ST. VRAIN & LEFT HAND WATER CONSERVANCY DISTRICT

St. Vrain & Left Hand Stream Management Plan

Phase 1 Summary Report

October 2020

ST. VRAIN & LEFT HAND WATER CONSERVANCY DISTRICT

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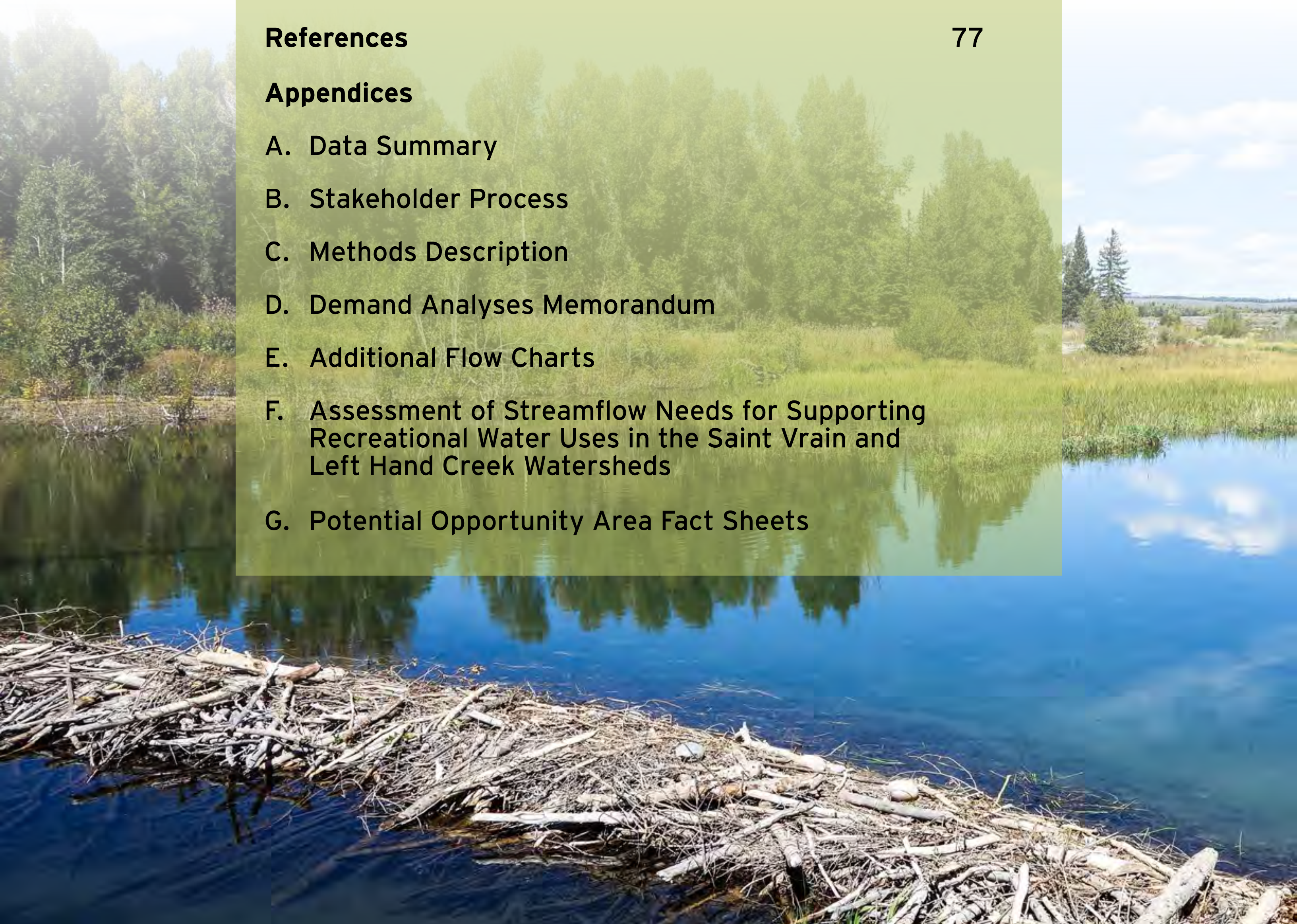


Acknowledgments

This Stream Management Planning effort would not have been possible without the generous participation of numerous individuals, far too many to name individually. The hallmark of any good plan is collaboration and we would like to thank everyone who volunteered their time to participate in numerous surveys, meetings, field tours, and community events so that we could shape a plan that reflects the values of St. Vrain Basin community. We also want to thank everyone who took time out of their busy schedules to review the draft language of this report and provide comments. Each comment was thoroughly reviewed, and your recommendations helped shape this plan.

FUNDING

American Whitewater

Boulder County

City of Longmont

Colorado Water Conservation Board

JBL Engineering

South Platte Basin Roundtable

St. Vrain and Left Hand Water Conservancy District

St. Vrain Anglers Chapter of Trout Unlimited

CONSULTING TEAM

Biohabitats Inc.

Wright Water Engineers

DiNatale Water Consultants

Peak Facilitation Group

Open Water Foundation

Left Hand Watershed Center

ABBREVIATIONS

BMI	Benthic macroinvertebrate index
BMP	Best Management Practice
C-BT	Colorado-Big Thompson transbasin project
CDSS	Colorado Decision Support System
CDPHE	Colorado Department of Health and Environment
CFS	Cubic Feet per Second
CIF	Creek Improvement Facilities
COSHAF	Colorado Stream Health Assessment Framework
CPW	Colorado Parks & Wildlife
CWCB	Colorado Water Conservation Board
DWR	Colorado Division of Water Resources
District	St. Vrain and Left Hand Water Conservancy District
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic information system
ISF	Instream flows
IWR	Irrigation water requirement
NGO	Non-governmental organization
NPS	National Park Service
SMP	Stream Management Plan
SVLHWCD	St. Vrain & Left Hand Water Conservancy District
SWPP	Source Water Protection Plan
TMDL	Total Maximum Daily Load
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

GLOSSARY

Actions—implementation tasks or activities

Adaptive management—is a method that uses monitoring to help resource managers track progress toward meeting project goals and respond to site needs as the system adjusts to management actions and new information becomes available

Approved recreation area—an area managed for public access as outlined in an approved management plan

Alternative transfer methods—a term used to describe a variety of water sharing agreements utilized to meet various water supply needs in ways that minimize permanent reductions in irrigated agriculture.

Augmentation—refers to replacement water for out-of-priority diversions to an affected river in an amount necessary to prevent injury to other water user.

Baseflow—the groundwater contribution to streamflow

Best management practice—a practice, or combination of practices, that is determined to be an effective and practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals

Desired conditions—the vision of what ultimate success means

Ecoregion—large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions. (Center for Biodiversity and Conservation, 2007)

Flow-ecology relationships—connections between a type of flow and the risk (low to very high) for a particular environmental element such as fish and riparian habitat

Ecological risks—relate to changes in flows that reduce the amount and quality of aquatic and riparian/wetland habitat. In this SMP, the term also describes the vulnerability of the riparian habitat from impaired ecological processes and stressors such as adjacent land uses and management.

Goals:

> **Management Goals**—what needs to be done or impact needed at a high level to meet desired condition

> **Stream Management Plan Goal**—is the overarching intention of the Stream Management Plan stated by the District that provided a framework for the Phase 1 process

Green infrastructure—an approach to water management that uses natural approaches to protect, restore, or mimic the natural water cycle (e.g.: planting trees and restoring wetlands, rather than building a water treatment plant)

Instream flow water rights—are appropriated by the Colorado Water Conservation Board to preserve the natural environment to a reasonable degree, including flows between designated points on a stream

Initiatives—procedures for near-term and mid to long term implementation of strategies

Lower watershed—transition and plains ecoregional zones

Nodes—locations of water diversions (sometimes multiple diversions combined into one point for StateMod)

Opportunity areas—geographic locations where applying the strategies can offer significant uplift or protection from anticipated stressors.

Preliminary objectives—a desired amount of change to reduce threats, improve degraded systems, or meet management goals. (Final objectives to be developed in Phase 2 with more specifics on timing, locations, etc.)

