

Colorado Water

September/October 2016

Reaching Higher

Implementing the Colorado
Water Plan's Goals for
Stream Management





The release of the Colorado Water Plan ushers in a new era in our water management, where environmental and recreational values are given the same sense of urgency as traditional water development. As communities look for ways to get involved in Water Plan implementation at the local level, Stream Management Plans (SMPs) are an excellent place to get started.

The concept of the SMPs is still new, with only a few communities having completed or in the process of working on their plans. So, there is plenty for everyone to learn, and the existing plans that are featured in this issue of Colorado Water provide inspiring models for how the plans can go beyond previous efforts and help to bring communities together.

The Colorado Water Plan highlighted the need for SMPs as a tool to protect watershed health, the environment, and recreation in Colorado. It stated an ambitious goal to “cover 80 percent of the locally prioritized lists of rivers with SMPs by...2030.”

SMPs are stakeholder-driven management plans that shepherd environmental and recreational goals and values into actionable projects aimed at “maintaining or improving flow regimes and other physical conditions,” for localized environmental and recreational water uses. Per the Water Plan, SMPs “can provide a framework [to basin roundtables, local stakeholders, and decision makers] for decision making and project implementation.”

This special issue of the Colorado Water newsletter is intended to serve as an initial resource guide with topics including an overview of what SMPs are, the steps of the process, available tools, and shared lessons learned from select case studies around the state. The case studies here, alongside others we were unable to include, provide a foundation of water management collaborations that have involved professionals and committed staff who are working on similar issues in every major river basin. Special thanks goes to CSU alumna Claudia Browne from Biohabitats for spearheading.

Two workshops supported by the Colorado Water Conservation Board provided forums for many of the contributors to gather and share these resources in August and October 2016. Workshop presenters included: representatives from the Colorado Water Conservation Board, the Colorado Water Trust, Trout Unlimited, The Nature Conservancy, Open Water Foundation, American Rivers, CSU, the City of Steamboat, and consultants, among others. Bridging the gap between academia and practitioners, CSU students, faculty, alumni, and partners are bringing integrated science, engineering, and social tools to the table. The process should yield better outcomes for Colorado's streams and rivers as SMPs are implemented.

SMPs are one part of the many approaches outlined in the Colorado Water Plan to secure future water supplies while protecting the environmental, social, and economic values held by Colorado citizens. The academic and research community has an important role in bringing objective science and education to the implementation process for the Water Plan. As the SMP process evolves, there will be room for many more creative minds and voices to help shape the future of wise water management for both humans and the environment.

Reagan Waskom

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Director, Colorado Water Institute

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On the cover: Flyfishing on the Eagle River reflects the Colorado Water Plan's stated need for SMPs as a tool to protect watershed health, the environment, and recreation in Colorado. Photo © 2016 iStock.com

Special Issue— Stream Management Plans



The Open Standards conservation planning approach ensures selected strategies will result in effective outcomes that are tied to priority issues. Healthy Country Planning, Australia 2012. Photo by Stuart Cowell.

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Cooperators include the Colorado State Forest Service, the Colorado Climate Center, and CSU's Water Resources Archive.

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Introduction to Stream Management Plans

What Are They and Why Now?

Amy Beatie, Executive Director, Colorado Water Trust

One of the goals of the Colorado Water Plan is to develop SMPs for 80% of the state's priority streams. SMPs focus on integrating environmental and recreational values with traditional agricultural and municipal values. Stream systems that struggle with low flows, degraded habitat, storage and water rights challenges, flooding, recreation needs or pressures—in other words many of the streams are good candidates for an SMP. By encouraging organizations to work together with stakeholders from both upstream and downstream, SMPs offer the chance for creative, whole-system problem solving.

To help jumpstart the SMP process, the Colorado Water Control Board (CWCB) is offering grant funding through their Watershed program. See application instructions

on their website at: <http://cwcb.state.co.us/LoansGrants/colorado-watershed-restoration-grants/Pages/main.aspx>. Applications will be due November 4, 2016. The grants have a 1:1 match ratio, and other funding parties will need to step up.

Colorado Water Trust also hosted a workshop at the Colorado Water Congress Summer Conference in Steamboat, Colorado this August with support from the CWCB and Colorado Water Congress (CWC). The workshop described ways to conduct an SMP, available funding, and showcased experiences from those who are experienced with this related work to help those getting started. A more condensed workshop is included in the Sustaining Colorado Watershed Conference located in Avon, Colorado this coming October.

A Photo Journal of Strategies Structural Improvements to Ensure Adequate Flows



Before the Sediment Removal

Fraser River Inlet upstream of the Denver Water's Fraser Diversion Dam/Sediment Project. Workers are at the sediment project's 30-inch water bypass gates/pipeline, which is used to dewater the diversion dam to remove sediments. Photo courtesy of Denver Water.



After Sediment Removal

Colorado Department of Transportation equipment removing accumulated sediments from Denver Water's Diversion Dam/Project. The pump is used to keep the diversion/settling pond area dewatered for sediment removal. Photo courtesy of Denver Water.



Well-developed Stream Management Plans should be grounded in the complex interplay of biology, hydrology, channel morphology, and alternative water use and management strategies.

According to the CWCB grant application guidelines:

“Well-developed Stream Management Plans should be grounded in the complex interplay of biology, hydrology, channel morphology, and alternative water use and management strategies. They should also consider the flow and other structural or management conditions needed to support both recreational uses and ecosystem function. A stream management plan should:

1. *Involve stakeholders to ensure their acceptance of the plan;*
2. *assess existing biological, hydrological, and geomorphological conditions at a reach scale;*
3. *identify flows and other physical conditions needed to support*

environmental and recreational water uses;

4. *incorporate environmental and recreational values and goals identified both locally and in a basin roundtable’s BIP; and*
5. *identify and prioritize alternative management actions to achieve measureable progress toward maintaining or improving flow regimes and other physical conditions. For basin roundtables, local stakeholder groups, and decision makers, such plans can provide a framework for decision-making and project implementation related to environmental and recreational water needs.”*



Before Dam Removal



After Dam Removal

Cache la Poudre River, Josh Ames Diversion Dam Structure, 2013. Photo courtesy of Biohabitats.

Cache la Poudre River after removal of Josh Ames Diversion Structure, 2014. Photo courtesy of Biohabitats.


The necessary steps for the development of an SMP include:

1. gathering stakeholders to participate in plan development;
2. identifying the plan's objectives;
3. identifying and prioritizing ecological and recreational values;
4. establishing goals for flows and other physical conditions in order to protect or enhance environmental and recreational attributes on streams and rivers within a given watershed;
5. collecting and synthesizing existing data describing flows for river ecosystems, boating, or other needs in the watershed;
6. assessing existing physical conditions of stream reaches, including geomorphological and riparian conditions;
7. selecting quantitative measures that can be used to assess progress made toward articulated goals;
8. determining what new information is needed and the best methods for obtaining that information;
9. quantifying specific numeric flow recommendations (or ranges of flow) and physical conditions and assessing the potential for channel reconfiguration to support environmental and recreational values;

10. identifying temporal, geographical, legal, or administrative constraints and opportunities that may limit or assist in the basin's ability to meet environmental and recreational goals; and
11. implementing a stakeholder-driven process to identify and prioritize environmental and recreational projects and methods.

SMPs should provide data-driven recommendations that have a high probability of protecting or enhancing environmental and recreational values on streams and rivers. More information on environmental and recreational projects and plans can be found in Chapter 6.6 and 7.1 of the Colorado Water Plan.

The conceptual framework in the Colorado Water Plan directs all interests to “identify, secure funding for, and implement projects that help recover imperiled species and enhance ecological resiliency, whether or not a new [transmountain diversion] is built.” The voluntary projects and processes that SMPs recommend will help roundtables and other organizations continue to better integrate multiple stakeholder objectives into project planning.

It has been said that the future begins in conversation, and SMPs help focus conversations on solutions to help the State better prepare for drought, floods, and population growth, while maintaining thriving natural resources, agriculture, recreation, and metropolitan economies. Now, nearly one year after the Colorado Water Plan was released, it is time to ramp up its implementation, and SMPs are an important place to begin. 

A Photo Journal of Strategies Structural Improvements to Ensure Adequate Flows

Continued



Bridge culvert impeding fish passage in Fort Goff Creek, Klamath National Forest, California. Photo courtesy of USFS.



Retrofitting bridge to allow fish passage in Fort Goff Creek, Klamath National Forest, California. Photo courtesy of USFS.



Before Cottonwood Regeneration

Remnant cottonwood forests along the Green River in Browns Park, Colorado. Photo by David Merritt, USFS/CSU.



After Cottonwood Regeneration

Cottonwood seedlings regenerating along Green River in Browns Park Colorado. Photo by David Merritt, USFS/CSU.



Before Natural Bank Stabilization

Eroding bank along Taryall Creek in Park County, Colorado. Photo courtesy of Biohabitats.



After Natural Bank Stabilization

Wood toe for stabilization and improved fish habitat at Taryall Creek in Park County, Colorado. Photo courtesy of Biohabitats.



Before Fish Passage

The Owens-Hall Diversion on Fountain Creek located between Colorado Springs and Pueblo, Colorado. Recently a fish passage was installed on the diversion with the guidance from Colorado Parks and Wildlife (upper left of the photograph). The goal of the structure is to improve native fish passage, especially for the at risk Flathead Chub and Arkansas Darter. Photo by Tyler Swarr, CSU.



After Fish Passage

The Fossil Creek Reservoir Inlet Diversion structure on the Cache la Poudre River near the CSU Environmental Learning Center. The diversion was destroyed after the 2013 flood but was rebuilt to include a rock ramp fishway. The fishway was completed in early 2016 to improve native and sport fish passage. Photo by Tyler Swarr, CSU.

Perspectives on Stream Management Challenges: A Survey

Summary of Key Questions from a 2016 Survey Effort

Whitney S. Beck, PhD Student, Graduate Degree Program in Ecology and Department of Biology, Colorado State University


During the summer of 2016, the Colorado Water Trust & Biohabitats, in collaboration with the Colorado Water Conservation Board, developed an SMP survey for water professionals working in governmental and non-governmental sectors across Colorado. The goal of the survey was to document the information, technical resources, or other needs of organizations interested in creating SMPs. The 49 survey respondents represented all of the major basins in Colorado. Respondents were in various stages of developing SMPs, although over half had not yet considered or had only briefly discussed SMPs.

When the water professionals were asked about recreational and environmental issues and opportunities, they usually highlighted the importance of basin water quantity rather than quality. Specifically, “altered flow regimes” and “low flow condition or absent riparian buffer” topped the survey rankings of the most important issues. Geomorphic processes such as floodplain connectivity and channel erosion were also identified as important environmental priorities. Policymakers and citizens across the state of Colorado are currently debating water rights allocations and future storage projects, and both of these issues were emphasized in the survey responses.

When asked to name agricultural and municipal water supply challenges, respondents highlighted the inefficiency of irrigation techniques and the need for a climate that encourages innovation by reducing its risks. The other top issues included lack of conservation incentives and inadequate storage. Although the question about supply did not

specifically ask about environmental issues, the water professionals linked agricultural and municipal water use to ecologically important topics such as: in-stream flows, intact riparian vegetation, and soil health.

Respondents also pointed out the socioeconomic barriers to pursuing management priorities. Funding constraints are an obvious limitation, but navigating the state of Colorado’s complicated system of water rights and in-stream flows can also be an enormous challenge. Respondents emphasized working together with the agricultural community to improve stream health, a process that relies on establishing trust and open lines of communication.

