upper Roaring Fork River[4].



In 2012, a very dry year the bypass schedule was revised to reflect a lower projected bypass amount and an earlier projected Cameo Call. The following graph shows the proposed bypass amounts.

[4] There have been several field visits to this site to discuss needs/solutions. As a result, a V-notch weir was installed below the diversion structure on the Upper Roaring Fork to be able to accurately measure by-pass flows. Mark Henneberg, USGS, participated in these visits when he worked for BOR and may recall the specific ideas that were discussed.



However, the V-notch weir on the Upper Roaring Fork River that measures flow below the IPTDS is limited in capacity to 4-5 cfs. A new gage or measuring device in this area would allow bypassing equal amounts in the future. To reflect this limitation starting on May 29, 2012 Lincoln Creek started bypassing 13 cfs, and the Roaring Fork at Lost Man bypassed 3 cfs.

DESCRIPTION OF REACH:

From State of the Roaring Fork Watershed 2008:

- Riparian and instream habitat are generally high quality.
- This area has been identified as part of a Potential Conservation Area by CNHP.
- The upper Roaring Fork River has good water quality.

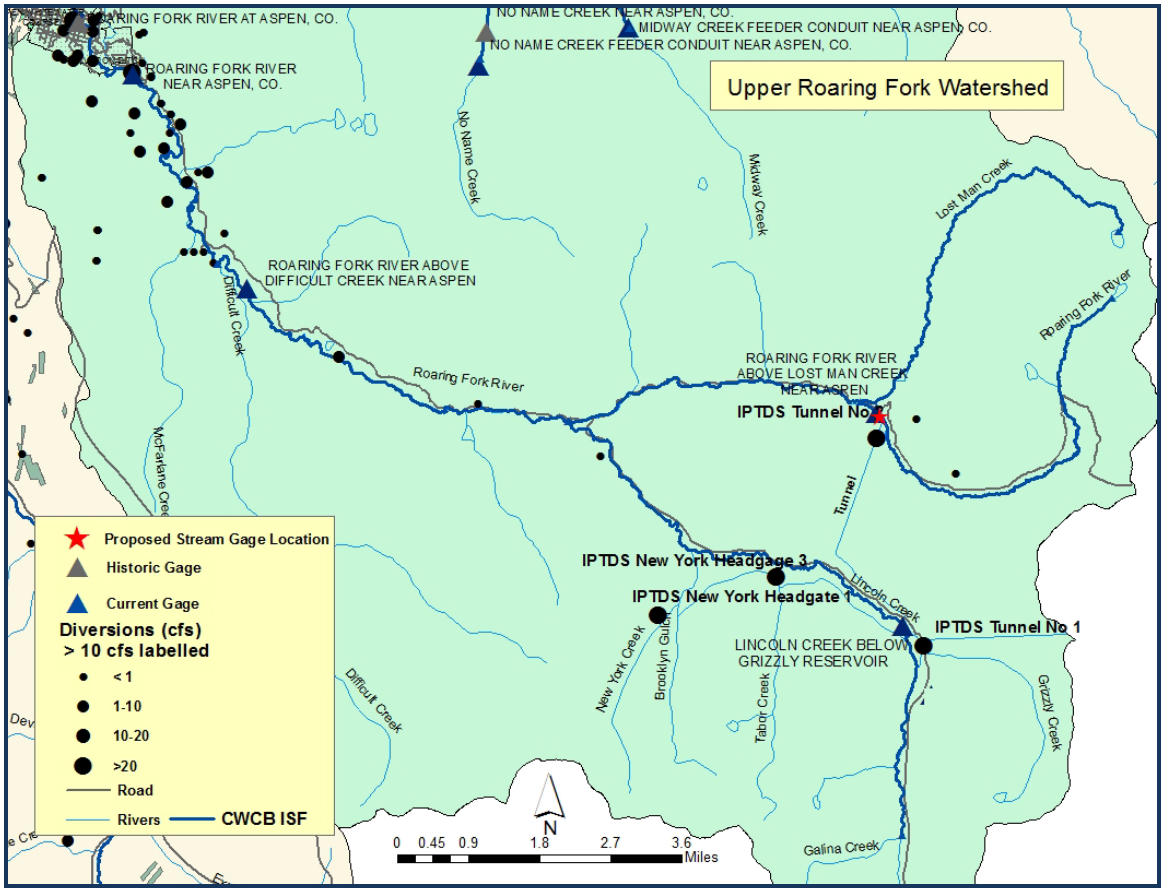
From other sources:

- The seasonal Roaring Fork River above Lost Man Creek near Aspen gage (May1-Oct 31) is operated by USGS and Bureau of Reclamation.
- The closest water quality monitoring is on the Roaring Fork River at Difficult Campground.
- This area is part of the Independence Pass Transmountain Diversion System (IPTDS)
- This site is within the White River National Forest and in a Wilderness Area.
- This gage is impacted by ice and the large boulder substrate makes accurate gage monitoring difficult icy conditions (See picture)
- A by-pass structure may be necessary for May - Oct.
- Winter access is difficult as it is only accessible via snowmobile/snowshoe.
- The USFS may be a good partner in maintaining and using information from this site.
- The CWCB ISF right on the Upper Roaring Fork River begins at the outlet of Independence Lake and extends to the confluence with Lincoln Creek. The ISF right was appropriated on January 14, 1976 for 10 cfs from Jan 1 to De3 31.

POTENTIAL FUNDING SOURCES:

Bureau of Reclamation

Roaring Fork above Lost Man Creek near Aspen stream flow gage (Oct, 2005). Ice and snow in the winter and the rocky substrate hinder accurate, year-round stream flow readings.



Coal Basin

Crystal River Sub-watershed; Pitkin County

DESCRIPTION OF NEED:
Water quality and quantity should be monitored in this basin. Both water quantity and quality data are needed to detect status and trends, plan and design restoration projects, and evaluate the effectiveness of restoration and reclamation projects in Coal Basin. This basin would also benefit from complementary weather and soil moisture monitoring capabilities. This highly altered basin could attract researchers interested in restoration projects.