Recreation In-channel Diversion (RICD)— a water right appropriated for beneficial recreational use based on minimal stream flows

Strategies—Actions with a common focus that address needs identified by stakeholders, Stream Health Assessment, and water management and infrastructure evaluations from Section 3

Stressors—threats which lead to degradation of natural resource quality, extent or function

Stakeholder themes—The key issues or topics of concern identified during the first phase of the Stream Management Plan—flow, habitat, water quality, and water management

Upper watershed—alpine/subalpine and canyons/foothills ecoregional zones

Executive Summary

As population growth and climate change apply increasing pressure on rivers across Colorado and the West, improved and coordinated water resource management is becoming ever more critical to support natural and cultural resources and water uses. Creative and flexible planning will be essential to support the interdependence of river and community health in the face of an uncertain future. On a local level, the 2013 flood was a call to action for the communities along St. Vrain and Left Hand Creeks to work together to identify potentials for enhanced water resource management that could achieve a net benefit for multiple uses (agriculture, domestic, environment, and recreation). This report is a completion of the first phase of a larger effort called a Stream Management Plan (SMP). This first phase SMP represents a culmination of values and science that provides a foundation to improve local stream management for the benefit of multiple uses.

THE VALUES

Values and priorities were obtained from the stakeholders through the hosting of workshops, surveys, one-on-one meetings, and on-the-ground field tours. In general, the stakeholder values fell into the following areas:

- Challenges present opportunities;
- Sustainable agriculture requires reliable water supplies;
- Certain reaches of the river require more immediate attention to address stream health issues;
- Infrastructure improvements, collaboration, and shared water supplies provide opportunities for mutual benefits; and
- Recreational experiences and access can be enhanced.

THE PROCESS

Throughout the development of this SMP, the St. Vrain and Left Hand Water Conservancy District (District) engaged a broad range of stakeholders to participate in this work. The purpose of the stakeholder engagement and community outreach task was to build upon post-flood work in the watershed, to integrate local knowledge, and to further develop capacity and relationships for future stream management efforts. Given the size and diversity of issues in the watershed, it was essential to have a wide range of key groups participate – local, state and federal government, water providers and ditch managers, private land owners, agricultural producers, recreationists, and non-profits.

Using funding provided by the District, Boulder County, City of Longmont, St. Vrain Anglers Chapter of Trout Unlimited, JBL Engineering, and grants provided by the South Platte Basin Roundtable and the Colorado Water Conservation Board, the District hired an expert team of consultants to facilitate the process to understand stakeholders values, analyze existing science, create new analytical information, and work with stakeholders to identify goals and strategies for implementation.

THE SCIENCE

The consulting team compiled existing data from studies covering 185 miles of streams within a 500-square mile planning area. The stream health evaluation[1] built on previous work, which included a review of pre-flood studies, post-flood master plans, the City of Longmont's Resilient St. Vrain flood management plans, and post-flood restoration projects to help understand the status of flood recovery and existing conditions. The existing information found that, in general, the stream reaches in the transition and plains present the greatest challenges, which helped focus the rapid field assessment in those areas. Flow modeling was conducted using StateMod and a point flow analysis to understand monthly and daily flow patterns. The Colorado Stream Health Assessment Framework (COSHAF) was used to evaluate the physical, chemical, and habitat conditions. The COSHAF method evaluates eleven total variables, four of which (flow regime, sediment regime, water quality, and landscape) are watershed-scale and seven of which (floodplain function, riparian condition, organic material, morphology, stability, physical structure, and trophic structure) address specific reaches. Evaluation results are summarized for this report in terms of ecological risks — from low to very high — based on evidence of impacts to stream functions.

THE THEMES

Stream health depends on dynamic ecological processes at both the watershed and stream reach scales, which are influenced by a wide range of land and water management practices. Protecting and maintaining stream health requires an understanding of key stressors and challenges to ecosystem functions. With stakeholder contributed values, flow modeling, and COSHAF, the Phase 1 SMP identified four major themes in achieving a net benefit for multiple uses:

- **Flow**
- **Habitat**
- **Water Quality**
- **Water Management**

These four themes are interrelated and contribute to overall stream health.

To better address management solutions, the stakeholders established the following desired conditions for each theme:

- The desired conditions for **flow** are to achieve a flow regime that satisfies the needs of the natural environment, non-consumptive users, and consumptive users.
- The desired conditions for **habitat** are to provide for diverse and resilient native plants and wildlife that, thrive in a network of riparian corridors and dynamic channels, complex instream habitat features, and connected floodplains. These conditions will ideally be compatible with water rights, private property rights, public land, and resource management plans.
- The desired conditions for **water quality** are to meet or exceed standards set for public health, environmental concerns, and intended uses.
- The desired conditions for **water management** are to achieve a balance among the needs of the natural environment, non-consumptive, and consumptive users.

THE RESULTS

Flow

The flow analysis characterized stream health issues related to annual flows, low flows (baseflows), and high flows. Of the 170 total creek miles included in the SMP flow analysis (note some tributaries were excluded due to insufficient data), approximately 20 miles are identified as being high risk or very high risk for low flow. Approximately 33% of the creeks (57 miles) are identified as high or very high risk for high flows, meaning there may be insufficient high flows to support healthy ecosystem functions. On St. Vrain Creek, baseflows are significantly altered and categorized as high or very high risk for habitat for approximately 16 miles. The very high risk reaches include approximately three miles in the transition zone that are critical to small native fish. Additionally, total annual flows and peak flows during spring runoff are also reduced along a 43-mile reach, resulting in high or very high-risk classifications.

On Left Hand Creek, baseflows are reduced and pose moderate to high risks for habitat degradation from about 1/2-mile west of Route 36 near the entrance to the canyon to the confluence with St. Vrain Creek. High flows are also diminished and pose a high risk for approximately eight miles below 63rd Avenue to the confluence with St. Vrain Creek.

Habitat

Stressors such as roads, recreation, and climate change negatively impact the quality of both aquatic and terrestrial habitat systems. Though high-quality wetland and riparian habitat exists throughout the watershed, stressors threaten their long-term sustainability. Approximately 45% of the reaches in the lower watershed, where rapid field assessments were conducted, are considered at high risk due to poor floodplain connectivity, presence of invasive species, narrow riparian width, and lack of regenerating native plants.

On St. Vrain Creek, riparian and wetland habitat is at high ecological risk in approximately 16 miles of the lower watershed (transition and plains zones). Additionally, aquatic habitat was identified as moderate to high risk for 23 miles in the transition and plains reaches, and ten diversion structures were identified by Colorado Parks and Wildlife as priorities for fish passage in St. Vrain Creek.

On Left Hand Creek, riparian and wetland habitat was identified as being in the high ecological risk category in six miles of the lower watershed (transition zone). Aquatic habitat was also identified as moderate to high risk in 12 miles of the transition zone. Eight diversion structures were identified by the Left Hand Watershed Center as providing total barriers to fish passage.

Water Quality

High levels of bacteria and nutrients (nitrogen and phosphorus) are present in 37 miles of St. Vrain and Dry Creeks. Impairments, particularly from metals and low pH, are found throughout Left Hand Creek from abandoned mining operations.

The majority of St. Vrain Creek and its tributaries do not contain high metal loads, except for elevated copper found in a one mile reach of South St. Vrain Creek at the confluence with the mainstem and elevated manganese levels in Dry Creek. The primary water quality issues in the St. Vrain Creek reaches are derived from high bacterial (E. coli) and nutrient loading in the mainstem of the creek, from approximately the Town of Hygiene to the confluence with the South Platte River.

Approximately 45 miles of Left Hand Creek, including 11 miles of James Creek, are impaired with high metals (copper, cadmium, zinc) and low pH. Extensive monitoring and mine clean-up activities are underway to mitigate the legacy watershed pollutants, but impacts have persisted.

Water Management

The cost to water and resource managers and ditch owners, for improving and maintaining raw water infrastructure on both St. Vrain and Left Hand Creeks continues to rise. The impacts from recreation and other stressors were identified by some stakeholders as being difficult to keep up with. Furthermore, improved coordination among water managers has been portrayed as desirable.