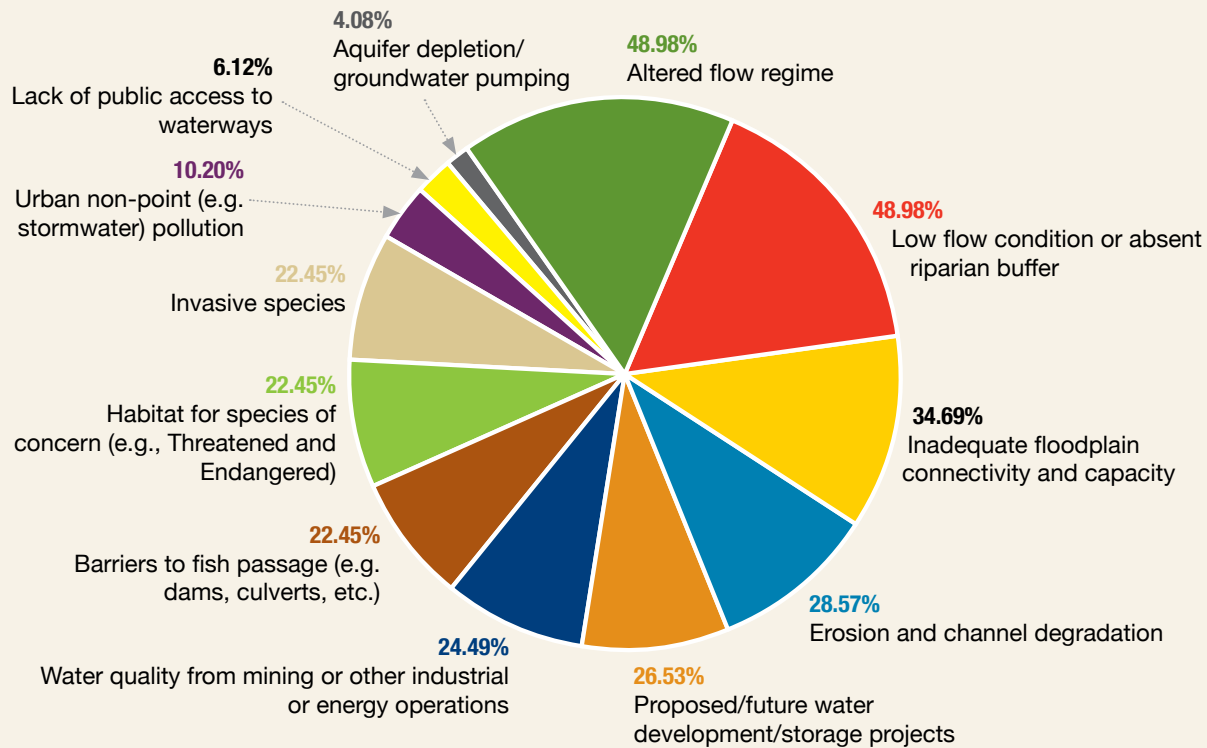
One of the questions implicit in the Colorado Water Plan’s SMP goals is the definition of priority streams. Therefore, survey respondents were asked to describe what makes a stream a priority. Two themes dominated the survey responses with 37% of participants prioritizing high quality streams and critical habitat values, while 34% of participants prioritized those that are most degraded by water depletion or water quality issues. The remainder of respondents offered a mixture of either both those priorities, were uncertain, or suggested priorities should relate to the needs of the users in the basin. Some respondents suggested focusing efforts on headwaters streams to allow benefits to trickle down, while others focused on the main stems that experience heavier use. Balancing these various perspectives will be an important part of future discussions as communities move forward with developing and funding SMPs at the basin and state levels. 



Whitewater Park in Salida, Colorado is one of many recreational areas on the Arkansas River. Photo by Galt57/Wikimedia Commons.



Q7 What are the three highest priority environmental and recreation issues and opportunities for improvement for the stream system where you work or where you are considering an SMP?



Q8 What are the three highest priority agricultural and municipal water supply issues and opportunities for the stream system where you work or where you are considering an SMP?

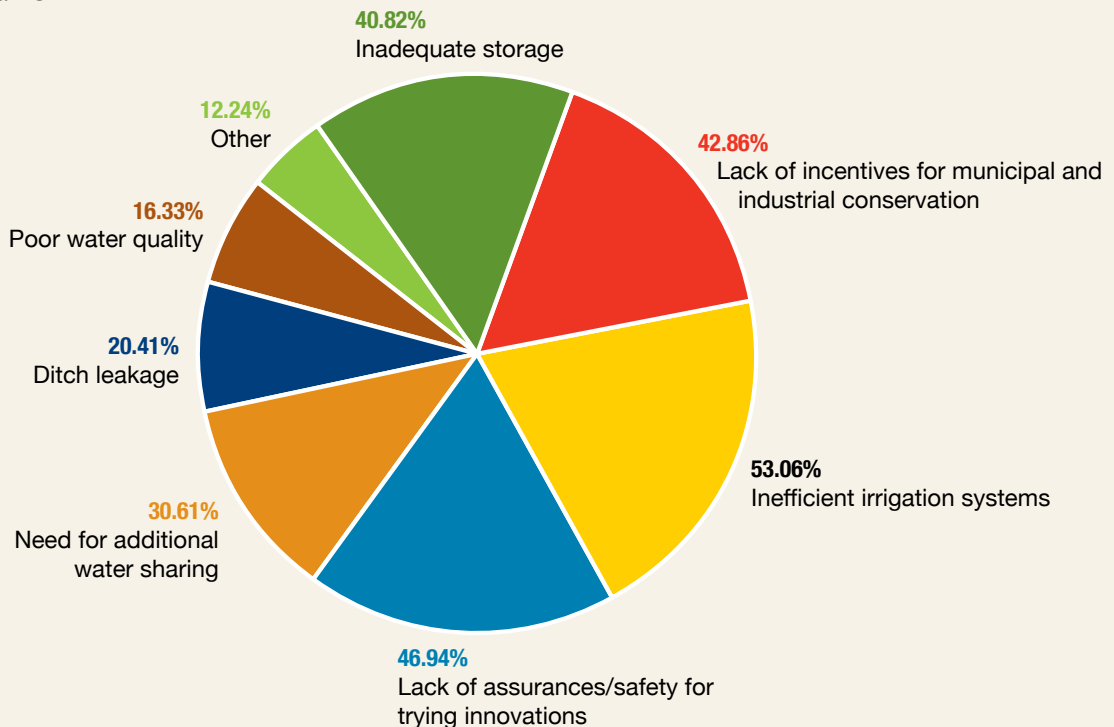


Figure 1. Stream Management Plans – Needs Assessment Survey

Stakeholders and the Crystal River Stream Management Plan

A Description of How the SMP Process Brought a Community Together Around Water Management

*Chelsea Congdon Brundige, Water Program Director, Public Counsel of the Rockies
Jonathan D. Bartsch, Principal/CEO, CDR Associates*

Overview

The Crystal River, in the lower Roaring Fork watershed, supports a biologically diverse ecosystem. It supports the water needs of three small municipalities, an extensive hay and cattle ranching economy, as well as increasing recreational and aesthetic uses. Over the past decade, numerous studies and projects have contributed to a piece-meal assessment of the overall health of the river ecosystem. The Crystal River Management Plan (CRMP) developed by Lotic Hydrological, Roaring Fork Conservancy, Public Counsel of the Rockies and CDR Associates is a science-based and stakeholder-driven assessment of the entire watershed that identifies, prioritizes, and guides management actions that honor local agricultural productivity, preserve existing water uses, and enhance the ecological integrity of the river.

Agricultural production has long been the cornerstone of the Crystal River Valley and remains so today. However, growing population and changing demographics in the valley have heightened interest in recreational, environmental, and aesthetic values of the Crystal River Valley. In recent drought years, record low flows fueled concerns and controversy about the health of the river. In response, the Roaring Fork Conservancy provided local capacity to develop the CRMP in a collaborative process to explore and discuss values, resource use priorities, and feasibility constraints around water management alternatives. The stakeholder process represented a significant investment of time, trust, and cooperation throughout the project, and provides a foundation for working together as a community to implement the CRMP recommendations.

Crystal River Management Plan Stakeholder Process

The stakeholder process was one of three components of the CRMP framework (Figure 1), and participants included agricultural producers, State water administrators, local municipalities, natural resource agencies, local and national environmental organizations, recreational advocates, and other water rights holders.

Community outreach to identify objectives and values (SMP Steps 1-3) began during the 2012 Crystal River Snapshot Assessment (S.K. Mason Environmental, LLC, 2013). That project demonstrated the vulnerability of the lower Crystal River to stream health degradation during drought and/or low flow conditions (Figure 2). Project partners shared the findings in conversations with local agricultural and municipal water users to initiate a dialogue about the impacts of water depletions.

Over the 18-month CRMP process, the project team produced quarterly newsletters, held group and individual meetings, and hosted “Crystal River Conversations” to clarify outstanding questions, summarize results from previous studies, refine objectives, and test the feasibility of management alternatives.

In early meetings, agricultural producers, water right holders, and staff of the town of Carbondale revealed strong personal, cultural, and economic values associated with the river. Stakeholders also raised questions about management goals, including:

1. How much water is needed to make a difference for the ecological health of the Crystal River?
2. Where is water needed most?
3. When is water needed most?
4. Are their engineering solutions to the issues in the watershed?

The stakeholder process represented a significant investment of time, trust, and cooperation throughout the project, and provides a foundation for working together as a community to implement the CRMP recommendations.



Figure 1. CRMP planning framework—The values and priorities of stakeholder groups [socio-economics] are characterized in relation to the condition of the riverine resources within the watershed [resource condition], and the physical processes that determine the movement of water, local channel forms, and impacts on aquatic life [physical processes].



Figure 2. The CRMP's catalyst—Streamflows observed on the Crystal River in the late summer of 2012. Green call-outs indicate measured flows. The thickness of the blue and yellow lines indicate the relative magnitudes of observed flows and the CWCB Instream Flow Right.

These questions helped guide planning with respect to Step 4 (establishing realistic goals for flow), Step 7 (selecting quantitative measures to assess progress), and Step 8 (determining new information that was needed). Specifically, the agricultural water users explicitly rejected both the CWCB's generalized ISF right for the river (100 cfs summer/ 60 cfs winter), as well as more targeted evaluations using R2Cross and Wetted Perimeter methods for specific reaches in the lower Crystal. This

resistance allowed project partners to understand existing constraints on any proposed flow targets. In response, we developed ecological metrics of aquatic habitat connectivity and quality, riparian recruitment, and channel structure to encompass the key processes crucial to a riverine ecosystem health. These metrics served to guide the evaluation of management alternatives. In addition, these questions demanded deeper discussions on the feasibility of adopting management alternatives.

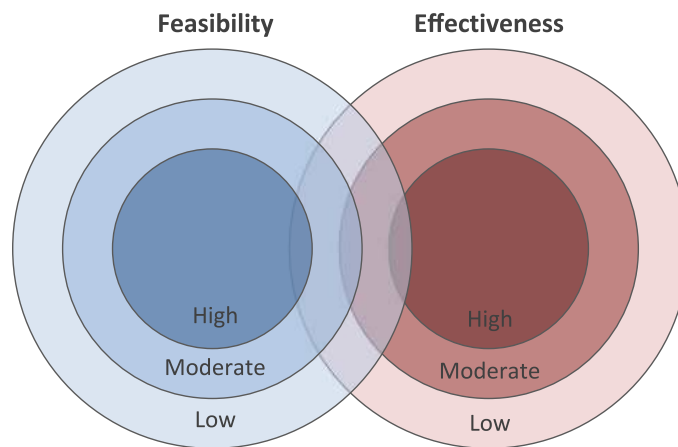


Figure 3. The most effective management options are rarely the most feasible. Optimization of management generally reflects some degree of compromise between the two.

The CRMP process required innovation in Step 9 (quantifying flow recommendation). Due to the prevailing skepticism about the figures and motives of local watershed and conservation project sponsors, the decision-making framework was designed to be *descriptive* rather than *prescriptive*. Integrating an ecosystem functional assessment of the watershed with hydrological modeling of water availability, surface water allocation under State law, and return flows resulted in a very robust tool for evaluating the ecological benefits associated with various levels of flow across a range of drought and flood conditions. This tool (the Ecological Decision Support System or EcoDSS) was designed to allow stakeholders to collaboratively choose flow targets and alternative management practices based on their shared values, priorities, and constraints.