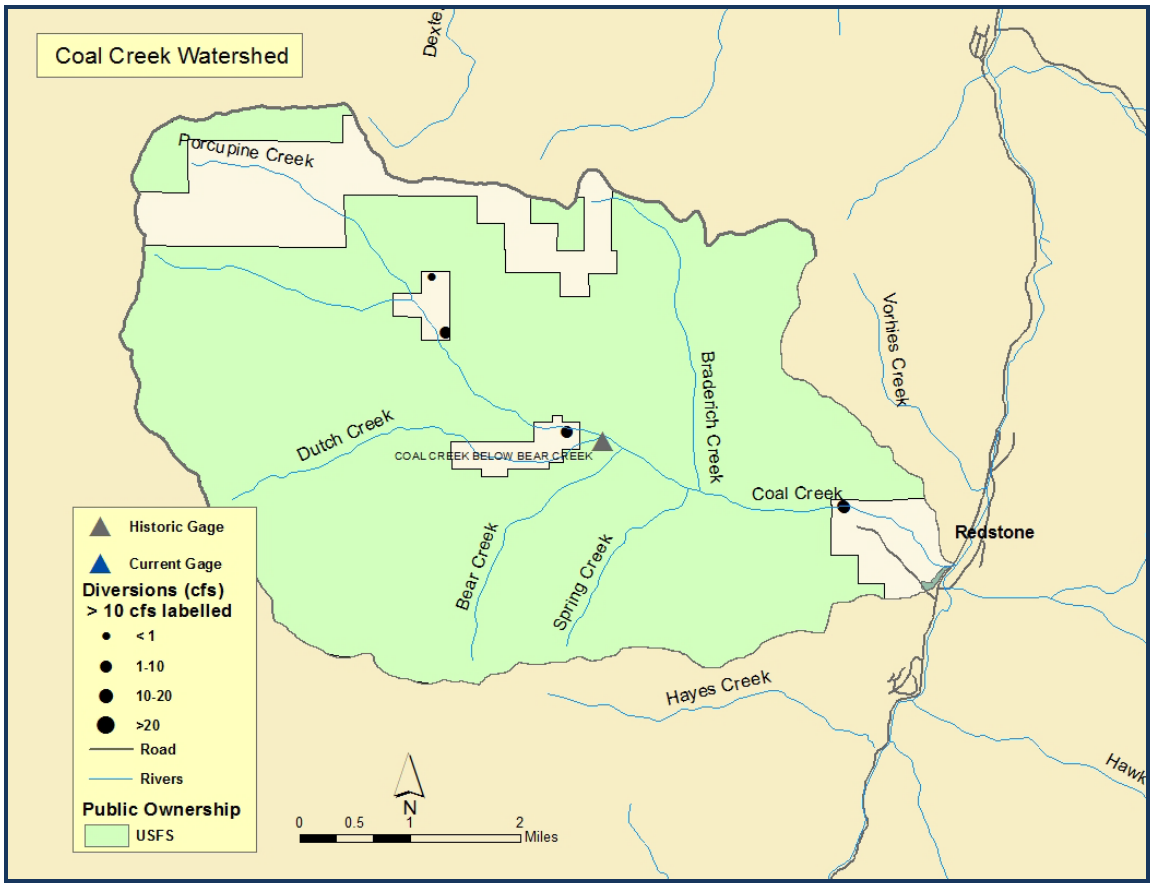
DESCRIPTION OF REACH:
From State of the Roaring Fork Watershed 2008:

- Coal Creek is a significant contributor to suspended solids in the Crystal River due to the unstable landscape and historical mining degradation.
- Coal Creek was on CPDHE's state list for total recoverable iron and on the monitoring and evaluating list for sediments.

From other sources:

- Coal Basin has a very "flashy" hydrograph and can move a large volume of large diameter bedload. Restoration/reclamation project are being planned to reduce sediment and attenuate the hydrograph.
- There are currently no gages in Coal Basin. The USGS has very limited historical flow data for this watershed. In 1981, they obtained flow data for Bear Creek at Coal Creek, Dutch Creek at Coal Creek, and Coal Creek below Bear Creek; flow data for the later site was obtained in 1985 as well.
- There is a current River Watch water quality monitoring site at the confluence of Coal Creek and Crystal River (#782). This site is monitored 4 times/year.
- RFC sampled Site # 782 for macroinvertebrates in the fall of 2011 and the USFS sampled four sites in Coal Basin. RFC is seeking funding to partner with them to resample these 4 sites in 2012.
- RFC is working with USFS on a 3 acre road reclamation restoration project on Dutch Creek in the fall of 2012.
- There are no CWCB ISF rights on Coal Creek.
- Coal Creek is accessible via Coal Creek Road. The road is not plowed in winter.

POTENTIAL FUNDING SOURCES:
State Water Supply Reserve Account, Pitkin County


Coal Creek Watershed
Dexte
Porcupine Creek
Dutch Creek
COAL CREEK BELOW BEAR CREEK
Braderich Creek
Vorhies Creek
Coal Creek
Redstone
Bear Creek
Spring Creek
Hayes Creek
Hawk
Historic Gage
Current Gage
Diversions (cfs)
> 10 cfs labelled
< 1
1-10
10-20
>20
Road
Rivers
Public Ownership
USFS
N
0
0.5
1
2
Miles

Fryingpan Arkansas Project's Ungaged Bypass Flows (3)

Fryingpan Sub-watershed; Pitkin and Eagle Counties

DESCRIPTION OF NEED:
This gage is needed to monitor Fryingpan-Arkansas Project bypass flows in creeks with bypass flows and no gages.
1. Carter (priority) 2. Mormon (priority) 3. M. Cunningham

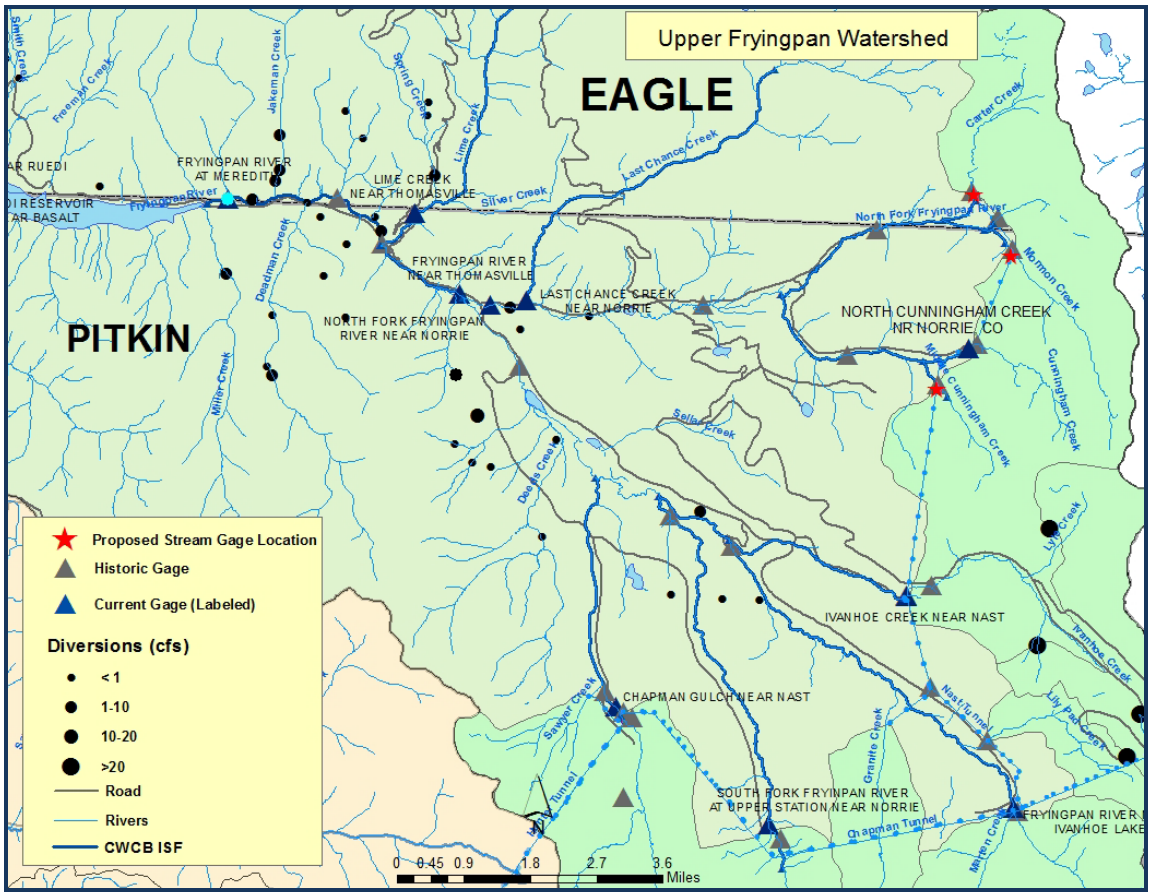
DESCRIPTION OF REACH:
From State of the Roaring Fork Watershed 2008:

- 41 percent of water is diverted from the Fryingpan River through the Fry-Ark Project Transmountain Diversion.
- The CWCB ISF right on Carter Creek begins at the headgate for the Fryingpan-Arkansas Project diversion and extends to the confluence with the North Fork Fryingpan River. The ISF right was appropriated on July 12, 1973 for 2 cfs from April 1 to Sept 30 and 1 cfs from Oct 1 to March 31.
- The CWCB ISF right on Mormon Creek begins at the headgate for the Fryingpan-Arkansas Project diversion and extends to the confluence with the North Fork Fryingpan River. The ISF right was appropriated on July 12, 1973 for 2 cfs from April 1 to Sept 30 and 1 cfs from Oct 1 to March 31.
- The CWCB ISF right on Middle Cunningham Creek begins at the headgate for the Fryingpan-Arkansas Project diversion and extends to the confluence with Cunningham Creek. The ISF right was appropriated on July 12, 1973 for 1 cfs from April 1 to Sept 30 and 0.5 cfs from Oct 1 to March 31.

From other sources:

- Current stream gaging sites are located on the Fryingpan River at Meredith (CDWR, NWS), Fryingpan River near Ivanhoe Lake (CDWR, BOR), South Fork Fryingpan River at Upper Station near Norrie (CDWR, BOR), Fryingpan River near Ruedi (USGS), Rocky Fork Creek near Meredith (CDWR, BOR), Chapman Gulch near Nast (CDWR, BOR) Ivanhoe Creek near Nast (BOR), Fryingpan River near Thomasville (CDRW), Ruedi Reservoir near Basalt (USGS, BOR), Lime Creek near Thomasville (USGS, BOR), Last Chance Creek near Norrie (USGS/BOR), North Fork Fryingpan near Norrie (CDWR), Busk-Ivanhoe Tunnel (CDWR),and Charles H. Boustead Tunnel (CDWR, BOR)
- Three River Watch sites are located in the Fryingpan. One above Ruedi Reservoir: Meredith (#776); and two below the reservoir: Baetis Bridge (#733), and Upper Basalt Bridge (#73). The first two are monitored 4 times/ year and the last one is monitored monthly.

POTENTIAL FUNDING SOURCES:
Bureau of Reclamation, USFS


Upper Fryingpan Watershed
EAGLE
PITKIN
FRYINGPAN RIVER AT MEREDITH
LIME CREEK NEAR THOMASVILLE
FRYINGPAN RIVER NEAR THOMASVILLE
NORTH FORK FRYINGPAN RIVER NEAR NORRIE
LAST CHANCE CREEK NEAR NORRIE
NORTH CUNNINGHAM CREEK NR NORRIE, CO
IVANHOE CREEK NEAR NAST
CHAPMAN GULCH NEAR NAST
SOUTH FORK FRYINPAN RIVER AT UPPER STATION NEAR NORRIE
Proposed Stream Gage Location
Historic Gage
Current Gage (Labeled)
Diversions (cfs)
< 1
1-10
10-20
>20
Road
Rivers
CWCB ISF
0 0.45 0.9 1.8 2.7 3.6
Miles

Brush Creek

Upper Middle Roaring Fork Sub-watershed; Pitkin County

DESCRIPTION OF NEED:
There is a need for stream flow monitoring on Brush Creek. Continuous versus periodic flow monitoring to monitor water quantity still needs to be discussed with the Town of Snowmass Village and the Snowmass Water and Sanitation District. These flow data would also be used to interpret water quality data. The need for continuous recording of water quality data also needs to be discussed.

DESCRIPTION OF REACH:
From State of the Roaring Fork Watershed 2008:

- There are frequent observations on Brush Creek exceeding state pH standards.
- Elevated phosphorus levels have been detected in Brush Creek.
- 38 percent of Brush Creek instream habitat is impacted by development and weeds.
- The riparian habitat on the right bank of Brush Creek is severely degraded over 27 percent of its length. 42 percent of the left bank is severely degraded.
- There are no CWCB ISF rights on Brush Creek.

From 2007 Brush Creek Water Quality Study:

- Although all pH levels did not exceed state standards in this study, there is a supposition that past pH elevation are coincidental with low flows. Testing of this hypothesis requires a stream gage.
- An established relationship between pH and flows could point towards a need to establish a CWCB instream flow right.
- There is a marked spike in nitrate levels between the Snowmass Chapel River Watch site (#889) and above Roundabout River Watch site (#887). The golf course is a potential source of pollutants between these sites.
- Although there were no state standards for phosphate, Brush Creek levels are consistently high, and increase from the Snowmass Chapel River Watch site (#889) to the Y (above Roundabout River Watch site-#887) in 3 of 4 sites sampled.