Additional streamflow gaging stations are needed to support more efficient water administration on several reaches of the study area. A larger stream gage network with real-time data collection will better enable water commissioners to administer augmentation water and instream flows without injuring senior water rights. The highest priority locations for additional streamflow gages are at the Highland diversion and between the Oligarchy diversion and Airport Road.

Infrastructure improvements are needed in several locations that have aging and flood damaged diversion structures. Some structures have received post-flood improvements but remain in need of additional modifications, while others would benefit from a complete redesign.

Regarding recreational safety, several opportunities also exist to remove low head dams that constitute a safety concern for recreational boaters and tubers. At minimum, policy coordination around safety improvements such as tie-offs on diversion structures for first responders during high water rescues is necessary.

THE PLAN

Despite the challenges surrounding water, the community of stakeholders continue to build upon the strong post-flood partnerships. By continuing to work together, this SMP can boost those relationships. With the completion of this SMP, opportunities are availed to identify new projects, programs, and services to enhance water resource management that could achieve a net benefit for multiple uses (agriculture, domestic, recreation, and environment). Working towards achieving the desired conditions and realizing the net benefit for multiple uses starts with a set of goals for the watershed, which are outlined below.

Flow Management Goal:

1. Maintain baseflows and peak flushing flows in the creeks necessary to support ecological function and connectivity for native and sport fish, recreation, and diversions for beneficial use.

Habitat Management Goals:

1. Preserve and restore riparian and instream habitat for native species.
2. Allow natural processes to occur in appropriate locations.
3. Implement appropriate land and water management strategies to maintain and enhance habitat along creek corridors.
4. Increase instream and riparian connectivity for native species.
5. Control non-native invasive species.

Water Quality Management Goals:

1. Remediate known point and non-point sources of water pollution in the watershed.
2. Monitor pollutants from historic mine sites.
3. Rehabilitate excessively eroding and impaired creek banks and channels based on natural channel design concepts where possible.
4. Restore healthy forests and improve forest-creek connections to keep pollution out of waterways.
5. Limit new sources of water pollution.

Water Management Goals:

1. Work with water rights holders to ensure their water supply needs are met and not interrupted, explore issues and concerns, and find opportunities for mutually beneficial management improvements.
2. Meet regularly with all stakeholders to discuss water management issues, potential solutions, funding opportunities, education and outreach, and other mutually beneficial opportunities.
3. Strive for a mutually beneficial balance between the needs of water users and the needs of the natural environment.

A WAY FORWARD

This Plan presents goals and strategies for each of the major themes, and then recommends initiatives describing near-term and long-term actions. Each initiative includes important catalysts — for leadership, projects, data collection, policies, and agreements — to get to the next stage of coordinated, holistic stream management and health. This Plan also identifies opportunity areas as example locations where applying the recommended actions can offer significant improvements or protection from existing and future stressors.

Maintaining and improving water management and the health of St. Vrain and Left Hand Creeks in the face of mounting pressures will require focused leadership, continued data collection, innovative projects, new policies, and mutually beneficial agreements as identified in this Plan. Phase 1 of the SMP has been a collaborative process among local, state and federal government, water providers and ditch managers, private landowners, agricultural producers, recreationists, and non-profits. As the process moves into Phase 2, progress will depend on continuing this collaboration.

When implemented, the strategies in this SMP will advance water stewardship for multiple benefits supported by the stakeholders within the watershed.

St. Vrain Creek Watershed Coalition 2017 canoe tour

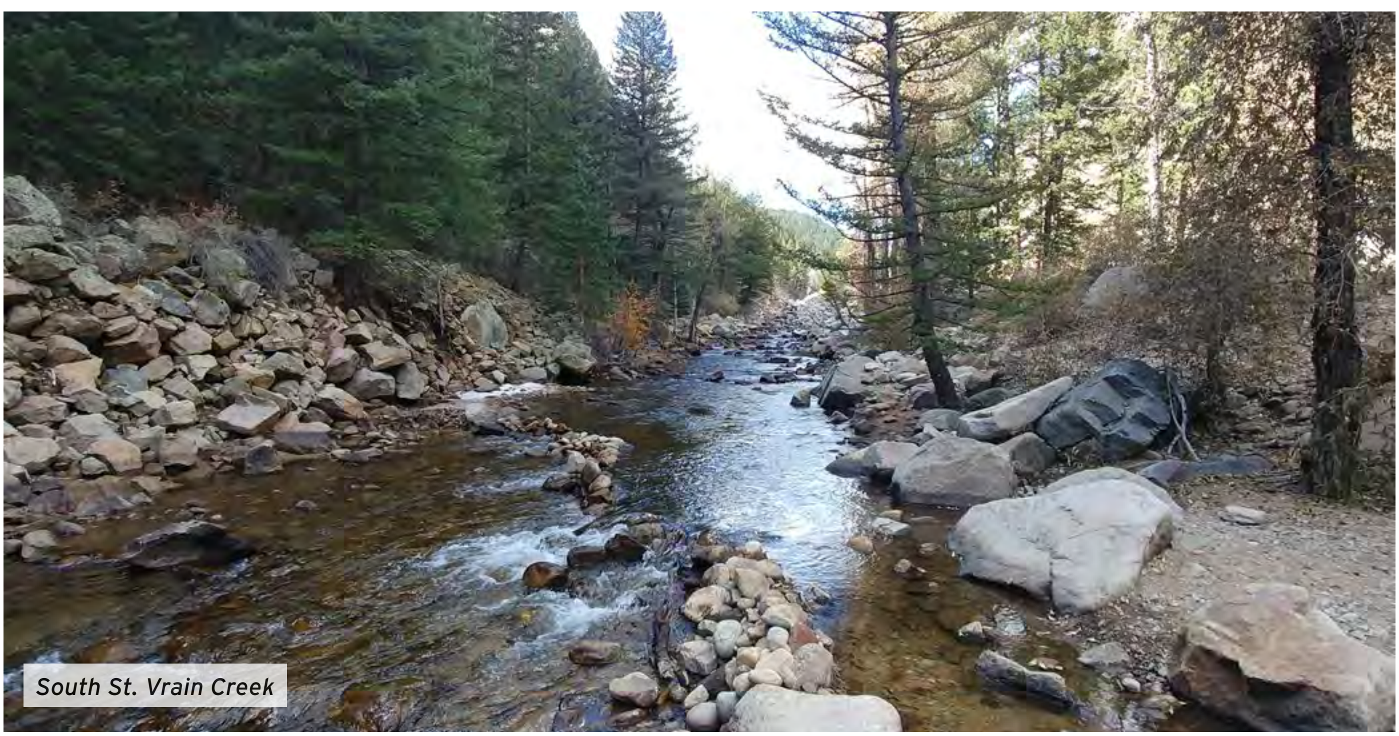
Section 1 – Introduction

The St. Vrain Creek and Left Hand Creek watershed is critical to maintaining the health, biodiversity, character, and economy of the region. To supplement native flows, the watershed receives Colorado River transmountain water, and its management supports one of Colorado's most economically productive agricultural areas. The watershed, with its headwaters in Rocky Mountain National Park and the Indian Peaks Wilderness, is home to diverse communities of native fish and attracts anglers, whitewater users, off-highway vehicles, birders, campers, hikers, and cyclists, and supplies water for numerous residents. As a result, the watershed has a diverse array of water stakeholders including private landowners, agricultural producers, domestic water providers, environmental enthusiasts, and recreational users. However, stressors are increasingly complex, and effective future management will require a more complete picture of how flows, habitat, water quality and uses interact to support a healthy creek system. This plan highlights improvement opportunities and lays the foundation for managers and partners to address current and future challenges.

1.1 COLORADO'S WATER PLAN AND STREAM MANAGEMENT PLANNING

In 2015, the State of Colorado adopted Colorado's Water Plan, a water management roadmap which included a goal to have Stream Management Plans (SMPs) developed for 80% of priority streams by 2030. SMPs are voluntary, locally driven, consensus-based plans developed by and for water stakeholders and their communities to improve river conditions and sustain existing uses. The St. Vrain and Left Hand Water Conservancy District (District) and its stakeholders are among the first water managers on the Front Range to respond to the Colorado Water Plan's call to action and help define and respond to the state's water challenges.