Through several days of facilitated meetings, stakeholders grew familiar with the methodology and results of the descriptive framework and developed confidence in the scientific assessment and hydrologic modeling. However, many expressed frustration with the absence of specific flow recommendations. In response, the project team presented a range of flow targets and the diversion reductions that would achieve threshold ranges of ecosystem benefits on the Crystal River under drought conditions.

Stakeholder input in early group meetings, informal “coffee shop” encounters, and community informational meetings also guided the choice of alternative management practices: market-based incentives for water conservation through bypassed flows; infrastructure improvements and efficiency upgrades; off-stream storage; and habitat enhancement through channel modification. This input illuminated management constraints beyond the ecological and physical processes such as agricultural operations, planting cycles, policies, markets, social attitudes, etc. (Step 10). In the final facilitated stakeholder process, the community contemplated adoption of flow targets to achieve *moderate* ecological benefit (or risk) under drought conditions, and the most acceptable projects or methods for achieving these flow benefits in the River (Step 11).

Conclusion

An effective stakeholder process begins at conceptualization, identifying individuals and organizations, framing questions, understanding stakeholder values and perspectives, building support for the scientific methodology, and clarifying the outcomes and timeframes.

The Crystal stakeholder process included substantial stakeholder engagement, particularly from the ranching community and other water rights holders, largely because the project evolved from a “quiet” or focused dialogue initiated by local conservation groups, and a recognized mutual concern about the river. The conversations that preceded public meetings built trust and collaboration.

The success of the CRMP depends on investment by stakeholders to articulate their *values* around the resource and evaluate and prioritize management alternatives. The CRMP process provided a forum for developing mutual understanding and confidence in data, results and process and fostered collaboration among stakeholder groups. This experience of discovery and trust-building helped the community focus on long-term management options that are both feasible and effective. (Figure 3)

The goal of the CRMP effort was to identify and evaluate management and structural alternatives that honor local agricultural heritage, preserve existing water uses, and enhance the ecological integrity of the river. But in the end it is only a plan. To realize the collective efforts of any SMP process, stakeholders must remain engaged and supported through the implementation process. To the extent possible, early discussion of expectations around implementation including: physical scope, funding, compensation, timeframe, responsibility, and leadership will help secure continued community collaboration to effect long-term change that balances agricultural, municipal, environmental, recreational and other needs.

The Crystal River Management Plan is available at the Roaring Fork Conservancy website: <http://www.roaringfork.org/publications/2016-crystal-river-management-plan/>



Finding, Analyzing, and Presenting Data for Stream Management Plans

A Practical Resource Guide to Types and Sources of Public-Access Data

Steve Malers, Founder and Chief Technology Officer, Open Water Foundation

Much of the data needed for an SMP is available through a clearing house of accurate, user-friendly databases maintained by the Colorado Division of Water Resources, and other publicly available sources such as the United States Geological Survey (USGS).

Colorado's Decision Support Systems (CDSS, <http://cdss.state.co.us/Pages/CDSSHome.aspx>) is the product of twenty-years of collaboration and refinement that has ultimately resulted in an approach the CDSS team refers to as "data-centered". In this approach, a collection of curated data is used with automated data processing to implement analyses that are self-documenting, repeatable, and transparent. The data-centered approach required investing in data processing tools and standard procedures. Significant up-front effort to scrutinize data and define processes resulted in efficiency gains as analysis and modeling efforts were scaled from prototypes to full implementation.

The primary requirement for maintaining and enhancing natural stream function is ensuring adequate water supply for environmental flows. Determining environmental flows is complicated by many factors including: site-specific conditions, requirements of different species, seasonal flow requirements, and the impact of steam channel geometry on depth and flow. Innovative approaches are needed to efficiently perform baseline analysis and explore options to understand environmental and recreational requirements.

CDSS as a modeling platform is intimidating in its complexity because the model datasets are virtual representations of complex physical and legal systems. The learning curve to effectively and efficiently use CDSS models is steep, more so for practitioners that do not work with the models or datasets on a regular basis. CDSS models' consideration of environmental and recreational (E&R) concerns is limited. The challenge and opportunity is to leverage CDSS and its data-centered

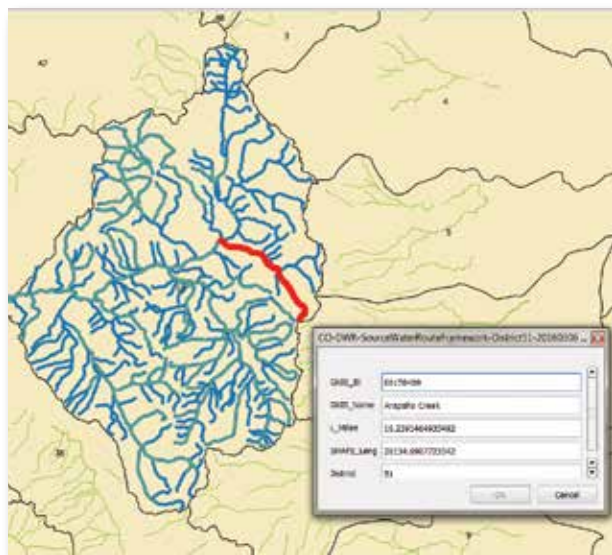


Illustration of spatial datasets created by Austin Severin of OWF from the state of Colorado datasets to facilitate use. Layers include streams from DWR's Source Water Route Framework (blue) and CWCB instream flow reaches (green). The SWRF layer allows users to manually select streams to see the full extent while the State is working to reference other data to this layer using stream mile. Courtesy of Steve Malers.

approach as a platform to support SMPs and enhance CDSS tools to better serve E&R purposes. Cultivating this "virtuous cycle" can result in more robust data and tools for SMP development and updates. The remainder of this article explores a number of tangible areas where CDSS and other technologies can benefit SMPs.

Time Series Data

Time series data for streamflow, diversions, reservoir releases, climate, and other data types are available from various sources, including the CDSS and other web services. Software that accesses machine-readable formats facilitates automated processing. SMPs can benefit from streamflow and other data at various time steps available

Spotlight on CSU Team and Large Wood Management in Streams

The Open Water Foundation works with CSU on collaborative research projects and also provides paid student internships to work on challenging water issues. These projects focus on developing data visualizations for complex water issues using cloud-hosted datasets and tools, which will be available on data.openwaterfoundation.org.

Current CSU Interns include:

- » **Katherine Bagnuolo**—CSU undergraduate majoring in Environmental Sociology and minoring in Business Administration. Katherine is helping to create an asset map of water organizations (including environmental NGOs) throughout the state of Colorado, to identify resources and opportunities to address complex water issues.
- » **Kory Clark**—CSU undergraduate majoring in Computer Science and minoring in Global Environmental Sustainability. Kory is helping to develop a standard approach for implementing WaterML 2.0, which is an open data standard for sharing hydrologic time series data between software tools.
- » **James Hansen**—CSU Graduate student in Civil Engineering with an emphasis in water resources—James is using Esri's ArcGIS and open source software to create animations of irrigated land and urban growth management areas.
- » **Austin Severin**—CSU undergraduate in Watershed Science. Austin is automating processing of public spatial datasets to create more value and improve access to datasets.

from the USGS National Water Information System (<http://waterservices.usgs.gov/>), State of Colorado web services (<http://water.state.co.us/DataMaps/WebServices/Pages/WebServices.aspx>), and other sources. However, the data may be difficult to normalize into a consistent format for analysis. For example, handling metadata such as units, spatial data, and data flags is often beyond the ability of simple formats such as comma-separated-value (CSV) and Excel tables. Time series utilized in a platform should include basic attributes such as location ID, data type, units, and data interval. The TSTool software developed for CDSS can be used to automate download and process time series data. Other tools such as R for statistics, geographic information system (GIS), Excel, and various models can also be utilized.

Spatial Data

Spatial data for water resources have in the past typically been available as geodatabases, ESRI shapefiles, and KML. Using these formats is straightforward with GIS software. However, spatial data are increasingly being used for web visualizations that use open data formats such as GeoJSON (<http://geojson.org/>), and well-known-text (WKT, https://en.wikipedia.org/wiki/Well-known_text) formats. These formats facilitate open data exchange and can be converted to other formats as needed. For example, the open data portal Socrata software used to implement the <https://data.colorado.gov/> website can provide GeoJSON datasets, and the Open Water Foundation is providing value-added datasets in GeoJSON format (<http://openwaterfoundation.org/>), including instream flow reaches for each water district and division in Colorado, with water right water district identifier corresponding to case number added to allow joining to the State's HydroBase database.

Analysis Platform/Framework

SMPs could benefit from the use of an analysis platform with shared software, standard data processes, and consistent conventions. A software platform can help ensure that a common core approach is implemented and will allow enhancements to be built as the process develops. The platform may use a tightly integrated set of tools and shared data management solution (such as CDSS and the HydroBase database) or a loosely integrated set of tools that relies on open data formats to allow components to share data. One example of such a platform is how CDSS data and software were used for the South Platte Basin Implementation Plan (BIP) where E&R data were associated with stream layer data to produce a "Stream Mile Representation Framework" with 0.10 mile stream segments, which allows for additional analysis of time series data at locations associated with the stream segments.



Cache la Poudre Watershed (District 3) Irrigated Agriculture

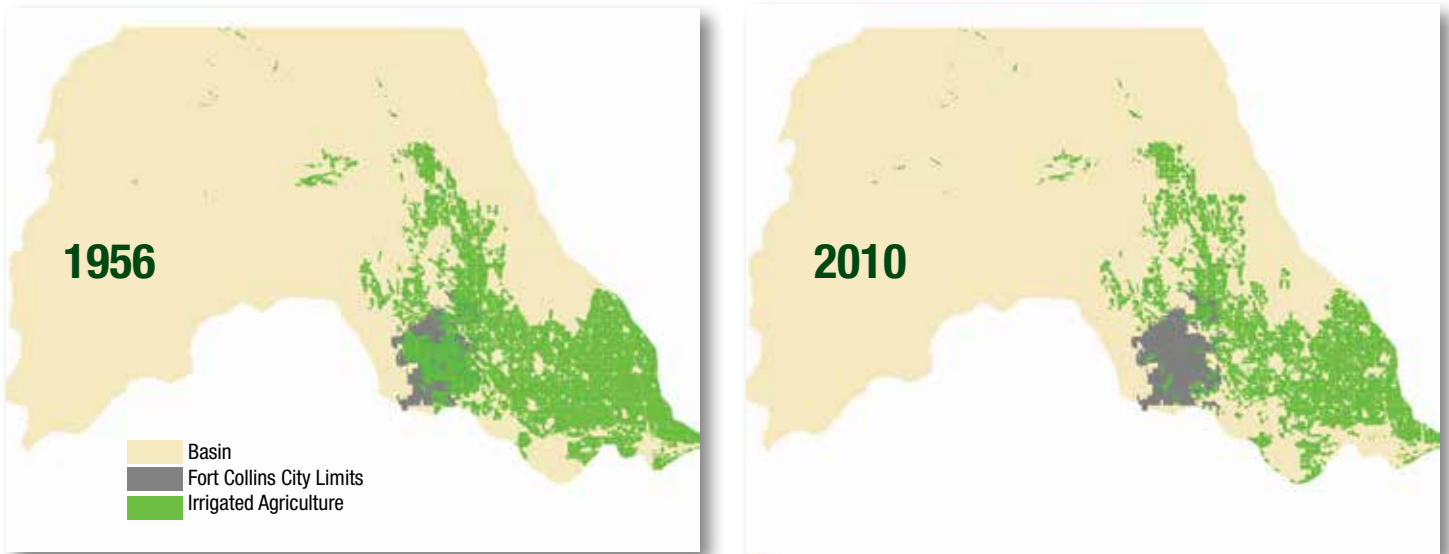


Illustration of spatial datasets created by OWF. Examples of irrigated areas along Cache la Poudre River from 1956-2010. Files are the result of James Hansen's efforts and illustrate changes in irrigated agriculture over time. Courtesy of Steve Malers.