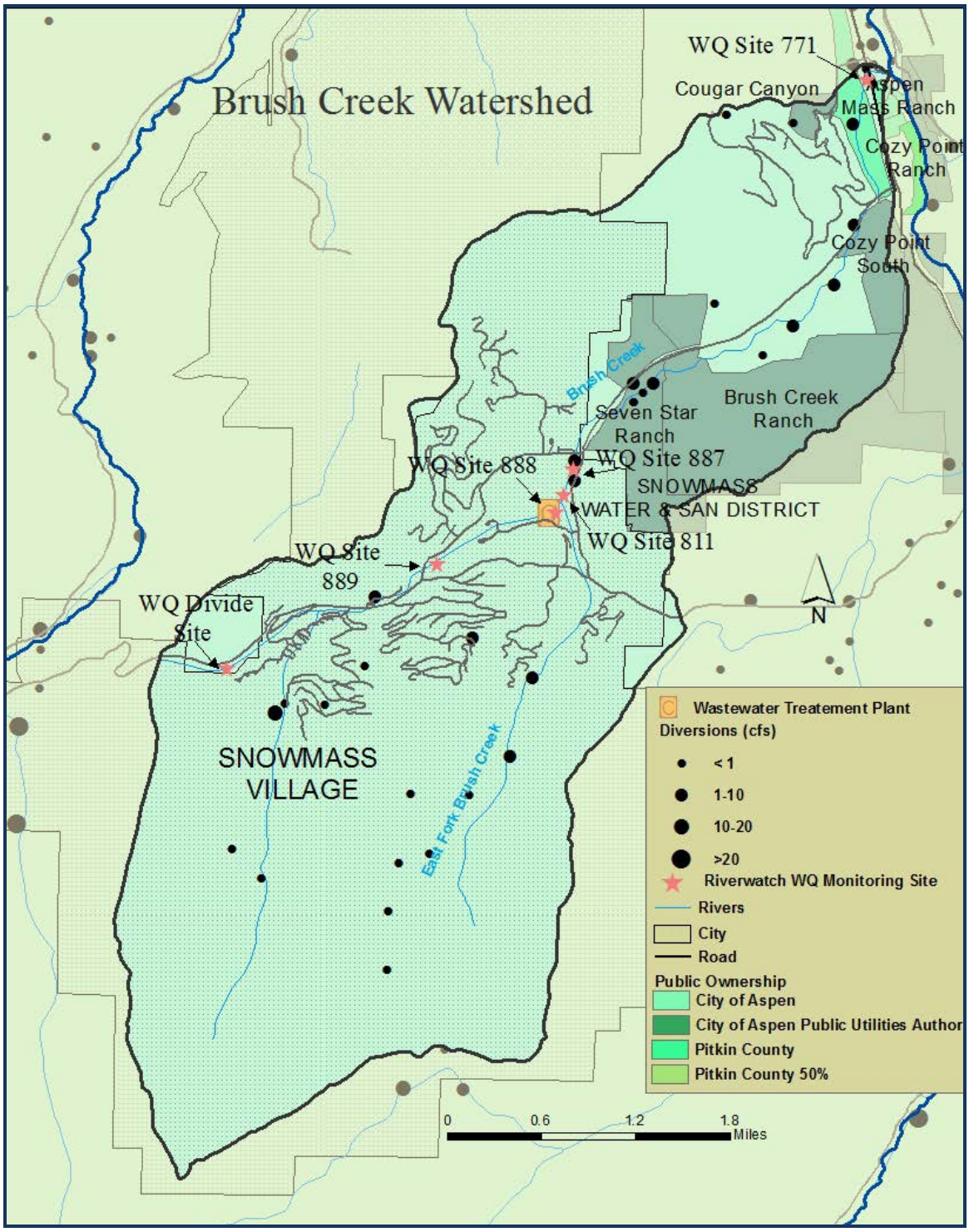
From other sources:

- There are no stream gages on Brush Creek and no historic gages.
- In a Roaring Fork Watershed Water Quality Monitoring Plan prepared by David Brown, USGS (2012) a new water quantity and water quality site was identified on Brush Creek (39 14 50.72 N, 106 53 12.67 W) to integrate urban impacts from Snowmass Village. The data would be used for concentrations, trends, and loads. He recommended field physical and chemical properties, E. coli bacteria, low level nutrients, and discharge be measured 8 times/year and major ions, trace elements, and selenium be measured 6 times/year. There was no collection of continuous parameters recommended.

- There are five active River Watch Sites on Brush Creek: Snowmass Chapel (#889), Clubhouse Drive Bridge (#888), below Snowmass Village and Snowmass Wastewater Treatment Plant (#811), above Roundabout (#887), and at the Highway 82 Bridge (#771). The last site is monitored by a RFC volunteer six times a year and the other four sites are monitored by RFC twice a year. A site on Upper Brush Creek (Divide Site) has historical data, but is no longer monitored. This site was used for the Brush Creek Study.
- Brush Creek is provisionally listed for aquatic life on the state's Section 303(D) list for impaired waters (CDPHE, 2012).
- Golf course pollutants are a potential concern on Brush Creek.
- A review of total phosphorus (TP) data for Brush Creek[5] below Snowmass Village River Watch Site near the junction of Brush Creek and Highline Roads, downstream of the Snowmass Village Wastewater Treatment Facility (2 samples per year from 2008- 2011) shows significant exceedances of the new interim values occurring every winter during low flow. One exceedance was 0.139 mg/L, just above the interim value, but the other three were well above, averaging 1.3 mg/L. In contrast, every high flow sample had TP results below the interim value. When these yearly results are used to calculate an annual median, the median still exceeds the interim value in three of the four years.
- The Snowmass Water and Sanitation District is considering monitoring water quality, macroinvertebrates, and stream flow at 4 sites above and below the Waste Water Treatment Plant as a targeted study to determine the source of water quality issues in the watershed. This would hopefully lead to solutions.
- RFC sampled Site # 887 for macroinvertebrates in the fall of 2011 and will partner with Snowmass Water and Sanitation District to sample 4 sites in 2012.

POTENTIAL FUNDING SOURCES:
Town of Snowmass Village and Snowmass Water and Sanitation District

[5] In March, 2012 Colorado Water Quality Control Commission provided preliminary approval of the new Nutrient Control Regulation 85 and changes to Regulation 31, Basic Standard. These regulations will set total phosphorus (TP) and total inorganic nitrogen (TIN) for the largest wastewater dischargers and set phosphorus and nitrogen interim values for rivers and streams. Interim value for total phosphorus in rivers and streams (0.11 mg/L).


Brush Creek Watershed
WQ Site 771
Cougar Canyon
Aspen Mass Ranch
Cozy Point Ranch
Cozy Point South
Brush Creek
Brush Creek Ranch
Seven Star Ranch
WQ Site 888
WQ Site 887
SNOWMASS WATER & SAN DISTRICT
WQ Site 811
WQ Site 889
WQ Divide Site
SNOWMASS VILLAGE
East Fork Brush Creek
N
Wastewater Treatement Plant
Diversions (cfs)
< 1
1-10
10-20
>20
Riverwatch WQ Monitoring Site
Rivers
City
Road
Public Ownership
City of Aspen
City of Aspen Public Utilities Author
Pitkin County
Pitkin County 50%
0
0.6
1.2
1.8
Miles

BIBLIOGRAPHY

Brown, D. 2012. Proposed Water Quality Sampling Locations: Final. Prepared for Mark Weinhold, U.S. Forest Service by USGS.