While the Colorado Water Conservation Board (CWCB) provides a framework to guide the SMP process, the specific scope and tasks involved depend on the entities leading the process and vary according to local stakeholder needs.



South St. Vrain Creek

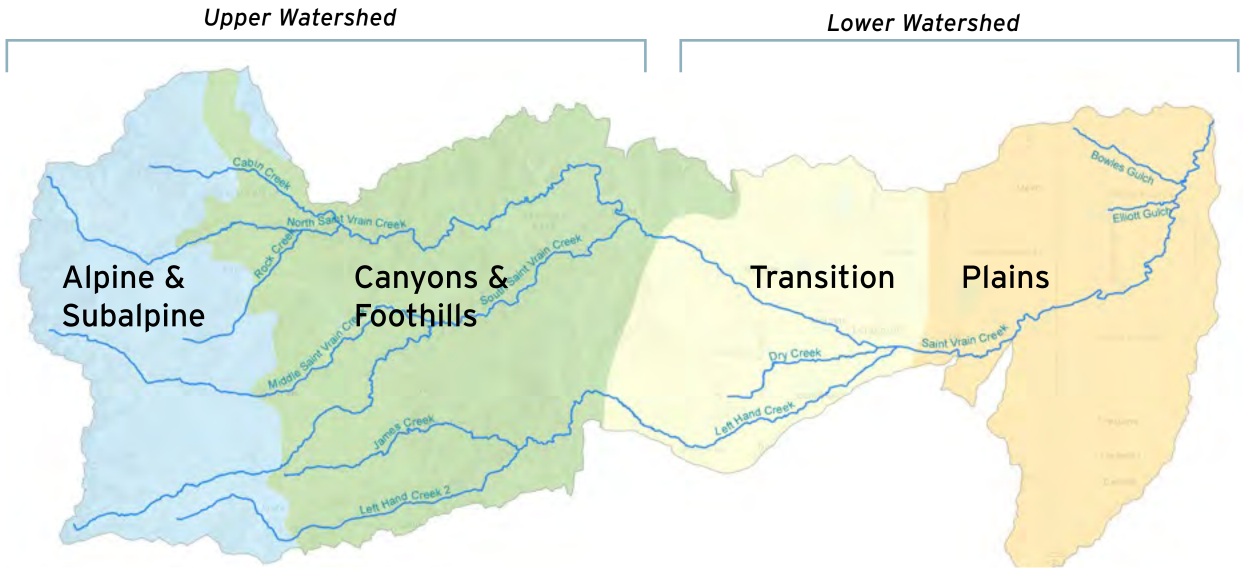


Figure 1.1—Four St Vrain and Left Hand Watershed SMP Planning Zones

The District and its stakeholders initiated this technical assessment to serve as Phase 1 of the planning process. To accomplish the assessment, the District:

- engaged a broad range of stakeholders,
- defined a planning framework and methodology,
- compiled and reviewed data,
- characterized flows and demands, including a recreational assessment,
- assessed conditions and risks,
- established desired conditions and management goals, and
- identified strategies and potential Phase 2 topics for implementation.

1.2 ST. VRAIN AND LEFT HAND STREAM MANAGEMENT PLAN OVERVIEW

The project planning area covers approximately 500 square miles, including parts of Boulder and Weld Counties, extending from the Southern Rockies to the Great Plains physiographic provinces, and spanning an elevation gradient from the Continental Divide to the confluence with the South Platte River. Within this highly varied region are six main ecoregions (alpine tundra, subalpine forests, mid-elevation forests, foothills shrublands, front range fans, and flat to rolling plains) that were used to define four planning zones: 1) the alpine/subalpine, 2) the canyons/foothills (mid-elevation forests and foothills shrublands), 3) transition (front range fans), and 3) the plains (Figure 1.1)[2].

St. Vrain Creek drains 426 square miles (sq mi) of the watershed and represents 141 miles of stream channel in the SMP[3], while the Left Hand Creek portion is a 73-sq mi drainage area[4] and nearly 45 miles of stream. Included in the planning area are the South St. Vrain, Middle St. Vrain, North St. Vrain, the main stem of the St. Vrain, Left Hand, James, Little James, and Dry Creeks. It does not include Boulder Creek, a major tributary that enters from the south near the boundary between the Transition and Plains zones.

Within this large, diverse landscape are an estimated 151,240 people living and working in the watershed. According to the U.S. Census Bureau 2019 estimates for the major population centers within the District boundaries, Longmont is just shy of 100,000 residents at 97,261. Populations of the other towns

2. Note the terminology and boundaries for zones used by the Left Hand Watershed Center vary somewhat from the SMP zones, because the Center separates the canyons and foothills and considers the transition zone as "plains."
3. Miles of stream channel are based on state data for Source Water Route Framework and excludes tributaries not included in the SMP.
4. The 73 sq mi area is based on USGS HUC12 drainage areas for Upper Left Hand Creek, Middle Left Hand Creek, Lower Left Hand Creek and Little James Creek. The Left Hand Watershed Center reported 132 sq mi area in the 2020 State of the Watershed Report, but data source unknown.

include Mead (4,731), Lyons (2,189), Firestone (16,177, but it is estimated less than 10% reside within District boundaries), Jamestown (249), and Ward at (161).

Public lands (236 square miles) account for 53% of land ownership in the watershed, primarily in the upper watershed (Figure 1.2). Public land managers include the Bureau of Land Management (BLM), National Park Service (NPS), US Forest Service (USFS), the State of Colorado, Boulder County, City of Longmont, and City of Boulder. The lower watershed is predominantly privately owned, with only 11% of public lands found in the transition and plains zones. Over half the buffer area (within 1/4 mile of the creeks, totallying 87 sq mi) is the reponisibility of public land managers (46 sq mi).

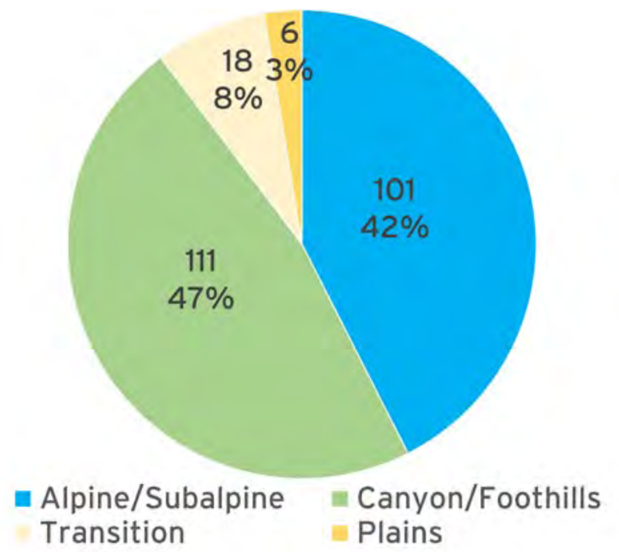


Figure 1.2—Public lands by planning zone (square miles)

View across upper watershed of alpine/subalpine to canyons/foothills zones

1.3 PROJECT BACKGROUND & REPORT ORGANIZATION

Funding for this Phase 1 of the SMP was provided by grants from the CWCB and the South Platte Basin Roundtable, District resources, and stakeholders including the City of Longmont, Boulder County, St. Vrain Anglers (a local chapter of Trout Unlimited), and JLB Engineering. American Whitewater contributed in-kind services by providing a study of boatable days[5] on the major creeks in the watershed.

The Phase 1 SMP process was conducted from September 2018 to September 2020. This report was prepared by the consultant team[6] on behalf of the District for a broad audience including stakeholders, water and resource managers, and the water user community. Report organization was guided by stakeholder input and descriptions of each remaining chapter are listed below.

Section 2. Purpose and Need: describes management challenges and opportunities.

Section 3. SMP Phase 1: summarizes overall project approach, including stakeholder engagement, inputs, and assessment.