Value-Added Datasets

Organizations publish data to meet their mission or statutory requirements, but often stop short of “connecting the dots” for more complex issues. Value-added datasets may involve joining datasets to create a new dataset, joining data across jurisdictional boundaries, providing a time-stamped archive of dataset versions, or reformatting data to facilitate use. Without such datasets, analysts and modelers must recreate the datasets themselves. Cloud-hosted data platforms facilitate data storage and access. For example, <https://data.colorado.gov/>, CDSS map viewer, and <https://databasin.org/> include basic and value-added datasets. Value-added datasets produced to support SMPs could be provided in the cloud to facilitate collaboration.

Process Automation and Scaling

Process automation is a key aspect of the data-centered approach and requires: (1) machine-readable data formats (avoid PDFs or obscure file formats) – for example, CSV, Excel tables, XML, JSON; (2) sufficient metadata for datasets (data units, handling of missing data, and data flags); (3) unique real-world identifiers for data objects, for example location identifiers, and standard identifiers for static data such as E&R attributes; (4) software tools that can represent analysis steps as a workflow; and (5) software tools that allow linking to other tools, to allow flexibility in addressing complex problems.

The CDSS TSTool and StateDMI software are examples of tools that meet the above criteria, and Python is often used with GIS processing. TSTool can be used to automate large processes involving many types of data. TSTool can be used to prototype a process and then scale to large systems, perhaps by combining GIS/Python,


TSTool, and Excel. The effort of defining well-documented automated processes helps ensure that processes use good science and can be repeated.

Visualization

Data visualization will increasingly be a component of many projects, extending beyond basic Excel graphs and GIS maps. Cloud visualization tools such as Tableau, ArcGIS Online, custom web visualizations, and many other technologies allow a web browser to become a visualization platform. Collective investment in useful SMP visualization techniques could result in shared tools that are applied efficiently and consistently across basins. With some effort, it is possible to enable interactive data sets that provide context and understanding of important water issues.

Publishing Results

Complex studies and models often suffer at the end of projects in that resources run out and work products default to “engineering reports” provided as PDFs. Platforms can help in this area because documentation for the platform is handled by the maintainer of the platform and projects can focus more on publishing data and documentation specific to the project. One approach is to plan at the start of a SMP project how all data and work products will be published and actively do so throughout the project.

Development of SMPs for Colorado's river basins will require extensive use of data and analysis tools. There is an opportunity to develop a data-centered platform that leverages CDSS and other tools, resulting in self-documented, repeatable, and transparent analysis products that quantify environmental flows and other measurable outcomes. 

Stream Management Planning

Establishing Targets and Metrics for Flow

Meg White, Freshwater Scientist, The Nature Conservancy

Completion of the Colorado Water Plan (CWP) sets in motion an implementation phase emphasizing the protection of our rivers, acceleration of urban conservation, improvements to aging agricultural infrastructure and on-farm irrigation efficiency, as well as improved flexibility to manage water to meet the needs of both people and nature. These activities have grassroots support. The 2016 State of the Rockies poll found that 77% of Colorado voters prefer using current water supply more wisely to address the state of Colorado's water needs rather than diverting more water from rivers.

SMPs are an opportunity to come together to seek better solutions in a process that is:

1. science-based and data-driven;
2. collaborative and stakeholder-driven;
3. focused on flows and opportunities to improve or protect environmental and recreational values; and
4. adaptive and scalable.

Because SMPs are only as powerful as they are specific, defining the main goals for the flows is critical, as is an emphasis on those measures that are quantitative, or measurable.

Deciding where to start in synthesizing flow data in an SMP can be overwhelming. While there is no single "right way" to approach an SMP, some key steps to strengthen the process and potential for success include: (1) defining a framework for stream management decisions and learning; (2) establishing quantifiable (and ideally scalable) goals and measurable outcomes; (3) determining data needs and gaps in knowledge; and (4) generating key actions and recommendations. The rest of this article walks through these steps and data sources available or needed to design a successful, and quantifiable, SMP. (These steps are embedded in steps 4, 8, and 11 of the SMP process described in the CWP.)

Defining a Framework for Stream Management Decisions and Learning

Freshwater conservation is often a moving target, and as water demands increase and supplies diminish, pressures continue to increase on water resources management for people and nature. How much protection is enough? Which



The Open Standards Conservation Planning Approach ensures selected strategies will result in effective outcomes that are tied to priority issues. Photo courtesy of Marion Tiemann.

approaches are the most effective? How do we know if costly projects and plans are actually working? Answering these questions is fundamental to successfully designing and implementing SMPs. As with any other complex challenge, a systematic approach is needed to assess the effectiveness of planning and management actions and introduces adaptive learning and management—one that helps organizations determine what works, how management can be improved, and directs actions for better outcomes.

One such established framework that is simple and presents a five-part project management cycle that can be applied across a wide spectrum of projects is the Open Standards Practice of Conservation (Open Standards; <http://cmp-openstandards.org/>) developed by a coalition of conservation groups called the Conservation Measures Partnership. *Open Standards* offers a framework, focused on conservation, that aims to bring together project design, management, and monitoring to help practitioners create a common terminology across initiatives and improve the efficiency and effectiveness of projects. Defining a framework for your SMP, like Open Standards, can serve as a powerful foundation to develop measurable outcomes, identify knowledge gaps and data needs, and generate recommendations for conservation success.

Establishing Measurable (and Scalable) Goals

Measurable goals serve as a way to articulate, in quantifiable terms, the desired state of a river and river flows. By framing the goals in a quantifiable way, stakeholders



Roundtail Chub illustration by Joseph R. Tomelleri.


can to identify specific outcomes and track measures of success for across multiple scales, and clearly identify ways in which the goals are linked. A strong outcome statement should be specific, measurable, and realistic such as: “Sustain, or improve, flow conditions in 10 different river locations to support populations of roundtail chub” or “Increase X acres of wetlands for shorebirds and waterfowl by 2017”. Ideally, the outcomes will be scalable (i.e., identified at local and regional scales) and developed in a process that is stakeholder driven. There are abundant examples of groups and processes that have identified measurable goals including: the Colorado Natural Heritage Program, American Whitewater Flow Surveys, The Nature Conservancy, Colorado's Wildlife Action Plan, and the Upper Colorado River Endangered Fish Recovery Implementation Program.

Identifying Flow and Data Gaps

Once measurable goals and outcomes have been created, the next step is to determine what types of flow data and knowledge exist for the specific river or region. By conducting an inventory of existing data and data gaps, stakeholders can outline specific steps to fill those data needs in order to understand baseline conditions. Baseline data, such as streamflow, water quality, and the extent and condition of riparian habitat, are often not available and the collection of additional field information may be required to establish baselines and outcomes. An example of an action step from this process could be: “Based on analysis of existing flow dynamics, currently only three river segments can sustain 3 (of the 10) critical populations of roundtail chub. As a result, we need to conduct flow gap analyses in X regions and identify seven additional stream segments to improve flows to sustain these important roundtail populations.” Steve Maler summarizes the data sources that can help establish flows and flow targets in this issue. They include: Colorado Natural Heritage Program for biodiversity data (<http://www.cnhp.colostate.edu>); U.S. Geological Survey (USGS) stream gage data for historic and current conditions (<http://waterdata.usgs.gov/nwis/rt>); Colorado's Decision Support Systems (CDSS; <http://cdss.state.co.us/Pages/CDSSHome.aspx>).

Quantifying Specific Recommendations/Actions for Habitat and Flow Conditions

Once goals have been established and flow needs identified, the last step in designing a successful SMP is to identify action steps and recommendations. As mentioned above, an explicit statement that highlights a key action might be: “From the flow gap analysis results, X section of river needs environmental flows to maintain roundtail populations and will require reservoir reoperation to achieve this outcome.” In order to generate these statements, there are a number of tools available to quantify and model flow needs across multiple scales to develop data-driven and science-based recommendations. Broader scale tools can be helpful in understanding baseline conditions and prioritizing implementation, but may not indicate what should be done in a particular location. Site-specific, local tools are needed for these purposes. Some of these broader scale tools include: (1) the Watershed Flow Evaluation Tool, which models and evaluates risk based on potential flow changes; (2) Colorado Wetlands Inventory, which provides comprehensive information on the extent and distribution of wetlands; and (3) StateMod (as part of CDSS), which is a monthly and daily surface water allocation and accounting model capable of simulating various historical and future water management policies. Local scale tools provide more explicit information and include: (1) Physical Habitat Simulation (PHABSIM), which predicts aquatic habitat changes associated with flow alterations; and (2) River 2D, which is a hydrodynamic model emphasizing fish habitat; and R2Cross, which models instream hydraulic parameters focusing on riffle habitat.

Using these steps to guide the SMP process provides an opportunity to establish a framework that is science-based, data-driven, actionable, and focused on water needs/flows for environmental and recreational outcomes. It should be noted, however, that SMPs may (and perhaps should) also include social and economic outcomes. While stakeholders can develop an SMP independently of watershed master plans, or even when planning for economic development, a more comprehensive approach would be to develop stream and watershed plans conjunctively. 

Environmental Flow Methods and Planning Approaches

An Introduction to the Four Broad Classes of Flow Evaluation Tools and Summary of their Advantages

Claudia Browne, Water Resource Specialist & Bioregion Team Leader, Biohabitats

How much water does a river need to support a healthy ecosystem while meeting human water needs? When and where are streamflows needed, and of what quality? These are the questions at the heart of determining environmental flows, which SMPs are designed to help to address.

A Global and Local Challenge

Throughout the world, interest in providing water for ecosystems is gaining momentum. With intensifying water demands, diminishing supplies, and uncertainty about climate change, water resource managers are being driven to find innovative water solutions to support native ecosystems. In Australia, the “*National Principles for the Provision of Water for Ecosystems*” was introduced in the late 1990s to define water requirements for various ecosystems. Since then, numerous countries have established similar policies, including the European Union’s “*Water Framework Directive*” to highlight the importance of integrating ecosystem function into water management. Some of the challenges of managing rivers for multiple objectives

and user groups date back hundreds of years. In the early 1800s, the United Kingdom established a Compensation Flow Policy which was applied early on when mill users were impacting downstream users and later when pollution impacts were required to be mitigated by dilution. During the late 1940s, in the western United States, Environmental Flow Requirements (EFRs) began to be a part of management of dam projects and continued to evolve through the 1970s as the environmental movement and concern about freshwater fisheries grew.

Colorado’s existing water management framework, much like the rest of the western United States, was not designed to take into account ecosystem needs and flow variability. The beneficial use tenet of state water rights means that water is allocated for human uses that are first in time. Rights are primarily defined in terms of agricultural, potable, and industrial uses. The prior appropriation doctrine further establishes that water is delivered to senior water right owners before being distributed to junior right owners. In the 1970s, the State’s Instream Flow Program was established to provide a mechanism

Ecological needs often go beyond minimum fish flows and managers need to consider riparian forest ecosystems and the species that live in these habitats that are increasingly at risk.



for protecting aquatic habitat and preventing cessation of flow in some river reaches by protecting minimum flows. The application of the instream flow program is limited, however, and more holistic strategies are also needed such as those highlighted in the 2015 Colorado Water Plan (CWP). More recently, Colorado's Statewide Water Supply Initiative recommended protecting environmental flows and pursuing water management strategies that provide sufficient water for temperature needs and lifecycle cues for both aquatic and riparian species. Ecological needs often go beyond minimum fish flows and managers need to consider riparian forest ecosystems and the species that live in these habitats that are increasingly at risk (as highlighted in David Merritt's article). To successfully manage rivers, a range of hydrologic conditions must be considered. Ensuring water for riparian and wetland areas is particularly important in

Colorado, because these areas cover less than 3% of the land area but provide critical habitats for 80% of wildlife species. In addition to habitat values, these wetlands and riparian areas offer other ecosystem services such as improved water quality and flood attenuation.

Fllooded with Tools

Over 200 environmental flow management tools have been developed through the years in over 40 countries to address flow challenges. Some focus on only one type of output such as hydrologic or hydraulic results, while others look at habitat simulation, and still others are more holistic or blend combinations of methods. Some tools are used to set environmental flow requirements based on thresholds and some EFRs are more incremental or dynamic. Below are brief descriptions of general flow evaluation tool categories.