Clarke, S., K. Crandall, J. Emerick, M. Fuller, J. Katzenberger, D. Malone, M. Masone, A. Slap, and J. Thomas. 2008. State of the Roaring Fork Watershed Report 2008. Sponsor: Ruedi Water and Power Authority. Lead Consultant: Roaring Fork Conservancy. http://www.roaringfork.org/watershedplan.

Clarke, S, M. Fuller, R. Sullivan. 2012. Roaring Fork Watershed Plan. Sponsor: Ruedi Water and Power Authority. Lead Consultant: Roaring Fork Conservancy. http://www.roaringfork.org/watershedplan.

CDPHE (Colorado Department of Public Health and Environment, Water Quality Control Commission). 2012. Colorado Section 303 (D) List of impaired waters and monitoring and evaluation list, effective March 30, 2012.

Colorado Division of Wildlife. 2011. Colorado River Watch: Information available on the web, accessed May 13, 2012 at http://wildlife.state.co.us/landwater/riverwatch/Pages/Riverwatch.aspx

Gardner-Smith, B. 2009. State board approves water trust with Pitco. Aspen Daily News. November 17. http://www.aspendailynews.com/section/home/137663

Roaring Fork Conservancy. 2008. Brush Creek Water Quality Study. http://www.roaringfork.org/publications.

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APPENDIX 1: List of Current and Historic Gages in the RF Watershed

SITE NUMBER	STATION NAME	CURRENT OPERATOR	DATE OPERATION BEGAN	SEASONAL
9081600	CRYSTAL RIVER ABOVE AVALANCHE CREEK NEAR REDSTONE	USGS	10/1/1955	Year-round
	CRYSTAL RIVER AT DOW FISH HATCHERY AB CARBONDALE	CDWR	?? 2006	April-Sept
9078500	NORTH FORK FRYINGPAN RIVER NEAR NORRIE	CDWR	10/1/1910	
9080100	FRYINGPAN RIVER AT MEREDITH	CDWR/NWS	10/1/1910	
9077500	BUSK-IVANHOE TUNNEL	CDWR	10/1/1947	
9077200	FRYING PAN RIVER NEAR IVANHOE LAKE	CDWR/BOR	10/1/1963	Year-round
9077900	SOUTH FORK FRYINGPAN RIVER AT UPPER STATION NEAR NORRIE	CDWR/BOR??	10/1/1963	
9080400	FRYINGPAN RIVER NEAR RUEDI	USGS	10/1/1964	Year-round
9080300	ROCKY FORK CREEK NEAR MEREDITH, CO.	CDWR/BOR	10/1/1968	
9077160	CHARLES H. BOUSTEAD TUNNEL	CDWR/BOR	10/1/1971	
9077945	CHAPMAN GULCH NEAR NAST	CDWR/BOR	10/1/1972	
9077610	IVANHOE CREEK NEAR NAST	BOR	10/1/1975	
9078600	FRYINGPAN RIVER NEAR THOMASVILLE	CDWR	10/1/1975	Year-round
9080190	RUEDI RESERVOIR NEAR BASALT	USGS/BOR		Year-round
9081000	ROARING FORK RIVER NEAR EMMA	USGS	3/12/1998	Year-round
9085000	ROARING FORK RIVER AT GLENWOOD SPRINGS	USGS	4/1/1906	Year-round
	SNOWMASS CREEK (391930107592001)	CDWR		
	ROARING FORK RIVER BELOW MAROON CREEK NEAR ASPEN	CDWR	10/1/1988	Year-round
	ROARING FORK RIVER AB FRYINGPAN RIVER NR BASALT	CDWR	10/1/2006	April-Sept
9073000	TWIN LAKES TUNNEL	CDWR	10/1/1934	
9074000	HUNTER CREEK NEAR ASPEN	USGS	6/1/1950	Year-round
9074500	HUNTER CREEK AT ASPEN, CO	USGS/BOR	9/16/2009	Year-round
9073400	ROARING FORK RIVER NEAR ASPEN	USGS	10/1/1964	Year-round
9075400	CASTLE CREEK AT ASPEN, CO	USGS/SOS	5/15/2012	Year-round
9073300	ROARING FORK RIVER ABOVE DIFFICULT CREEK NEAR ASPEN	USGS/BOR	10/1/1979	Year-round
9072550	ROARING FORK RIVER ABOVE LOST MAN CREEK NEAR ASPEN	USGS/BOR	10/1/1980	May 1- Oct 31
9073005	LINCOLN CREEK BELOW GRIZZLY RESERVOIR NEAR ASPEN	USGS/BOR	10/1/1980	Year-round
9079450	LIME CREEK NEAR THOMASVILLE	USGS/BOR	4/10/2009	April-Sept
9078475	LAST CHANCE CREEK NEAR NORRIE	USGS/BOR	4/10/2009	April-Sept
9078141	NORTH CUNNINGHAM CREEK CONDUIT BYPASS NR NORRIE,CO	USGS/BOR	4/11/2009	April-Sept
9073721	HUNTER CREEK CONDUIT BYPASS NEAR ASPEN,CO	USGS/BOR	4/9/2009	April-Sept
9073720	HUNTER CREEK FEEDER CONDUIT NEAR ASPEN, CO.	USGS/BOR	5/20/1980	April-Sept
9073891	NONAME CONDUIT BYPASS NEAR	USGS/BOR	4/8/2009	April-Sept