Section 4. Desired Conditions and Management Goals: identifies the overall vision and goals, key themes, including flows, habitat, water quality, and water management.

Section 5. Stream Health Evaluation Results: presents results of the stream health evaluation for flow, habitat, water quality, and water management.

Section 6. Strategies: proposes potential actions to address key stressors, along with examples of opportunity areas well-suited for projects.

Section 7. Next Steps: recommends tasks for Phase 2 and a framework for near-term and longer-term actions.

Supplemental information is available through the District, including mapping and database resources, as well as auxiliary information such as Frequently Asked Questions and meeting notes.

Agricultural land and ditch near Union Reservoir

5. Grant application identified the value of the in-kind donation at $7,000.
6. Biohabitats was lead author, with input provided throughout the planning process from sub-consultants including Wright Water Engineers, Inc., DiNatale Water Consultants, Peak Facilitation Group, Open Water Foundation, and Left Hand Watershed Center (formerly the Left Hand Watershed Oversight Group).

Section 2 – Purpose & Need

2.1 PURPOSE

With few exceptions, St. Vrain and Left Hand Creeks have historically been managed without an encompassing vision to ensure continued and effective use while also ensuring ecological health. The flooding caused by a 1,000-year rain event in September 2013 reenergized and expanded collaboration among water managers and other stakeholders and brought hundreds of millions of dollars for stream restoration to the Front Range. Flood recovery generated trust and partnership among stakeholders, and many are ready to continue moving forward with management efforts that ensure future creek projects continue to support environmental, recreational, agricultural, and domestic uses. With such a diverse range of interests, the SMP presents both a challenge and an opportunity to balance stream health with the needs of water users.

The purpose of this SMP therefore is to assess the available watershed and flow data and collaboratively identify priorities and strategies in both St. Vrain and Left Hand Creeks that transition stakeholders from flood recovery to long-term creek health projects. These projects should create a foundation for improving the ecological conditions of the riverine areas while also meeting the needs of water users. To be successful, the plan and projects must not infringe on private property rights, should coordinate with and compliment public land and resource management plans, and honor the prior appropriation system. Phase 1 is focused on developing an understanding of the health and functional condition of St. Vrain and Left Hand Creeks, including physical, chemical and biological conditions; establishing an understanding of the challenges facing the watershed; and recommending potential strategies and opportunity areas to address those challenges. This plan is intended as a tool to guide the District and its partners when evaluating potential future projects and opportunities.

"Nineteenth-century water law, twentieth-century infrastructure, and twenty-first-century population growth and climate change are on a collision course throughout the West."

(Pelz, 2017)

2.2 CHALLENGES

Water managers in the West are facing unprecedented challenges related to water infrastructure, uses, and quality of a limited precious resource. In addition to already complex water issues, biodiversity that depends on healthy riverine and riparian habitats is being lost at increasing rates, and the cumulative impacts of these mounting pressures are evident in Colorado's rivers and creeks. The following are brief descriptions of the key issues within the St. Vrain and Left Hand watersheds.

Water Rights Over-Appropriation

There are over 400 decreed water rights in the St. Vrain basin including both St. Vrain and Left Hand Creeks, and like many waterways in Colorado, the creeks have been over appropriated. As a result, during most years the creeks experience a shortage of water (and sometimes dry up) in certain reaches during later summer and often into winter.

Water Delivery Infrastructure

There is a web of aging infrastructure including over 50 ditches (~125 miles), 65 diversions, and nearly 300 reservoirs built over the past 150 years to support water management. Though it has historically been a reliable water supply and provided for a diverse and productive agricultural industry, the system has significantly altered the natural flow regime (e.g., timing, duration, and magnitude of peak flows) and habitat connectivity in St. Vrain and Left Hand Creeks. Maintaining and replacing the aging infrastructure also presents challenges due to the individual and collective costs of rehabilitating and upgrading the numerous structures and conveyance features in the basin.

Climate Change

The impacts to stream flow from warmer temperatures and changes in frequency and magnitude of precipitation events - from drought to flooding – will vary spatially, but general trends are expected to include earlier snowmelt and reductions in late summer baseflow (CWCB, 2019).

Warmer temperatures lead to higher evaporation and evapotranspiration, causing irrigation water demands to increase while water availability may simultaneously decline in a changing climate. A warmer and dryer climate also poses the increased threat of wildfires, which in turn threaten stream health and water quality.

Biodiversity Loss

Streams, wetlands, and riparian corridors are a stronghold for biodiversity, providing refuge, food sources and connectivity through a wide range of habitat types. In the often semi-arid west, high quality riparian and wetland areas comprise less than 3% of the land area but provide critical habitat for 80% of wildlife species (McKinstry et al., 2004, NRCS, 1996). Habitat and biodiversity are pressured by stresses from altered native flow regimes, climate change, invasive species, habitat degradation and loss, poor connectivity, land use change, and water quality. One prominent example is the decline in beaver populations, which has fundamentally altered habitat quality and stream health throughout the watershed.

Growth Pressures

As the state's population grows, the demand for municipal water and recreational access to water resources grows, creating potential conflict with existing water rights and impacting habitat. Over the last 10 years, Colorado's population has grown by 20%; in 2018, Colorado was the nation's 7th fastest-growing state. Colorado's population, now 5.7 million, is projected to exceed 8 million in 30 years, and much of that growth is and will be occurring in the Front Range, with water demands increasing accordingly.

In summary, mounting pressures and the competing demands of both consumptive (municipal, industrial, and agricultural) and non-consumptive uses (recreational and environmental) are becoming more intense in the basin. Creative and flexible planning will be essential to support the interdependence of river and community health in the face of an uncertain future.

2.3 SMP RELATION TO OTHER PLANS AND STUDIES

Many plans and studies have been completed in the St. Vrain and Left Hand watershed, but most have been narrowly focused to address specific needs. Therefore, the SMP provides a framework that integrates and synthesizes information collected from across the watershed over the past 10-20 years. Key resources that provided background for this SMP are summarized below.

The South Platte Basin Implementation Plan (HDR, 2015) highlighted St. Vrain Creek for its environmental and recreational opportunities. The Basin Implementation Plan (BIP) estimated streamflows needed to achieve environmental and recreational outcomes and concluded that significant additional flow information is necessary, stream channel and fish passage modifications should be further analyzed, and voluntary operational flow agreements, (such as those previously operated by the St. Vrain Corridor Committee) should be explored.

South Platte Decision Support System Water Resource Planning Model (CWCB, 2017) provides a tool and information on diversions and flows based on water rights and hydrology. Preparation of the model included generation of the historical dataset from 1950 to 2012, based on the State Engineer's Colorado Decision Support System (CDSS) "StateMod" code to simulate "demands changing through time, current infrastructure and projects coming on-line, and the current administrative environment." St. Vrain and Left Hand watershed records were extracted from the model for the current watershed project to obtain recent past and naturalized flows.

Municipal planning reports include Longmont's Water Demand Evaluation Update (Jacobs, May 2019) and Envision Longmont Comprehensive Plan (City of Longmont, 2016). The demand update summarizes future demands and supply gaps under various land use and population scenarios in Envision Longmont. The St. Vrain Basin Water Source Study (ERC, 2016) prepared for the Towns of Firestone and Dacono along with the Little Thompson Water District and Central Weld County Water District identified supplies for their projected demands that could potentially be sourced from the lower St. Vrain Creek.

Northern Colorado Water Conservancy District's Daily Point Flow Analysis (accessed 2019) used data for the period of 1980-2007 for St. Vrain Creek. Daily point flow analysis is based on a volume balance approach to calculate flows from inputs including daily streamflow gaging stations, diversions, inflows, and dry points.

St. Vrain Basin Watershed-Based Plan: Boulder Creek, St. Vrain Creek and Tributaries (Keep it Clean Partners and WWE 2015, updated 2018) also called the "319 Watershed Plan" and Watershed Management Plan for the Upper Left Hand Creek Watershed (LWOG, 2005) provide summaries of water quality data based on impaired segments of the creeks. Data focus on metals, E. coli, and nutrients. Management planning includes monitoring programs and best management practices to address mine contamination. Also, the State of the Watershed (Left Hand Watershed Center, 2020) report summarized 2018-19 monitoring results of the restoration projects implemented in response to the 2013 flood.