Thinking Outside the Channel Flows for Riparian Habitat

*Interview with David Merritt, Riparian Plant Ecologist, National Stream and Aquatic Ecology Center
USDA Forest Service, & CSU Affiliate Faculty, Department of Forest & Rangeland Stewardship
Jessica Hardesty Norris, Ecologist and Technical Writer, Biohabitats*

An SMP will be more robust if it looks beyond a single species and beyond the channel. The riparian habitat along river banks is created and maintained by hydrology, which means that these areas can flourish or wither in accordance with the stream management.

Flows that are defined only in relation to single fish species, will not capture the needs of the adjacent flood plain and riparian habitat, and could result in a piecemeal approach to stream management, according to David Merritt, a Riparian Plant Ecologist with the U.S. Forest Service and CSU Affiliate faculty member in the Department of Forest and Rangeland Stewardship. We ignore them at our peril. "Wetlands and riparian areas have a disproportionately important role in landscape function relative to the acres they occupy," Merritt adds.

Historically, we have approached modeling riparian vegetation as a function of hydrology and have used models that focus on aquatic species and occasionally one or two plants. The designated species might be selected to represent a larger group or because they are particularly popular, like cottonwoods. The specifications about how much water a species can tolerate and how often can be complicated, and it just is not feasible to create a single model that can

handle all 300 species that may be found within a riparian forest.

Merritt and his colleagues, on the other hand, have developed groups or guilds of riparian species that have similar hydrologic adaptations, using a lumping technique that can transform the list of 300 species and convert it into nine functional guilds.

This idea of functional types is innovative in stream modeling, but it is hardly a novel concept. When Merritt's lab first got involved with helping managers support riparian habitat in the Grand Canyon, they presented their approach to a large stakeholder meeting. Merritt described to the public how their approach would separate the species from their taxonomic species names, and instead would look at their form and function and then group them according to their likenesses and similarities. "The representative from the Hopi tribe spoke up and said that the tribe supported that approach, and that their people for a very long time had looked at the world in a similar way, where, instead of genus and species, you look at how the plant acts and how it responds to its environment." So there is an "ancient and deep philosophy" that supports this broader way of looking at ecosystem interconnections.

1. Hydrologic Methods

- » An index approach that provides simplified rules of thumb based on historic data for annual average stream flow (AAF). Most common is Tennant (Montana) Method from 1976 which established thresholds as % of annual flow for fish:
 - ◇ 10% of AAF = Minimum flow for short-term fish survival
 - ◇ 30% of AAF = Fair
 - ◇ 60%+ of AAF = Excellent to outstanding (optimum)
- » Has been used by 25 countries
- » Since 1990s, methods have expanded added flow variability, such as range of variability approach (RVA) based on 32 indicators of hydrologic alteration, and analysis of possible scenarios
- » Can provide very preliminary estimates, but needs to be modified to account for monthly flows

2. Hydraulic Rating Methods

- » Methods based on field observations at riffles (shallow sections)
- » Wetted-perimeter method relates the river width to discharge. Produces environmental flow regimes that are based on “breakpoints” of habitat decline for fish and macroinvertebrates. For example, a “Habitat retention” criteria may be based on maximum allowable percent change in wetted area
- » R2CROSS, Colorado’s standard method is used to establish requirements for instream flow rights looking at depth, percent of bankfull wetted perimeter, and average water velocity

3. Habitat Simulation Methods

- » Similar to hydraulic methods but ties hydraulic properties to specific species
- » IFIMs—Instream Flow Incremental Method
 - ◇ Includes US Fish and Wildlife Service PHABSIM physical habitat simulation
 - ◇ Usually specific to *single species*
 - ◇ Establishes suitable habitat cross-sectional velocities
 - ◇ Results in effective habitat over time
- » Approx. 60 methods developed worldwide, but many only used a few times. Computer-aided simulation model for instream flow requirements (CASI-MIR) used in Europe
- » Methods are widely used and advancing in complexity

4. Holistic Methods

- » Refers broadly to methods ranging from prescriptive to conceptual that address ecosystem

as a whole not just hydraulic parameters or biologic needs of single species


- » Often utilize team of experts
- » Building Block Method (BBM) most commonly used of holistic methods
- » South Africa and Australia are most frequent users

Since the late 1990s, holistic flow assessments appear to have gained momentum. Indicators of Hydrological Alteration (IHA) was one of the first flow assessments that identified the collective impor-

Indicators of Hydrological Alteration (IHA) was one of the first flow assessments that identified the collective importance of key components of flow variability.

tance of key components of flow variability: magnitude, timing, frequency, duration, and rate of change. Building on the IHA method, the natural flow regime, linked temporal flow components to ecological responses and introduced an important framework for describing riverine processes. In 2010, CSU professors LeRoy Poff, Brian Bledsoe, and David Merritt and other individuals built on their earlier work and proposed the Ecological Limits of Hydrologic Alteration (ELOHA) approach based on understanding the following: 1) the hydrologic framework; 2) the regional classification of the river system; 3) the degree of alteration; and 4) flow-ecology relationships.

The recent developments in environmental flow tools all highlight the need to evaluate flow regimes based on a variety of ecological functions. Depending on the circumstances, these functions may include not only minimal baseflows to support aquatic species, but flows to moderate temperature, flood flows of inundation periods for native species recruitment and riparian vegetation distribution, effective discharge for sediment transport and channel maintenance, and surface water and groundwater interactions associated with alluvial storage.

Choosing which flow evaluation tool(s) to use for a SMP process will depend on the availability of existing data and questions that need to be answered in a specific stream system, which is why it is so important to shape the process and conversation around a results based process tailored to the local setting and stakeholders as described in Meg White’s article and elsewhere in this newsletter issue. 



Developing a Scientific Foundation to Assess and Improve a Community River

Case study from the Cache la Poudre River in Fort Collins, Colorado



Daniel W. Baker, Civil & Environmental Engineering, Colorado State University
Jennifer Shanahan, Watershed Planner, Natural Areas Department, City of Fort Collins

The Cache la Poudre River is a hard-working river. Not only does it provide much of the irrigation and drinking water for the northern portion of the Colorado Front Range, but it also serves as a beloved ecological, aesthetic, and recreational asset to the communities it flows through. When the 2010 update to the Fort Collins City Plan (<http://www.fcgov.com/planfortcollins/pdf/pfc-summary.pdf>) adopted the goal of managing a healthy and resilient Poudre River, city staff asked themselves a series of reflective questions:

- » What is a healthy and resilient river?
- » Is the Poudre River currently healthy and resilient?
- » If not, what can be done to make the Poudre River move the Poudre toward this goal?

These questions also catalyzed a series of applied research projects to provide the data and tools to better understand, communicate and plan for the future of the Poudre River.

Need For Assessment and Decision-Making Tools

Sometimes the hardest part of solving a problem is deciding on the first step. While a mottled history of data existed for various aspects of the river's condition, the data components had never before been pulled together into a single

conceptual framework. Thus, in 2011, the conceptual backbone of the Poudre River Ecological Response Model (ERM; <http://www.fcgov.com/naturalareas/eco-response.php>) was created using existing data and scientific knowledge of ecological functions of the river. The ERM was a collaboration between scientists from the city of Fort Collins, Colorado State University, the U.S. Forest Service (USFS), The Nature Conservancy, and the U.S. Geological Survey (USGS). Early in the process it became clear that the best model structure would need to allow the team to incorporate both quantitative and qualitative information. This was necessary because comparable data were not available for each topic (for example flow data are abundant and temperature data scarce).

The group adopted a probabilistic modeling framework that integrates many different subjects into a common unit. Next, all of the available hydrologic, geomorphic, water quality, biotic, and riparian data were evaluated and incorporated into the model. Finally, a spectrum of past, present, and future flow scenarios was created and run through the model to determine the effects of each flow scenario on the condition of key indicators of river health. As a scientific tool to holistically evaluate likely trends in *future* river condition, the ERM model worked well, though the knowledge gained from this modeling process was not specific enough to be directly applicable to boots-on-the-ground projects that require an immediate understanding of *current* conditions, both locally and at the landscape scale.



Flooding in the riparian area along the Cache la Poudre River in Fort Collins, Colorado. Photo courtesy of the City of Fort Collins.

Build an Assessment Framework and Form City Goals

The next big step in the process was to apply the knowledge gained from the ERM into an ecological assessment and communication tool. Thus, in 2014 the city of Fort Collins launched the River Health Assessment Framework (RHAF; <http://www.fcgov.com/naturalareas/riverhealth.php>). This project served three goals:

1. create a scientifically based framework to be able to assess current and monitor future ecological function;
2. identify thresholds and recommended ranges for ecological indicators to more clearly define the City's aspirations for river health; and
3. provide a scientifically based yet readily understandable communication tool.

Meeting these goals would in turn help guide and inform the City's river related initiatives. The RHAF was organized around ten indicators that represent the essential physical, chemical, and biological elements of the river and the method uses a standard A to F grading scale. Also, as with the ERM, the RHAF team sought to communicate the functioning condition of the interrelated and interdependent parts of the ecosystem. This integration within a single project differs from the more traditional approach of studying and managing rivers in fragments and unnatural political jurisdictions. Therefore the team selected a methodology that allows for the use of existing technical information and also provides the opportunity to fill data gaps using a rapid-assessment style evaluation.

Assess and Report River Condition

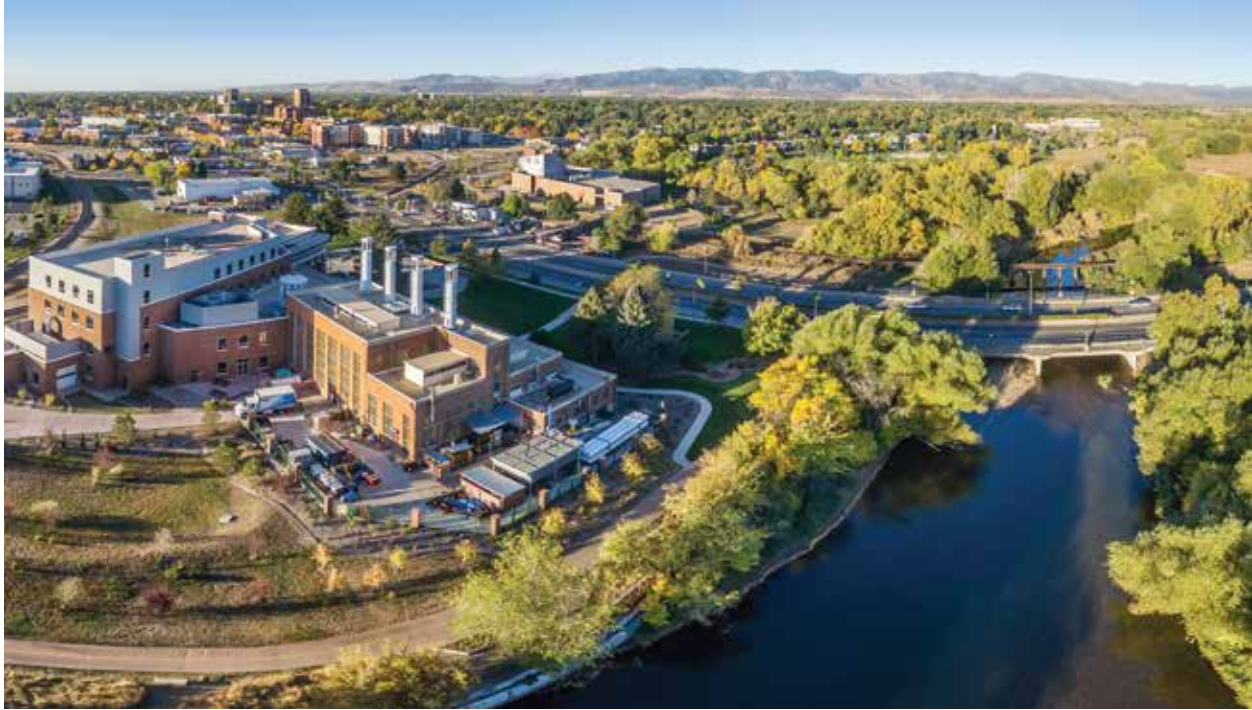
With the River Health Assessment Framework serving as the scaffolding, in 2016 the city of Fort Collins is now in the process of conducting its first comprehensive

The RHAF was organized around ten indicators that represent the essential physical, chemical, and biological elements of the river and the method uses a standard A to F grading scale.

ecological assessment (for defined reaches of the Poudre). The outcome of this effort will be presented in the City's inaugural State of the Poudre River report in early 2017. This project will assess current conditions of the river as a baseline for future change and supports decision making. As well, the summary will be in the form of a "River Report Card", which will serve as a tool for informed engagement by non-technical audiences such as city leaders and the Fort Collins community. By fostering this involvement and in turn considering the broader perspectives brought by diverse stakeholders, discussions and project prioritization of Poudre River management efforts will have greater chances of success, buy-in, and fiscal sustainability.