	ASPEN, CO			
9073890	NO NAME CREEK FEEDER CONDUIT NEAR ASPEN, CO.	USGS/BOR	5/18/1980	April-Sept
9073791	MIDWAY CREEK CONDUIT BYPASS NEAR ASPEN, CO	USGS/BOR	4/9/2009	April-Sept
9073790	MIDWAY CREEK FEEDER CONDUIT NEAR ASPEN, CO.	USGS/BOR	5/6/1980	April-Sept
HISTORIC		**HISTORIC OPERATOR**		
9075000	CASTLE CREEK NEAR ASPEN, CO.		10/1/1911	
9074800	CASTLE CREEK ABOVE ASPEN, CO.		9/1/1969	
9084000	CATTLE CREEK NEAR CARBONDALE, CO.	USGS	10/1/1950	
9081500	CRYSTAL RIVER AT MARBLE, CO.		11/1/1910	
9083800	CRYSTAL RIVER BELOW CARBONDALE, CO.	USGS	5/18/2000	
9082500	CRYSTAL RIVER NEAR REDSTONE, CO.	USGS	10/1/1935	
9083000	THOMPSON CREEK NEAR CARBONDALE	USGS	10/1/1950	
9081550	CRYSTAL RIVER AT PLACITA, CO.		10/1/1959	
9082880	NORTH THOMPSON CREEK NEAR CARBONDALE, CO.	USGS	10/1/1963	
9083700	PRINCE CREEK NEAR CARBONDALE, CO.	USGS	10/1/1963	
	THOMPSON CREEK FEEDER DITCH NEAR HAYSTACK, CO	CDWR		
9078000	FRYINGPAN RIVER AT NORRIE, CO.	USGS	10/1/1910	
9080000	FRYINGPAN RIVER AT THOMASVILLE, CO.	USGS	3/1/1915	
9079500	LIME CREEK AT THOMASVILLE, CO.	USGS	6/1/1950	
9079000	LIME CREEK AT TROUTVILLE, CO.	USGS	6/1/1950	
9080200	FRYINGPAN RIVER AT RUEDI, CO.	USGS	10/1/1959	
9078140	CUNNINGHAM CREEK NEAR NORRIE, CO.	USGS	10/1/1963	
9077400	FRYING PAN RIVER NEAR IVANHOE LAKE*	USGS	10/1/1963	
9077200	FRYINGPAN RIVER NEAR NORRIE, CO.	USGS	10/1/1963	
9077600	IVANHOE CREEK NEAR NORRIE, CO.	USGS	10/1/1963	
9078900	LIME CREEK NEAR TROUTVILLE, CO.	USGS	10/1/1963	
9078100	NF FRYINGPAN R AB CUNNINGHAM C, NR NORRIE, CO.	USGS	10/1/1963	
9078300	NF FRYINGPAN R BL CUNNINGHAM C, NR NORRIE, CO.	USGS	10/1/1963	
9077800	SOUTH FORK FRYINGPAN RIVER AT UPPER STATION NEAR NORRIE*	USGS	10/1/1963	
9077900	SOUTH FORK FRYINGPAN RIVER NEAR NORRIE, CO.	USGS	10/1/1963	
9077950	CHAPMAN GULCH NEAR NORRIE, CO.	USGS	10/1/1966	
9077940	CHAPMAN GULCH FEEDER CANAL NEAR NORRIE, CO.	USGS	10/1/1971	
9077150	FRYINGPAN RIVER FEEDER CANAL NEAR NORRIE, CO.	USGS	10/1/1971	
9077960	SAWYER CREEK FEEDER CANAL NEAR NORRIE, CO.	USGS	10/1/1971	
9077750	SF FRYINGPAN RIVER FEEDER	USGS	10/1/1971	

	CANAL NEAR NORRIE, CO.			
9077250	LILY PAD CREEK FEEDER CANAL NEAR NORRIE, CO.	USGS	10/1/1973	
9077605	IVANHOE CREEK FEEDER CANAL NEAR NAST, CO.	USGS	10/1/1975	
9078140	CUNNINGHAM CREEK FEEDER CANAL NEAR NORRIE, CO.	USGS	6/1/1979	
9078150	MIDDLE CUNNINGHAM CREEK FEEDER CANAL NR.	USGS	6/1/1979	
9078050	MORMON CREEK FEEDER CANAL NEAR NORRIE, CO.	USGS	6/1/1979	
9078060	CARTER CREEK FEEDER CANAL NEAR NORRIE, CO.	USGS	4/27/1981	
9078040	NF FRYINGPAN RIVER FEEDER CANAL NEAR NORRIE, CO.	USGS	4/30/1981	
9077300	GRANITE CREEK FEEDER CONDUIT NEAR NORRIE,CO.	USGS	5/5/1981	
	CHAPMAN CONTROL HOUSE			
	MEREDITH (CLIMATOLOGICAL)			
	MIDDLE CUNNINGHAM CREEK FEEDER CANAL NR.			
	MORMON CONTROL HOUSE			
9080300	ROCKY FORK CREEK NEAR MEREDITH	USGS	10/1/1968	
9080800	WEST SOPRIS CREEK NEAR BASALT, CO.	USGS	10/1/1963	
9084500	FOURMILE CREEK NEAR CARBONDALE, CO.	USGS	10/1/1941	
9084600	FOURMILE CREEK NEAR GLENWOOD SPRINGS, CO.	USGS	10/1/1957	
	PORTER THREEMILE DITCH AT THREEMILE PASS			
9076000	MAROON CREEK NEAR ASPEN, CO.	USGS	1/1/1911	
9075700	MAROON CREEK ABOVE ASPEN, CO.	USGS	9/1/1969	
9075500	ROARING FORK RIVER BELOW ASPEN, CO.	USGS	10/1/1913	
9076520	OWL CREEK NEAR ASPEN, CO.	USGS	10/1/1974	
9073500	ROARING FORK RIVER AT ASPEN, CO.	USGS	10/1/1910	
9073700	HUNTER CREEK ABOVE MIDWAY CREEK, NEAR ASPEN, CO.	USGS	10/1/1964	
9073900	NO NAME CREEK NEAR ASPEN, CO.	USGS	10/1/1970	
9073800	MIDWAY CREEK NEAR ASPEN, CO.	USGS/BOR	10/1/1970	
	COAL CREEK	USGS	1981; 1985	
	* still in operation-with new operator			

APPENDIX 2: List of Stream Flow Data Uses

Environmental Studies

- Non-point source pollution
- Channel morphology evolution
- Sediment studies
- Wetlands ecology
- Tidal gate studies
- Vegetation studies
- Wildlife studies
- Fish studies
- Benthic studies
- Instream flow analysis
- Aquatic habitat studies
- Wild & Scenic determination

Hydraulic Design

- Roadways
- Bridges and culverts
- Dams, spillways and reservoirs
- Channel modifications
- Flood-plain development
- Hydraulic modeling
- Urban beautification
- Navigable rivers for travel

Reservoir Management

- Routine operations
- Flood suppression
- Droughts
- Hydropower operation
- Scheduling bridge and dam inspections/repairs

Statistical Analysis

- Flood frequency
- Low flow frequency
- Flow duration
- Storage requirements
- Areal studies
- Safe yield analysis

Water Management

- Water supply, public and private
- Waste disposal
- Water use
- Irrigation
- Emergency flood alert
- Water diversion permits
- Compliance with instream flow requirements
- Tide monitoring

Urban Studies

- Storm run-off
- Flood inundation
- Zoning and design regulations
- Pollution studies
- Scenic and wildlife suitability assessments

Water Quality

- Assimilative capacity
- Cumulative impacts assessment
- Baseline conditions
- Long-term trends
- Point-source impacts
- Interstate pollution transport
- Surface water – ground water relationships
- Salinity studies
- Dissolved oxygen studies
- Vegetation studies
- Nutrient loading studies
- Recreation suitability
- Regulatory monitoring

Recreation

- Canoeing activities
- Scenic river tour operations
- Sport fishing
- Competition rowing, swimming, water-skiing ...
- Pleasure boating

This list was taken from: Recommendations for a stream gaging network in Rhode Island. Prepared by the DEM-WRB Streamflow Committee. April 2004.