Open space plans including the City of Longmont's **St. Vrain Creek Riparian Corridor Protection Plan** (Biohabitats, 2011) and St. Vrain Creek Corridor Open Space Management Plan (Boulder County, 2004) provided habitat information and recommendations for restoration and enhancements, as well as other land management and public access. These plans also assessed the existing ecosystem quality, with the more recent plan evaluating morphological and vegetation quality.

Post-2013 flood restoration **Master Plans** and monitoring documents including Flood Recovery Project Monitoring Methods (Beardsley and Johnson, 2018). These included multiple post-flood hydrologic analyses and restoration plans such as the St. Vrain Creek Watershed Master Plan (Michael Baker, 2014), Left Hand Creek Watershed Master Plan (AMEC, 2014), Hydrologic Evaluation of the St. Vrain Watershed Post-September 2013 Flood Event (Jacobs, 2014), and Hydrologic Evaluation of the Left Hand Creek Watershed (Jacobs, 2014). The City of Longmont's Resilient St. Vrain project provided information on projects and conditions in the urban corridor.

Multiple previous plans were also consulted to assist with stakeholder engagement, and specifically for comparison of goals and objectives from past plans. These plans included: Button Rock Preserve Forest Stewardship Plan (City of Longmont, 2017); Sustainable River Corridor Action Plan (Town of Lyons, 2014); Parks, Recreation, and Trails Master Plan (City of Longmont, 2014), and; Parks and Open Space Water Policy (Boulder County Parks and Open Space, 2012).

Section 3 – SMP Phase 1 Process

The Phase 1 SMP process followed the scope of work outlined by the District and stakeholders in the CWCB grant application and is summarized below, and the tasks and general timeline of Phase 1 are illustrated in Figure 3.1. The project was initiated in September 2018, with each task informing the next one and with ongoing stakeholder engagement throughout. Supplemental process information is presented in Appendices B and C.

3.1 STAKEHOLDER ENGAGEMENT & COMMUNITY OUTREACH (TASK 1)

The purpose of the stakeholder engagement and community outreach task was to build upon post-flood work in the watershed, to integrate local knowledge, and to further develop capacity and relationships for future stream management efforts. Given the size and diversity of issues in the watershed, it was essential to have a wide range of key groups participate – local, federal and state government, water providers and ditch managers, private land owners, agricultural producers, recreationists, businesses, and non-profits. Core stakeholders, described in this section, played a significant role, and contributed a variety of perspectives, data, and expertise, which provided guidance throughout the process. Engagement with the agriculture community was another critical piece of this SMP's outreach effort. In addition to including an agricultural liaison to have one-on-one and on-the-ground discussions, this SMP participated in statewide efforts of the agriculture community to learn more about the needs of working landowners and best practices for engagement. A brief summary of the engagement task is below, and details of the process, including challenges, are provided in Appendix B.

3.1.1 People and Process

At the outset, a group of about **100 stakeholders** were identified from the District's and project partners' lists of water and land managers, water providers, agricultural producers, recreational users, and environmental supporters. The contacts were familiar with the needs and opportunities of the watershed and supported the development of the SMP. Members of the initial larger group participated in a survey of interests and the project kickoff meeting in September 2018. Outreach was also conducted to the **larger community** through surveys and information tables at community events in fall 2018. The input from the broader stakeholders and community (see inset box) helped to shape not only this plan, but the vision of the watershed the stakeholders want to create.

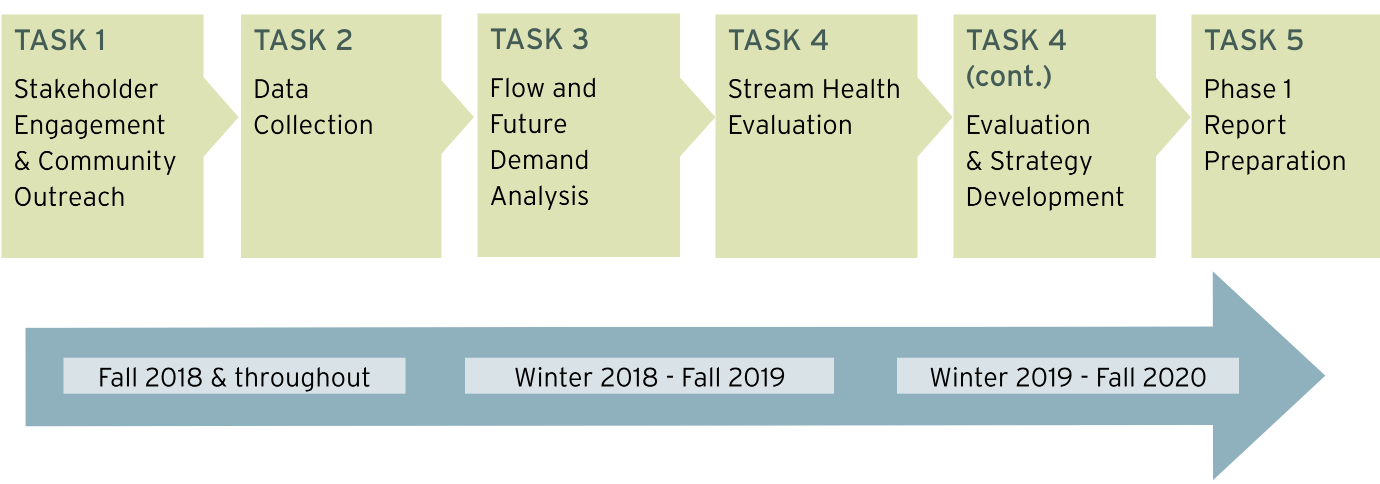


Figure 3.1–Overview of Phase 1 SMP Process

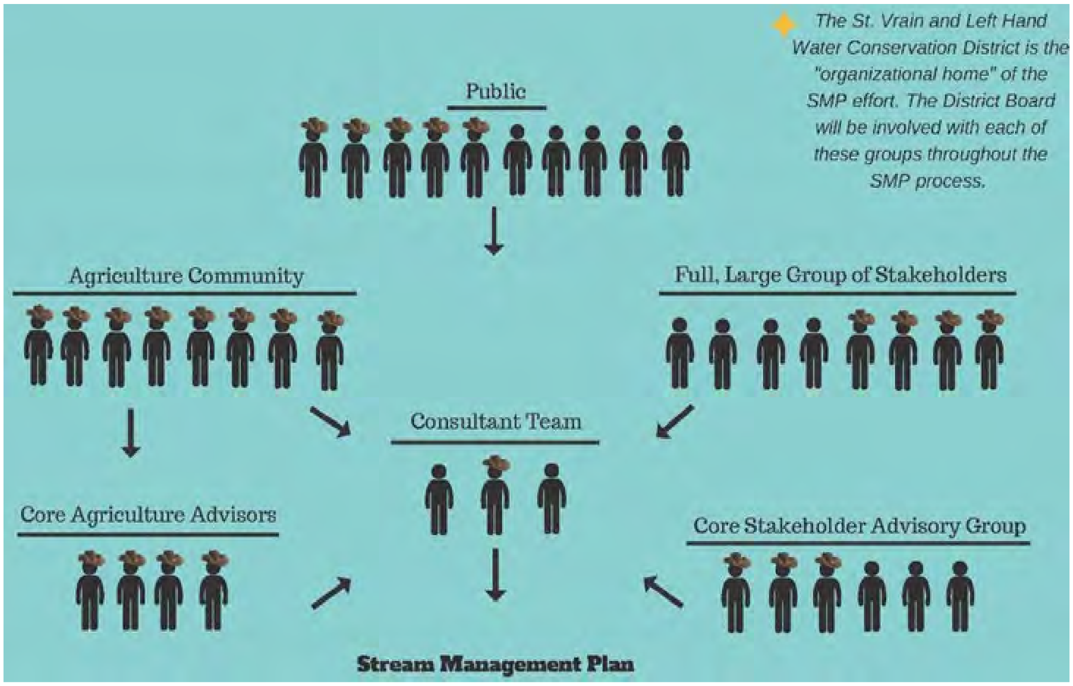


Diagram of Stakeholder Interactions Among Key SMP Groups, Courtesy of Peak Facilitation.