Find Operable Solutions to Meet City Goals

The final step in the process is to find boots-on-the-ground solutions to meet the City's goals. Currently, the city of Fort Collins is working with various interdisciplinary and interagency teams to continue to understand and improve the valued Cache la Poudre River. Projects range from fish passage to recreational improvements to studies that are diving deeper into the



The City of Fort Collins, Colorado is working with various interdisciplinary and interagency teams to continue to understand and improve the valued Cache la Poudre River. © iStock.com


complex hydrology and exploring innovative solutions to meet flow-related river health goals. Solutions are often multi-pronged, as reinforced by lessons learned in a riparian restoration project in the McMurry Natural Area, where an extensive new generation of native cottonwoods has recently established due to the combined effects of the physical lowering of a the floodplain with a well-timed moderate natural flood event. Hence, solutions are often complex, but no more complex than the lengthy and layered history that has caused the degradation of Front Range Rivers.

Lessons Learned

This process of going from data to modeling to problem solving has created a highly valuable ongoing dialog. The key lessons learned include:

- » A community cannot wait for all possible data

to become available before rivers ecosystems can be modeled, assessed and planned: hence build a flexible model framework which can adapt to new information.

- » Methods should be able to incorporate technical data *and* utilize local knowledge or rapid style evaluation to produce a holistic ecological assessment that is achievable within reasonable cost and time.
- » A model without buy-in from stakeholders won't get the job done, in the case of the Poudre it was necessary to have a multiple steps after the initial model development to build buy-in, produce an applicable product and determine feasible solutions.
- » Solutions are often as complex (or more so) than the causes of degradation. 

Maps from Models

One trick to bringing people together around shared science is building confidence in the modeling process itself. "Skepticism about modeling just comes from people not understanding it and thinking that it's hocus pocus. Seeing an equation or p-values, that can be intimidating," says David Merritt, who models riparian vegetation for the United States Forest Service (USFS). He has found that mapping helps create consensus.

"One of the most important things we've been doing is working with spatial models that show the results on a

map. You can see where this types of vegetation is today, and then show different scenarios of where the forest would be under proposed conditions." He finds that the best way to overcome any skepticism about the models is to show how well they do at predicting what is there now. His models of riparian vegetation by functional type can show what is bare, what mature forest is, and where scrub shrub dominate. Once stakeholders see how accurate the model is in mapping the current landscape, they are willing to put more faith in the predictive models.

Science-Based Strategies

The Critical Role Quantitative Methods and Simulations Play in Successful Integrated Management Planning

Lessons from the Crystal River Management Plan on a Framework for Using Quantitative Methods and Simulations to Build Consensus

Seth Mason, Lotic Hydrological

Bill Hoblitzell, Lotic Hydrological

Selecting the most appropriate stream management alternative is often a fraught process, because it is often difficult to reach consensus about existing conditions or predict the impact of management actions. In the face of this uncertainty, flexible tools that can quantify management targets and evaluate benefits of different alternatives can meet the needs of stakeholders and practitioners alike. This article shares the approach we developed for the Crystal River Management Planning process.

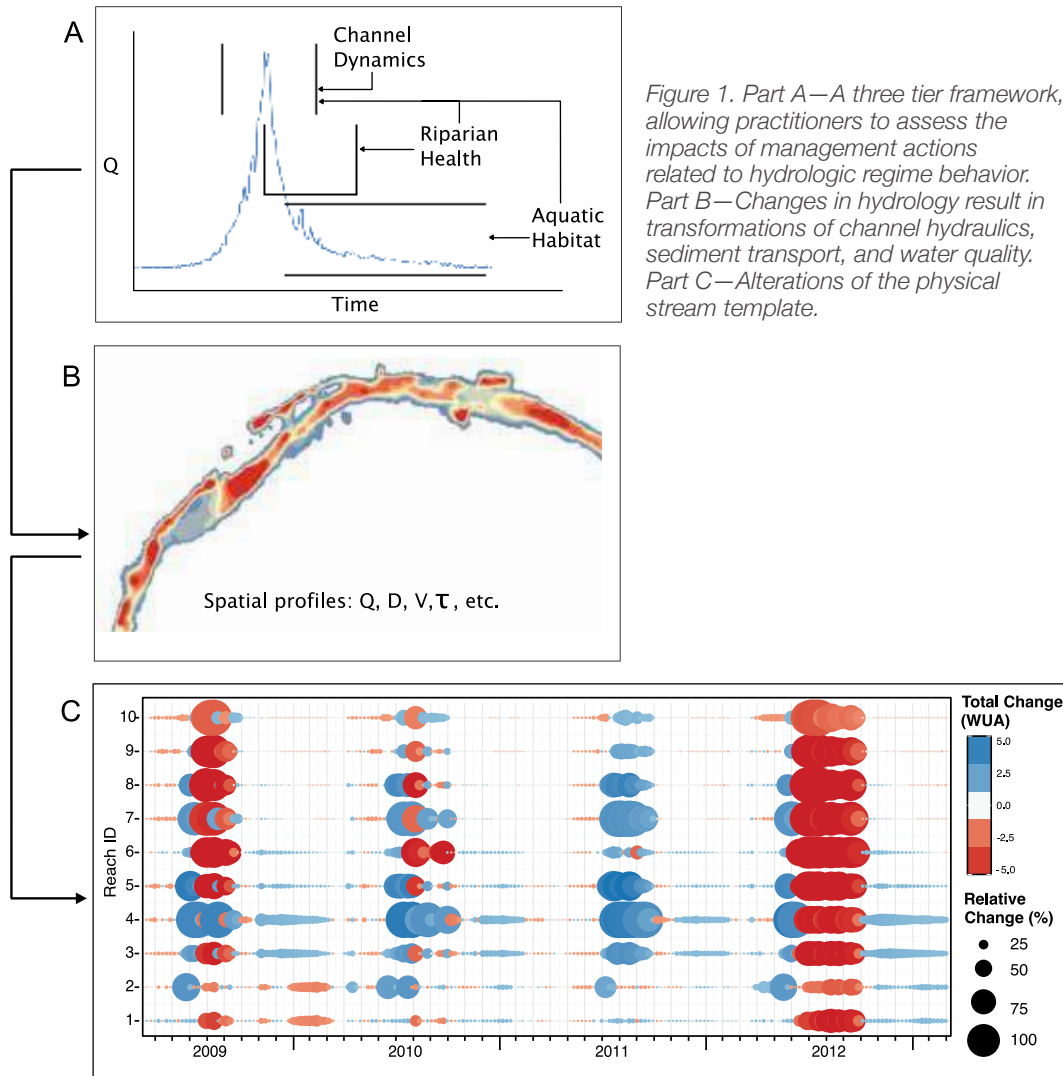
For example, robust cost-benefit analyses and consensus-building exercises must consider the inherent economic, social, environmental, and recreational pros and cons of the various management approaches available. These activities require strong quantitative foundations to ensure the credibility and viability of the resulting policy or management decisions.

To understand how management choices affect the ecological function of aquatic resources, practitioners can use science-based tools to connect the dots between cause and effect. Scalable, integrated, quantitative methods and simulation modeling approaches are commonplace in traditional water resource management decision-making processes. These approaches are likely to see increasing use in integrated SMPs within Colorado due to the complex nature of the problems these planning efforts consider. For example, complications frequently arise when characterizations of aquatic resource health—amidst the many positive and negative feedbacks that exist between patterns of land and water use, geomorphological processes, riparian corridor health, and aquatic habitat—rely solely on expert opinion. Such qualitative evaluations,

while important in their own right, do not lend themselves well development of benchmarks to reference future planning successes or failures against. In a similar manner, considering the impacts of agricultural efficiency improvements on groundwater recharge and late season return flows, or attempting to predict the aquatic or riparian habitat benefits associated with several possible channel designs, must be based on a rigorous assessment of predicted mechanistic or ecological changes to the system. Using a three-tiered hierarchical framework to analyze the spatial and temporal effects of river management provides a useful paradigm for integrated resource planning and construction of quantitative investigations:

- » Assess 1st—order effects: Management changes to the hydrologic regime control the magnitude, frequency, and duration of various ecologically relevant flow indicators.
- » Assess 2nd—order effects: The interplay between hydrology, channel structure, and flow regime impacts channel hydraulics and water quality characteristics.
- » Assess 3rd—order effects: Channel hydraulics and water quality intersect with the processes and conditions most relevant to recreational uses, channel dynamics, aquatic habitat and/or riparian biota.

The selection of specific quantitative or modeling approaches for evaluating each tier will likely be informed by the specifics of local management issues, stakeholder



acceptance/consensus, budget, and the geographic and jurisdictional scale or scope of a given planning exercise. Practitioners may apply a wide array of available scientific methods and software models to help understand impacts to non-consumptive use needs from changing water management, infrastructure efficiency, or channel structure (Table 1). Implementing the framework in its entirety may produce a collection of loosely coupled simulation and statistical models to 1) predict and simulate rainfall-runoff processes contributing streamflow to the segments of interest; 2) allocate and account for ‘paper’ and ‘real’ water along the segment according to Colorado Water Law; 3) estimate spatially distributed channel hydraulics or water quality conditions corresponding to a range of hydrological conditions, water conservation scenarios, or physical channel modifications; and 4) quantify ecological responses or perceived recreational quality to changing streamflow, water quality, or streambed topography on adjoining reaches of the river. Depending on the individual needs of a basin or community, a partial implementation of the framework may be a viable alternative. Integrated SMP efforts that utilize the framework will be adept at: (1) describing how water rights administration

affects stream flows at the reach level; (2) clarifying how flow changes influence physical channel structure and processes; (3) quantitatively linking hydrologic and hydraulic changes to ecological and recreational attributes of interest; and (4) successfully communicating results to decision makers and stakeholders in a fashion that allows for values-based planning and negotiation.

When executed well, integrated management plans should provide the documentation and decision support tools necessary for negotiating and implementing management decisions that reflect local needs and values. They can serve as master plans for how to manage water in times of scarcity, blueprints for restoring or rehabilitating a degraded river system, or pre-emptive protection for a basin likely to face increasing pressures from population growth, climate change, or shifting social values. The final form of any planning exercise will necessarily reflect the individual needs and concerns of the community and river system that produces it. However, those plans founded on strong scientific and quantitative methodologies are likely to enjoy a broader base, reduce the opacity of planning outcomes and recommendations, and improve repeatability and transferability of the adopted approach.

Fish Passage on the Front Range

Research and Application of Fishways to Improve Habitat Connectivity for Fish

Tyler Swarr, Master's Candidate, CSU Fish Physiological Ecology Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University

Christopher Myrick, Professor and Director, CSU Fish Physiological Ecology Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University



*The Orangespotted Sunfish (*Lepomis humilis*) is a native Great Plains fish species. Adults do not grow much larger than 4 in, but display brilliant colors when they are ready to spawn. They are closely related to Bluegill and Pumpkinseed, both of which are not native to Colorado. Photo by Jonathan Wardell.*

Along Colorado's Front Range, our ability to control and manage our waterways has led to greater flood control, improved irrigation, and improved delivery of domestic water, but the physical changes pose significant and in some cases insurmountable challenges for some species of fish. Therefore, supporting and restoring fish passage is often a habitat goal for SMPs.