APPENDIX 3: Participant Contact Information

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APPENDIX 4: Priority Ranking Sheet

Priority	Reach Name	Region	Total
1)	Maroon Creek @ Stapleton Ditch	Middle Roaring Fork	39
2)	RF above Castle Creek (in Aspen)	Upper Roaring Fork	36
3)	Lower Crystal (above fish hatchery)	Lower Roaring Fork	36
4)	RF near Lost Man	Upper Roaring Fork	23
5)	Coal Creek	Lower Roaring Fork	22
6)	(4) FP Bypasses	Frying Pan	19
7)	Brush Creek	Middle Roaring Fork	18
**)	Castle Creek	Middle Roaring Fork	18
8)	Maroon Creek (below diversions)	Middle Roaring Fork	17
9)	Cattle Creek	Lower Roaring Fork	14
10)	(3) Hunter Creek (at no name, midway and hunter creek diversions)	Upper Roaring Fork	13
11)	Thompson Creek	Lower Roaring Fork	13
12)	FP Deferred area	Frying Pan	11
13)	Four Mile	Lower Roaring Fork	8
14)	Capitol Creek	Middle Roaring Fork	6
15)	Woody Creek (lower)	Middle Roaring Fork	5

Notes:
After reviewing notes from participants' rating sheets, a few numbers were updated from what was originally displayed at the library. These changes did not affect the order of priority reaches.

**One of the pre-identified reaches was on Castle Creek below the return flow of the City of Aspen's proposed Castle Creek Energy Center. On April 26, a local non-profit, Saving Our Streams, arranged for the installment of USGS stream gage in that reach. Therefore, although it received a high priority ranking, Castle Creek will not be further considered in this report. See Appendix 5 for a map of the gaging site and more details.

APPENDIX 5: Update on New Castle Creek Gage

USGS 09075400 Castle Creek at Aspen, CO

Installed: April 26, 2012

USGS gage web resource: http://waterdata.usgs.gov/co/nwis

Station operated by the U.S. Geological Survey (Grand Junction Western Colorado Office) in cooperation with Saving Our Streams. Continuous temperature data are collected at this gage location.

APPENDIX 6: Monitoring Network Cost Estimate

Monitoring Network Cost Estimate, S.K. Mason Environmental

S.K.Mason Environmental, LLC
856 Colorado Avenue
Carbondale, CO 81623

MEMORANDUM

Date: April 17, 2012

To: Sharon Clark, Roaring Fork Conservancy

From: Seth Mason, S.K.Mason Environmental, LLC

Subject: Aspen Area Stream Discharge Monitoring Network – Cost Estimate

Dear Sharon,

I am pleased to provide this cost estimate for the Roaring Fork Conservancy and the Upper Roaring Fork Watershed stakeholder group interested in the installation, operation, and maintenance of several stream discharge gauging stations. I've done my best to provide estimates for several gauging scenarios, each fulfilling a different data-use need.

The following is a preliminary estimate only; intended to aid the group in discussions that continue to refine the project goals and scope. Thus, this document comes along with the following terms and conditions:

1. This is an unofficial, nonbinding document for the purpose of communicating approximate pricing options for installation, operation and maintenance of gauging stations in the Upper Roaring Fork Watershed.

2. Infrastructure costs for gauging stations may change (in some cases, significantly) depending on access constraints and telemetry network requirements unique to individual sites.

3. Equipment prices provided by the vendor are subject to change at any time without notice and do not include sales tax, shipping, or insurance.

4. Operation and Maintenance costs are largely a function of site-access and may change following final selection of gauging locations.

Each of the scenarios described below assumes that gauging stations are located on a stream that can be waded at all times of the year. Larger, faster flowing streams that preclude wading will require use of additional equipment for the creation of rating curves. This will add approximately $1,000 to the cost associated with the Hach FH90 Velocity Flow Meter System listed below.

Telephone: 970.903.7561 | Email: seth@skmason-envi.com | Web: www.skmason-envi.com 1

Scenario 1

Description: Periodic point-measurements of stream discharge collected and referenced against a staff gauge installed in the streambed. A velocity flow meter is used to create a rating curve (stream stage vs. stream discharge) for each site. Calibrated staff gauges allow discharge to be approximated by visiting a given site and manually recording the water height on the gauge. This scenario is best suited to

Infrastructure:

First Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge	$45.00
Hach FH950	Velocity Flow Meter System	$5,300.00
	Subtotal:	**$5,345.00**
Each Additional Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge	$45.00
	Subtotal:	**$45.00**

Setup and Installation:

- Approximate one-time cost per site: $250.00
- Actual cost will be a function of site access characteristics.

Operation and Maintenance:

- Approximate cost per site, per visit: $200.00
- Actual cost may vary due to site access characteristics.

Data Management:

- Approximate cost per site per year: $300.00
- Includes QAQC of data and archiving in an existing database
- Development of a custom database will incur additional costs

Scenario 2

Description: Periodic point-measurements of stream discharge collected and referenced against water depth readings collected by an automated data collection system. A velocity flow meter is used to create a rating curve (stream stage vs. stream discharge) for each site. Calibrated stations approximate discharge in real-time, but stored data must be collected manually by visiting each site at regular intervals. This scenario is best suited for use-cases that require data be collected at a fine time interval but do not depend on access to data in real-time.

Infrastructure: Estimate includes the cost of instrumentation necessary for completing discharge measurements necessary to satisfy the scenario, but does not include material costs associated with mounting and housing the equipment in the field. Many different methods/materials are available to accomplish this task. Material selection and subsequent cost estimation should, thus, follow gauging site selection and identification of access restrictions and the existence of previously installed infrastructure.

First Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge (Optional)	$45.00
Campbell Sci. CR200	Datalogger	$450.00
CS-450-L	Pressure Transducer	$695.00
10-Watt PV Panel	Solar Panel	$50.00
12 V 12 AH Gell Cell	Battery	$35.00
Hach FH950	Velocity Flow Meter System	$4,300.00
	Subtotal:	**$5,575.00**
Each Additional Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge (Optional)	$45.00
Campbell Sci. CR200	Datalogger	$450.00
CS-450-L	Pressure Transducer	$695.00
10-Watt PV Panel	Solar Panel	$50.00
12 V 12 AH Gell Cell	Battery	$35.00
	Subtotal:	**$1,275.00**

Note: Pressure transducer may be swapped with one of the instruments listed below

Item	**Description**	**Price**
Campbell Sci. CS470	OTT CBS Compact Bubbler	$3,220.00
Campbell Sci. SR50A-L	Sonic Ranging Sensor	$1,050.00

Setup and Installation:

- Approximate cost per site: $800.00
- Actual cost may vary due to site access characteristics.