To effectively communicate stakeholder values over the course of the project, a **Core Stakeholder Advisory Group** was created as a representative subset of the initial large group (noted above). The Core Stakeholder Advisory Group met at important milestones during the planning process to be updated on progress and provide input and direction, with the intent that the plan reflects the needs and values of the communities and entities they represent.

Examples of Core Stakeholder Advisory Group involvement included:

- attending meetings with the project team to provide overall guidance on the approach and themes (see inset box)
- providing input on the engagement process and serving as liaisons to other stakeholders (e.g. attending the Colorado Agricultural Water Alliance meeting), described more below
- identifying desired conditions and goals (presented in Section 4)
- providing data and reviewing initial assessment results (discussed in Section 5), and
- refining ideas for specific strategies and opportunities (in Section 6).

Key Stakeholder Themes & Example Inputs

Flow
- Consider the "working" nature of the creeks along with other diverse needs across the watershed

Habitat
- Concerns include critical habitat for native fish and channel connectivity, degraded riparian areas needing restoration, and noxious weeds

Water Quality
- Agricultural and mine runoff are priorities for improvement
- Concerns include sediment transport and debris buildup near diversions

Infrastructure
- Priority issues are reservoir outlets and structures maintenance
- Concerns include dry up points and fish passage

Recreation
- Improved access for recreation is a desire
- Concerns include public safety of existing recreational structures and the opportunity for improvements

To collect additional input from the rural communities, a group of **Core Agricultural Advisors** was formed. The group included members of the Board of Directors of the St. Vrain and Left Hand Water Conservancy District and representatives from Boulder and Weld Counties. Outreach to the group occurred early on to understand engagement needs and at key touchpoints in the process. The consultant team's agriculture liaison conducted one-on-one conversations and site visits to introduce the SMP process and gather input. The District and the Colorado Agricultural Water Alliance (CAWA) also hosted a workshop and provided input to the Colorado Agricultural Alliance (CAA) survey (see Appendix B).

3.1.2 Stakeholder Input

In September 2018, a preliminary stakeholder survey helped lay the groundwork for the SMP kickoff meeting and initial discussions (see word cloud). The kickoff meeting was attended by the large stakeholder group (~30) to provide input on values and management goals, needs, and opportunities to be addressed by the SMP. Stakeholders and community participants identified key themes to be addressed by the SMP such as flow, water quality, habitat, recreation, and infrastructure (see inset). In addition to key themes, stakeholder input resulted in mapping over 100 features representing good-quality areas, problem areas, and opportunities for infrastructure, habitat, water quality and recreation (see photo next page). This created the "Stakeholder Values" layer in the geographic information system (GIS).

Word cloud of stakeholder hopes and visions for the creek

Community outreach occurred through information table events at the Longmont Farmers Market and Watershed Days, informational flyers, and an online survey. Highlights of these inputs are in Appendix B. Stakeholder and community input was then used to inform follow-up engagement meetings and team efforts related to data collection (Task 2), flow and demand analysis (Task 3), and the stream health evaluation (Task 4). In the follow-up meetings (Oct 2018-Sept 2019), the Core Stakeholder Advisory Group provided input on the assessment process and findings as well as report needs.

In November 2018, the District and the Colorado Agricultural Water Alliance (CAWA) held a joint workshop to explore the potential role and benefits of SMPs to the agricultural community. Issues that were identified as important by participants included diversion structure improvements, streamlined water leasing and sharing, restoration projects that reduce sediment issues, streamflow enhancements, more help with maintenance and funding, and educational outreach.

Additionally, Colorado Cattlemen's Association (CCA) Ag Water Network conducted a state-wide Watershed Management Plan Survey from January to April 2019 (with approximately 300 responses) to assess priorities of the agricultural community. The issues that respondents in Boulder, Weld, and Larimer County most wanted to see improved included planning and enhancement of the amount of water for existing uses, delivery infrastructure, water storage, and irrigation efficiency (see CCA 2019 full report at www.agwaternetwork.org)

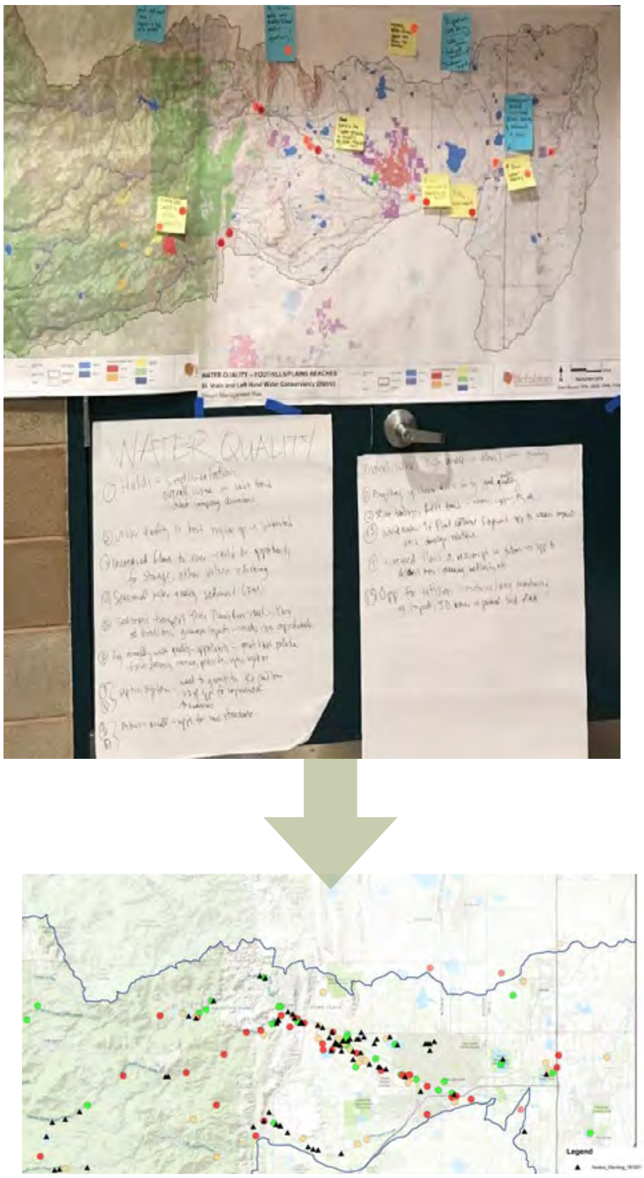
Because they are vital stakeholders, the agricultural community has a critical role in the development and future implementation of the SMP. However, because of several constraints, engagement in Phase 1 was not as robust as originally anticipated. Some of the lessons learned from the agricultural stakeholders included the need to:

- **Consider timing.** Develop a project timeline and approach during the time of season (non-growing season) and time of day (early or late) that allows agricultural stakeholders to engage.
- **"Pick-up truck" meetings.** If possible, meet agricultural participants at their farms, ranches, homes or other locations that are convenient for them, rather than asking them to drive long distances to meetings.
- **Be specific.** Agricultural participants are busy and noted that in addition to general communication updates by email, some participants expressed their desire for

meetings that are specific to management issues as opposed to general planning discussions.

- **Liaisons can work.** Other stakeholders are paid to participate, and agricultural representatives may benefit from designated persons who are compensated as well.

See also Appendix B and related attachments for more detailed accounts of deliberations and engagement process.



Stakeholder mapping input converted to GIS

3.2 DATA COLLECTION (TASK 2)

Geospatial data, streamflow data, previous assessments, and other relevant information were compiled from dozens of sources (Appendix A) including federal, state[1], and local agencies; non-governmental organizations (NGOs); and other consultants, into a preliminary online map platform. Data layers were overlaid and evaluated to determine which were most relevant based on extent and types of information included and filtered accordingly. Because a major focus of the SMP is understanding how flow patterns relate to stream health, the diversions (or nodes) used in the state flow model were used as the dividing points between reaches.