Irrigation diversions and grade control structures often incorporate vertical drops that can block the upstream and sometimes the downstream movement of our native fishes. Fish biologists have long recognized that the marquee anadromous species like Atlantic and Pacific Salmon need to be able to migrate up rivers to reach their spawning grounds, but only more recently have we come to understand that the need to move freely up and down a stream or river is shared by most stream and river dwelling fishes.

Because of their smaller size and lack of sport or commercial uses, the habitat needed to accommodate movements by many of our native stream and river fishes is often underestimated. Even at adult sizes of nine inches or less, they can travel incredible distances in a short period of time. Research conducted at CSU on the swimming abilities of Great Plains fishes shows that some of these species will travel over 30 miles in three days without stopping. Our native fishes migrate using the longitudinal

connectivity of streams to reach spawning grounds, to avoid severe environmental conditions (e.g., drought or extremely high flows), or to reach ideal rearing habitats where food is plentiful and potential predators are not. Unfortunately, the structures that allow us to divert or store water, reduce erosion, and prevent flooding in our urban areas can disrupt this connectivity. An estimated 82% of Great Plains fish species are in decline due to reduced stream connectivity and habitat alteration.

Removing the barriers and other instream structures that reduce stream connectivity would benefit the native fish communities of the Front Range, but it is not always feasible because of the economic and societal functions of active structures. However, such structures can be made more "fish-friendly" by installing fish passage devices (fish ladders), which restore connectivity while retaining the hydrologic function of the structure. A large body of research has been completed on the development and design of fish passage structures in the Pacific Northwest, but these designs are generally optimized for large, strong swimming, or jumping species like salmon and steelhead.

The CSU Fish Physiological Ecology Laboratory (FPEL) has shown that the small fish species native to the Front Range are very good swimmers, relative to their size, but they are at best mediocre jumpers, which is not surprising given that they did not evolve in stream systems where vertical obstacles were common. The FPEL applies



The CSU FPEL experimental rock ramp fishway, which was built to better understand the needs of small-bodied fishes as they attempt to traverse fish passage structures. The CSU FPEL plans to use the results of the experimental fishway in future recommendations to improve other field designs. Photo by Tyler Swarr.

that research in collaboration with Colorado Parks and Wildlife to tailor fishway designs to our small fishes with good swimming ability.


Rock ramp (or natural) fishways consist of a sloped portion of channel that has rocks scattered throughout to provide refuge for the fish as they ascend the fishway. To better understand the needs of fish in terms of slope and cover as they traverse the fishway, the FPEL designed and constructed a full-scale indoor experimental rock ramp fishway with funding from the federal Great Plains Landscape Conservation Cooperative. A fishway that is passable by the slowest members of the fish community (e.g. small, bottom-dwelling fish like darters that are not very strong swimmers), stands a good chance of providing passage of most other fish species over the barrier.

The ultimate goal of the FPEL's work on fish passage, including the new experimental fishway, is to provide information that can improve practical applications, so the CSU researchers have worked in concert with Colorado Parks and Wildlife researchers and biologists, and with private and public stakeholders on the development and design of rock ramp fishways across the Front Range. The newest was recently installed on the Fossil Creek Diversion on the Cache la Poudre River in Fort Collins,

Spotlight on CSU Team and Large Wood Management in Streams

Many CSU professors and students are working in multiple departments, studying biological, physical, and engineering aspects of river management. One notable effort was just published in the April 2016 issue of the Journal of the American Water Resources Association (JAWRA). The paper highlighted the collaborative efforts of Professors Ellen Wohl (Geosciences), Brian Bledsoe and Michael Gooseff (Civil and Environmental Engineering), Kurt Fausch and Senior Research Scientist Kevin Bestgen (Department of Fish, Wildlife, and Conservation), and PhD Candidate Natalie Kramer (Geosciences), developing a framework for assessing the hazards and benefits of large wood in streams. The CSU team proposed a decision-making approach for large wood management using a series of stepwise tools. The process includes: an initial assessment checklist to evaluate threats to public safety, recreational users, property and infrastructure, private structures, and legal issues, followed by use of additional more refined tools as warranted. Given the significant benefits to aquatic habitat as well as influences on flows and storage in the alluvium, retention, and addition of large wood can be an important stream management strategy. Though the framework is still under development, stream management plans (SMPs) may benefit from considering the range of issues offered by the CSU team and perhaps the development of a large wood program in could be included in recommended actions for some SMPs.

Colorado. In the near future, the applied research on rock ramp fishways will also include determining the optimal slope for fish passage, adding bends to fishways, evaluation of recently installed fishways, and optimizing the geometry and spacing of the rocks.

Over coming years, we expect to see fishways integrated into more of Colorado's diversion structures, restoring the stream connectivity that will allow our streams to continue to harbor a colorful and thriving community of tough plains fishes. 

The Future of Water Markets

Opportunities for Innovation in the SMP Process

A Review of Current Water Markets and Water Sharing Strategies and a Description of the Potential of SMPs to Further Such Innovations

Spencer Williams, Business Development and Consulting Manager, Ponderosa Advisors LLC
MaryLou Smith, Policy and Collaboration Specialist, Colorado Water Institute

As is always the case with matters concerning water, scarcity dictates the need for collaboration and innovation. That being said, conflicting interests can be caught in seemingly constant opposition that gridlocks common sense approaches to complex problems. But finding our way out of such gridlock is possible. Any SMP will benefit environmental and recreational water use, but their comprehensive and stakeholder driven approach offers greater potential. The SMP process has the potential to serve as a proving ground for innovative approaches to water sharing and water market development.

Water Markets in Context

The purpose of SMPs as explained in the Water Plan is to protect or increase stream flows for environmental and recreational water uses on a watershed scale. But finding more water in already resource strapped watersheds is easier said than done.

Increasing efficiency among large water users can, in certain circumstances, reduce diversions from streams, while stream bed and riparian improvements can make the most of water that is already there. Both of these options should be implemented where appropriate. The conversation, however, would be incomplete without considering water sharing mechanisms that allow temporary transfers from high yield, senior water rights—namely agriculture—to environmental and recreational uses.

The divisive reality is that water-sharing mechanisms are un-proven and often require farmers to take on

disproportionate risk. Opponents in the agricultural sector have grounded fears: the threat of “buy and dry” and the loss of sustainable agricultural communities, unintended impacts on water rights ownership in light of the prior-appropriation

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doctrine, and re-timing or loss of return flows relied upon by downstream irrigators. Put simply, an agricultural operation cannot afford to jeopardize its most valuable asset.

In an effort to mitigate this potentially challenging impasse, organizations like the Colorado Water Trust, Trout Unlimited, and the Colorado Water Conservation Board have partnered to implement market-based allocation programs that protect and preserve water rights in agriculture, while allowing arm's length market-based transactions between recreational/ environmental groups and agriculture. The SMP process may have the necessary components to transform the methods used in these independent projects into integrated, watershed-wide markets that efficiently direct water towards its highest and best use.



Non-diversion agreements provide compensation to agricultural or other types of water users who reduce their water diversions. © iStock.com

Existing Water Sharing Methods

Current mechanisms are available that provide partial solutions to this supply and demand challenge. All of these mechanisms promote the idea of redirecting the water supply through market based transactions that will not permanently dry up existing farmland or negatively impact agricultural water rights.

- » *Temporary CWCB ISF leases:* The Colorado Water Conservation Board (CWCB) is working in conjunction with the Colorado Water Trust to enter into short-terms loans and leases of direct flow or stored water rights for use in Colorado's Instream Flow Program. These contracts can transfer full or partial rights with the approval of the State Engineer's Office, and have historically provided ecosystem functionality benefits as they shepherd leased water through instream flow reaches, particularly in dry years.
- » *Non-diversion agreements:* These agreements provide compensation to agricultural or other types of water users who reduce their water diversions. The agreements require no regulatory approval, but they do not provide a mechanism to shepherd water past downstream junior diversions, making them less effective in some scenarios.
- » *Permanent split season irrigation:* In efforts like the Colorado Water Trust's (CWT) McKinley Ditch project, Water Court-approved split-season irrigation will enable sharing between agriculture and environmental use. An irrigation water right can be changed, in coordination with the Colorado Water Conservation Board, to benefit instream

The Colorado Water Conservation Board (CWCB) is working in conjunction with the Colorado Water Trust to enter into short-terms loans and leases of direct flow or stored water rights for use in Colorado's Instream Flow Program.

flows, allowing typical agricultural practices during early summer but then protecting water in the river at the end of the summer when stream flows drop. Admittedly, these types of projects are complex to facilitate, but they provide a permanent solution to inadequate stream flows.

- » *Colorado Agriculture Water Protection Act (CAWPA):* As an alternative to historic "buy and dry" practices, this bill was signed into law earlier this year and is still in the early stages of implementation. CAWPA allows the owner of an irrigation water right to change the right through Water Court to allow leasing for other beneficial uses, without the need to first identify a lessee. Farmers and ranchers can keep and use their land and water, and with the approval of the State Engineer, lease their water when market conditions are favorable.

All of these tools can provide wet water for recreational and environmental uses, and they have a shared benefit: they put money in the water users' pockets, compensating them for any water they might furnish.



The purpose of SMPs as explained in the Colorado Water Plan is to protect and/or increase stream flows for environmental and recreational water uses on a watershed scale. © iStock.com

A successful water market must include willing sellers, willing buyers, and the ability to efficiently deliver water on demand from those sellers to the buyers.

While the benefits are numerous, these tools also have shortcomings and face formidable hurdles. Transaction costs vary between relatively simple non-diversion agreements to complex and costly water right change cases in water court. Organizations like the Water Trust do try to defray these costs for water users participating in their projects. The agricultural community also remains skeptical about the feasibility of leasing given the costs of fallowing land, the need for long term planning and forecasting, and the lack of necessary infrastructure to convey and store water to meet market demands.


The Future of Water Markets

Real potential exists through the SMP process to produce viable water markets, leveraging the existing water sharing tools into functional and efficient systems that satisfy all parties.

A successful water market must include willing sellers,

willing buyers, and the ability to efficiently deliver water on demand from those sellers to the buyers. Stakeholder engagement in the SMP process already brings the market participants together, creating opportunities for streamlined discussions and negotiations between sellers and buyers. Basin-wide analysis necessary for these projects could reveal opportunities to utilize existing infrastructure that allows a market to function efficiently through water banking or other storage based systems. This comprehensive process may also uncover the best opportunities for leasing – opportunities that justify transaction costs based on their impact. And, where multiple parties participate and benefit, the costs of implementation can be shared and scaled to larger projects with bigger and more lasting impacts.

Moreover, the potential for functioning water markets may attract new sources of funding. Some impact investors want to solve big water problems and see the development of water markets as a sustainable solution. Instead of the old model of continuously throwing money at an unsolved problem through grants, they are instead seeking to deploy capital into projects with an expectation of a social and financial return. An active market may create predictable and sustainable revenue that attracts this kind of investment.

Innovation and flexibility offer the greatest hope for the development of viable water markets, values that intersect with the SMP process. While water is scarce, it can stretch further if all parties are willing to contribute their abundance of experience and ideas in collaboration for a universal solution. 

Building Consensus

Grand County's Stream Management Planning Process — A Case Study

A Retrospective Analysis of Grand County's SMP Experience: Lurline Underbrink Curran

Jessica Hardesty Norris, Ecologist and Technical Writer, Biohabitats

Stream planning in Grand County, Colorado began earlier than most other watersheds, putting it on the forefront of SMPs within the state. Grand County is the most impacted county in the state when it comes to trans-mountain diversions, and their planning process was spurred by specific drivers in regional water planning. In the early 2000s, Denver Water and the Northern Colorado Water Conservancy Municipal Subdistrict initiated “firming” projects, designed to firm up the yield from existing water rights in the Upper Colorado River. As they developed the concepts, Denver Water and Northern Colorado Water Conservancy Municipal Subdistrict came to Grand County to ask what mitigation projects the county would propose. “When you get asked what you want, you have to be sure that your wants are the same as your needs,” says Lurline Curran, who was the Grand County Manager throughout their planning process through 2015 and still works with the county on water issues. In those early days, there was consensus over neither.