Operation and Maintenance:

- Approximate annual cost per site: $1,500.00
- Actual cost will be a function of site access characteristics.
- Includes (12) annual site visits for data download, rating-curve calibration, and instrument cleaning, as well as as-needed on-site troubleshooting.

Data Management:

- Approximate cost per site per year: $2,000.00
- Includes QAQC of data and archiving in an existing database
- Creation of a custom database would incur additional costs

Scenario 3

Description: Periodic point-measurements of stream discharge collected and referenced against water depth readings collected by an automated data collection system. A velocity flow meter is used to create a rating curve (stream stage vs. stream discharge) for each site. Calibrated stations approximate discharge in real-time. A radio telemetry system transmits real-time data to a base station where provisional data can be viewed in real-time. This scenario is best suited for those sites in a gauging network that are located near existing communication infrastructure (e.g. lower reaches of Castle and Maroon).

Infrastructure: Estimate includes the cost of instrumentation necessary for completing discharge measurements necessary to satisfy the scenario, but does not include material costs associated with mounting and housing the equipment in the field. Many different methods/materials are available to accomplish this task. Material selection and subsequent cost estimation should, thus, follow gauging site selection and identification of access restrictions and the existence of previously installed infrastructure.

An unknown number of repeater stations will likely need to be installed in order to ensure clear and consistent communication between gauging stations and a base station. Determination of the appropriate number of repeater stations will require a line-of-sight terrain analysis following final site selection. The cost estimate below assumes one repeater is needed per gauging station.

First Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge (Optional)	$45.00
Campbell Sci. CR206X	Datalogger w/ 915-MHz Radio	$685.00
900 MHz 9dBd Yagi	Antenna	$195.00
Radio Telemetry Repeater Station	CR206X, PV Panel, antenna, battery	$1,660.00
CS-450-L	Pressure Transducer	$695.00
10-Watt PV Panel	Solar Panel	$50.00
12 V 12 AH Gel Cell	Battery	$35.00
Hach FH950	Velocity Flow Meter System	$5,300.00
	Subtotal:	**$8,665.00**
Each Additional Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge (Optional)	$45.00
Campbell Sci. CR206X	Datalogger w/ 915-MHz Radio	$685.00
Radio Telemetry Repeater Station	CR206X, PV Panel, antenna, battery	$1,660.00
CS-450-L	Pressure Transducer	$695.00
10-Watt PV Panel	Solar Panel	$50.00
12 V 12 AH Gel Cell	Battery	$35.00
	Subtotal:	**$3,170.00**

Note: Pressure transducer may be swapped with one of the instruments listed below

Item	Description	Price
Campbell Sci. CS470	OTT CBS Compact Bubbler	$3,220.00
Campbell Sci. SR50A-L	Sonic Ranging Sensor	$1,050.00

Setup and Installation:

- Approximate cost per site: $1,500.00
- Actual cost may vary due to site access characteristics.

Operation and Maintenance:

- Approximate annual cost per site: $2,000.00
- Actual cost will be a function of site access characteristics.
- Includes (12) annual site visits for rating-curve calibration and instrument cleaning, as well as as-needed on-site troubleshooting.

Data Management:

- Approximate cost per site per year: $2000.00
- Includes QAQC of data and archiving in an existing database
- Development of a custom database will incur additional costs

Scenario 4

Description: Periodic point-measurements of stream discharge collected and referenced against water depth readings collected by an automated data collection system. A velocity flow meter is used to create a rating curve (stream stage vs. stream discharge) for each site. Calibrated stations approximate discharge in real-time. A satellite telemetry system periodically transmits data to a base station. This scenario relies on the GOES satellite system, the use of which requires USGS sponsorship. This scenario is best suited for remote gauging locations where development of a radio telemetry system is cost prohibitive. This may be the best solution for obtaining real-time data from the upper reaches of Hunter Creek.

Infrastructure: Estimate includes the cost of instrumentation necessary for completing discharge measurements necessary to satisfy the scenario, but does not include material costs associated with mounting and housing the equipment in the field. Many different methods/materials are available to accomplish this task. Material selection and subsequent cost estimation should, thus, follow gauging site selection and identification of access restrictions and the existence of previously installed infrastructure.

First Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge (Optional)	$45.00
Campbell Sci.DPC200	Datalogger w/ GOES Satellite System	$4,500.00
CS-450-L	Pressure Transducer	$695.00
Hach FH950	Velocity Flow Meter System	$5,300.00
	Subtotal:	**$10,540.00**
Each Additional Station		
Item	**Description**	**Price**
Style A Stream Gauge	Staff Gauge (Optional)	$45.00
Campbell Sci.DPC200	Datalogger w/ GOES Satellite System	$4,500.00
CS-450-L	Pressure Transducer	$695.00
	Subtotal:	**$5,240.00**

Note: Pressure transducer may be swapped with one of the instruments listed below

Item	**Description**	**Price**
Campbell Sci. CS470	OTT CBS Compact Bubbler	$3,220.00
Campbell Sci. SR50A-L	Sonic Ranging Sensor	$1,050.00

Setup and Installation:

- Approximate cost per site: $1,800.00
- Actual cost may vary due to site access characteristics.

Operation and Maintenance:

- Approximate annual cost per site: $2,000.00
- Actual cost will be a function of site access characteristics.
- Includes (12) annual site visits for rating-curve calibration and instrument cleaning, as well as as-needed on-site troubleshooting.

Data Management:

- Approximate cost per site per year: $2,000.00
- Includes QAQC of data and archiving in an existing database
- Development of a custom database will incur additional costs

These cost estimates are based on the premise that no equipment is currently available for use in the development of gauging stations and for subsequent creation of rating curves. Additionally, in composing this estimate I developed each scenario independently of the others. Therefore, some cost savings will be realized if multiple scenarios are simultaneously used in the development of the gauging network. Specifically, the "Hach FH950" listed in each cost estimate can be shared between sites and/or scenarios. Only one of these velocity flow meters is actually needed for the entire gauging network. If a velocity flow meter is currently available for use (as Sam suggested at the meeting last week), the cost for each gauging scenario will drop accordingly.

Please do not hesitate to contact me if you have any questions or are in need of any clarification. I look forward to ongoing collaboration with the Roaring Fork Conservancy on this and other projects.