One of the fundamental questions was identifying the desired level of flow for each reach. The interested parties had a wide range of definitions for optimal, and there was little agreement on the underlying science, either. The county decided to invest in putting a foundation of shared information and goals in place. They decided to hire a consultant to assess the entire system of reaches and propose a set of indicators to establish a common definition of stream health. Funded entirely by the County, Tetra Tech undertook a million dollar, year-long process to complete Phase I and offer a definition of stream health for all parties to share.

“Fish were the indicator that everyone could get behind,”

says Curran. They could all agree that managing for Rainbow or Brown Trout would encompass multiple considerations into a holistic view of the system. The fish relied on specific parameters of flow, sediment transport, temperature, aquatic invertebrates among others. Furthermore, the needs changed throughout the year and as you move downstream.

The Phase 1 planning project was not small. They started by examining the full extent of the Frazier and the Colorado Rivers from the Fraser headwaters to its confluence with the Colorado downstream to where the river exits the county. Each reach underwent a complete analysis, and then the reaches were divided into categories according to basic stream health factors such as riparian cover, geomorphology, and flows.

The resulting SMP was the foundation for the Colorado River Cooperative Agreement (CRCA) negotiation with Denver Water and the Windy Gap IGA with the Municipal Subdistrict of the Northern Colorado Water Conservancy District. Mid-negotiation, before a signed agreement was even in place, the County worked with CDOT and Denver Water to address one pressing issue. The County placed a detention pond high in the watershed, at the diversion, with CDOT removing the sand every year. About 650 tons of sediment have been taken every year for the last three years, and the downstream evidence of success is measurable. “Today, the spring flows are able to move the sediment downstream,” says Curran, which directly improves stream health.

The stream management plan gave the County a basis for discussing the enhancements in the CRCA and Windy Gap IGA. It also gave information to discuss proposed mitigation with the lead agency for each project.

Overall, the experience of stream planning in Grand

In the Grand County experience, continuity has been key, and in large part a result of the Learning by Doing model of the CWCA.

Country was exceptional in its large scale, early timing, and the financial support for the work. However, some of the lessons learned are applicable to every SMP, no matter the scale.

The Power of Science

“Once you get agreement over the science, with parties representing different interests, you take the argument over data out of it,” says Curran. Establishing a common set of facts and the authority on interpreting them was crucial to the eventual success of the process.

Curran is quick to point out that agreement over the science is not agreement over everything. However, subsequent arguments become grounded in data, and the standards for supporting claims are more rigorous and clear.

A Foundation of Trust

One key point was that the SMP contractors be allowed to work independently in the data collection phase, uninfluenced by the political, financial, or other interests of the County or, conversely, of the utility companies. Grand County began by finding contractors that had not worked for Denver Water or Northern Colorado Water Conservancy District in the past.

Then, throughout the Phase I data collection, the county set a moratorium on technical communication between the consultants and the County or utilities until the report was released. This avoided any future suspicion or complaints about the data collection and prioritization process. There are, after all, value judgments inherent in even the earliest stages of the planning process. But in the case of Grand County, the consultants alone were responsible for explaining and justifying such

decisions. Although the County’s experience was special in having such large and interested parties watching the process closely, this is a lesson that can be applied even to the planning of a single reach. Bringing people together in the appropriately neutral settings with a set of information that everyone can agree on is key.


The Force of Habit

One common challenge in stream planning processes is the variability in political will as elected officials come and go. When budget balances and political leaders shift, entire planning efforts can sometimes be scrapped or put on a shelf until they are too dated to guide decisions. In the Grand County experience, continuity has been key, and in large part a result of the Learning by Doing model of the CWCA. Curran emphasizes that it has to become habit for implementing organizations to participate on a regular basis.

The Timelines of Progress

Finally, Grand County’s successes did not develop overnight, nor are they an accomplishment of the past. The planning and stewardship are continual processes.

The process, though, has changed views on all sides. “What we would have said we needed would not have been correct,” says Curran, because no one could look at the whole system collectively. We were able to look at the health of the whole system and planning a phased implementation of projects moving downriver. Previously, the County had had the experience of fixing something in one reach and seen that the project had negative effects upstream.

One of the biggest surprises was simply how valuable this tool was, and how it has shaped not only the CRCA and the Windy gap IGA, but also influenced the approach of the Basin Roundtable. Colorado’s Water for the 21st Century Act (House Bill 05-1177), established the Round Tables as place for Coloradans to come together to discuss and move forward on meeting multiple water needs. SMPs can offer important contributions to the dialogue. 



The confluence of the Fraser and the Colorado rivers near Granby, Colorado. Photo by Jeffrey Beall.

Reach Description		Restoration Opportunities										Notes	
River	Section description	Ranking	Applyenhancement flowstolowflows	Applyenhancements toflushingflows	In-streamhabitat features	Channell bank revegetation	Channell restoration	Enhancefishpassage	Irrigationdiversionand pumpintakes	OverbankBMPs	SedimentBasin		Rampingguide lines
Colorado River	Windy Gap to Williams Fork	-6	✓	✓	✓		✓	✓	✓				Highly impacted reach; recommendations include both enhancements and physical restoration
Fraser River	DW Diversion to WPWSD intake	-3	✓	✓						✓	✓		Flow enhancements, sediment basin, passage of spawning gravels and Moffat tunnel discharge treatment are recommended
Colorado River	Granby Reservoir to Windy Gap	-3	✓	✓	✓				✓	✓		✓	Previous and ongoing restoration is extensive. Additional study is recommended. Flow enhancements for CR4 will improve CR3
Fraser River Trib	Ranch Creek ds of gage to confluence	-2	✓	✓	✓	✓	✓						F-RC2 benefits from flow enhancements recommended for F- RC1
Fraser River Trib	Ranch Creek to ds of gage	-2	✓	✓									Investigate culvert capacities downstream to accommodate increased flushing flows
Fraser River	WPWSD intake to Town of WP	-2								✓			Recommendations in F2 will provide benefits in F3
Muddy Creek	Wolford to Colorado River	-2	✓	✓			✓	✓		✓		✓	Allow stream to stabilize before developing restoration recommendations
Fraser River	Town of WP to Town of Fraser	-2			✓					✓			Recommendations in F2 will provide benefits in F4
Colorado River	North Fork to Shadow Mountain	-1											Additional study required in conjunction with Red Top diversion changes
Colorado River	KB Ditch to Blue River Confluence	0			✓				✓				Recommend additional study to address grade control structures
Colorado River	W illiams Fork to KB Ditch	0			✓				✓				CR5 benefits from flow enhancements in CR4
Fraser River	Fraser CWWTP to Ranch Creek	0				✓	✓			✓			Partner on existing projects
Fraser River	Ranch Creek to mouth of Canyon	0			✓	✓							Consider public access and trail enhancements
Fraser River	Canyon	0											Consider public access
Fraser River	Canyon to Granby	1					✓						Partner on existing projects
Blue River	Green Mountain to Colorado River	1				✓						✓	Develop ramping and flow management strategies to support spawning
Colorado River	Blue River to County line	1											Maintain target flows and support recommendations from W ild and Scenic alternative
Fraser River	Town of Fraser to Fraser CWWTP	2								✓			
Fraser River	Granby to Colorado River at Windy Gap	2						✓					
Fraser River Trib	St. Louis Creek	4					✓						Support efforts to restore native cut throat populations
Fraser River	US 40 to DW Diversion	5								✓			
W illiams Fork	Below reservoir to Colorado River	7										✓	Monitor for and address low DO levels
Fraser River Trib	Vasquez Creek	*						✓					
Fraser River	Jim Creek	*											No recommendations made at this time
Willow Creek	Reservoir to Colorado River	*											No recommendations made at this time
Muddy Creek	Inflow to Wolford	*											No recommendations made at this time
Fraser River	Tenmile Creek	*											No recommendations made at this time
Colorado River	Shadow Mountain to Granby Reservoir	*											No recommendations made at this time
Colorado Trib	Hwy 40 to confluence	*											No recommendations made at this time
Colorado Trib	Cty Rd 33 to confluence	*											No recommendations made at this time

Grand County Stream Management Plan Summary of Restoration Opportunities, August 2010.

Laying the Groundwork for Stream Management Planning and Implementation

*Interview with Nicole Silk Executive Director of River Network
Jessica Hardesty Norris, Ecologist and Technical Writer, Biohabitats*

Colorado's Water Plan promotes watershed health and supports the development of watershed coalitions that address the needs of a diverse set of local stakeholders (Chapter 7, Colorado Water Plan (2015)). Watershed coalitions who can unify diverse interests, establish priorities for improving river health (e.g., through the creation of a stream management plan (SMP)), and implement projects that contribute to river health can play an important role in Colorado's water future. Whether local watershed coalitions have a lead role or a supporting role in SMPs, the SMP process is an exceptional opportunity to become engaged in efforts to restore and protect water essential to healthy rivers and the future of Colorado.

Institutional Capacity

SMPs will be important to the future of Colorado's river for many reasons. Among them, the SMP process has the power to enlarge the pipeline of groups who are ready and able to plan and implement solutions for river health. Ideally, leadership of the SMP requires mature organizations with longevity, dedicated full-time staff, annual work plans, independent audits, and an outside Board of Directors or similar governance. The leading organization also must be able to have the trust of the community and be respected as an honest broker of the conversations. Organizations that do not meet these criteria can also have important role in SMPs as contributors and collaborators. The opportunity to lead a SMP opportunity may also serve as an incentive for some groups to invest in themselves and in the professionalization of their efforts.

Community Partners

At the heart of the team building needed for SMPs is the ability to look both upstream and downstream. Often local watershed organizations and coalitions emerge due to a particular concern on one stretch of a river. The reality is that rivers are always on the move, connecting headwaters springs and snowmelt, and rain to farms and cities, fish and fisherman, energy production, and industry as they head downstream on their gravity-fed journey toward the sea. Any stretch of river exists within a networked system of tributaries, ponds, wetlands, precipitation patterns, and patterns of water extraction and return that fuel a wide range of livelihoods and economic activity. And this stretch is connected to the next stretch that also has its own set of unique patterns. Each also exists within a complex combination of water authorities, water managers, political boundaries, and water rights. Taking a systems approach both to understand the ecological function of a river and to understanding the array of water utilities, municipal governments, other NGOs, community groups, and private citizens with aligned interests in healthy rivers is an important precursor to identifying (and eventually implementing) creative community supported solutions for river restoration and protection.

Understanding

To be effective, the SMP team needs a foundational level of understanding of not only how freshwater systems function and the river's unique hydrologic regime, but also a sophisticated understanding of when that river is out of balance



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Fly-fishing in the Blue River, Summit County, Colorado. © iStock.com

The reality is that rivers are always on the move, connecting headwaters springs and snowmelt, and rain to farms and cities, fish and fisherman, energy production, and industry as they head downstream on their gravity-fed journey toward the sea.

within specific reaches and what can be done to bring water back to these areas. Being able to define a river's water budget and its unique environmental flow regime is an important skill set. Additionally, they need the skills necessary to build a vision for their watershed, unite their community to solve water problems, define science needs, identify and pursue

projects to achieve a healthy watershed that are adequately funded and adaptively managed, and, when relevant, become sustainable organizations themselves. Although experts and consultants can help design and run models helpful to understanding current conditions and opportunities for progress, the local organization or coalition is essential in building local ownership, keeping up the momentum necessary to see these projects through, and defining a future for our communities that involves healthy rivers. The prioritization process made possible through developing a SMP helps make this future possible.

If You Plan It, They Will Come

No planning process begins with all the answers in hand. But by engaging in planning, and creating an open and welcoming place for local knowledge and interested partners to come together, clarity can emerge around what is possible, as well as certainty for how to move toward that dream, plus how to engage local human and financial resources to achieve success. For example, the Cache la Poudre Natural Areas Conservation Action Plan process began without dedicated funding for implementation, but within five years of starting the planning, several of the highly ranked projects had been implemented. <https://www.rivernet.org/our-work/strong-champions/best-practices/> 



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Wood toe under construction for stabilization and improved fish habitat along Taryall Creek in Park County, Colorado. Photo courtesy of Biohabitats