As would be expected for such a large project area, challenges related to geospatial data collection were encountered. Because rivers are dynamic systems, differences between geospatial data and actual conditions are common, leading to accuracy issues (e.g., recent flood impacts and restoration were not entirely captured in the Source Water Route Framework[2]). Outdated wetland and riparian mapping data were addressed by using them only as general indicators of the relative distribution and potential for wetland habitat. Land cover data were supplemented by a newly created layer using combinations of aerial imagery analyses e.g., spectral and Light Detection and Ranging (LiDAR) data that distinguished among mature tree canopy, subcanopy, herbaceous vegetation, and developed lands.

3.3 CHARACTERIZATION AND ASSESSMENT OF CONDITIONS (TASKS 3 & 4)

As discussed in Section 2, a critical part of Phase 1 of the SMP is to understand the health and functional condition of St. Vrain and Left Hand Creeks, including the interrelationships among physical, chemical and biological factors. When one component of a stream system is altered, other components adjust accordingly. Assessing and measuring these dynamics can be complex, as described briefly in this section and in more detail in Appendix C.

1. Mapping of streams and diversions primarily relied on state data to allow for transparency, documentation, and future updates.
2. The Source Water Route Framework is a CO Division of Water Resources dataset. Refer to Appendix A for details.

3.3.1 Flow & Future Demand Analysis (Task 3)

For the first phase of the SMP, flow data were compiled from a variety of sources including stream gages (Figure 3.2), the U.S. Geological Survey (USGS), Colorado Decision Support System (CDSS) data and models, and the Northern Colorado Water Conservancy District (Northern Water) Point Flow Analysis (accessed 2019). Stream gages are distributed across the watershed, with two in the alpine/subalpine zone, three in the canyon/foothills, three in the transition zone, and two in the plains zone (Figure 3.2). Although the periods of record for streamflow data vary in the watershed, ten stations had sufficient data available for the St. Vrain StateMod model to estimate monthly flows for both natural and existing conditions (see Table C-2 in Appendix C and Section 5 for details). In addition to the flow analysis, this task evaluated future demands (municipal and agricultural) to identify gaps between supply and demand as a result of population projections.

Updated hydrologic and risk information became available on a rolling basis during the project, often while analysis was underway or already complete. For example, the Northern Water Conservancy District's Daily Point Flow Analysis became available in April 2019; additional guidance from the state on flow-ecological risks was released in August 2019; and the City of Longmont's updated demand analysis came out in May 2019. While the SMP integrated these new resources throughout, similar analyses in future phases will need to continue to incorporate newly collected data. See Appendix D for additional details on demand analysis.

3.3.2 Stream Health Evaluation (Task 4)

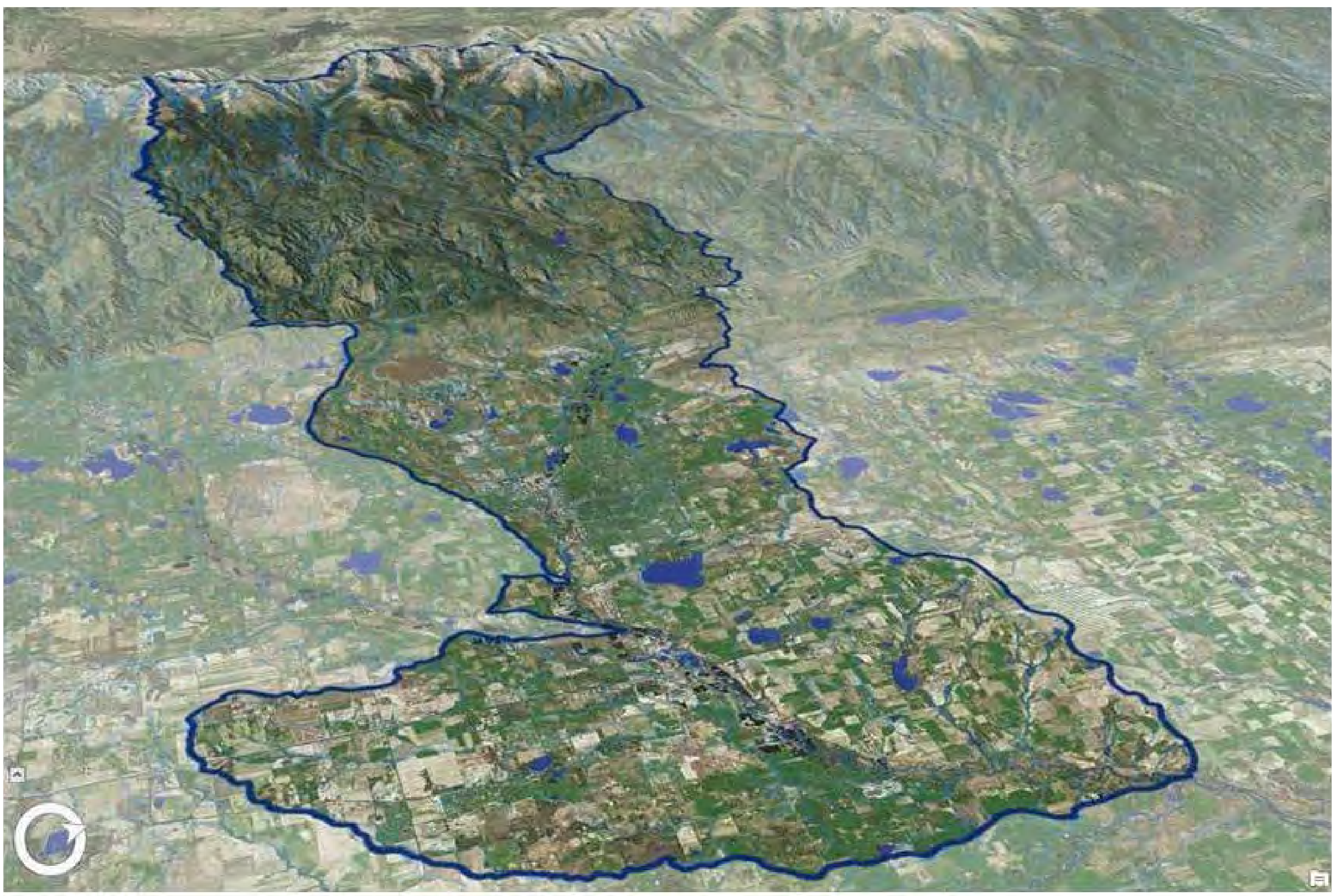
As part of Task 4, current conditions were synthesized by gathering stakeholder input, compiling and reviewing existing data, conducting rapid field assessments (see following paragraph), identifying geospatial relationships (mapping and desktop analysis), and evaluating the results. The overall approach of the stream health evaluation[3] was to build on previous work, which included review of post flood master plans, City of Longmont's Resilient St Vrain flood management plans, post-flood restoration extents and select monitoring data to help understand the current status of recovery and existing conditions. Desktop analysis was ongoing, but initially it was used to overlay available geospatial data and view related issues and possible stressors, e.g for water quality, flow alterations and habitat layers to screen the study area. The early desktop analysis assisted in identifying potential opportunity areas with multiple stressors to include in the site visits. There are various rapid assessment techniques that can estimate the

Figure 3.2 Location of Stream Gages and Source Water Route Framework (SWRF) Nodes included in SMP Flow Analysis

3. Note that this SMP uses the term stream health "evaluation", rather than "assessment" to refer to the broader study which includes the functional assessment along with considerations of recreation and infrastructure.

degree of departure from a reference state as indicated by flow, channel, riparian, and biological conditions. Due to the extreme geographic variability of the watershed, the Colorado Stream Health Assessment Framework or COSHAF (Beardsley and Johnson, 2018) was selected as the most suitable assessment technique for Phase 1 of the SMP. Appropriate for a wide variety of stream conditions, COSHAF is also used by the CWCB to assess flood recovery restoration projects along the Front Range, including those in the watershed.

The COSHAF method builds on the similar Functional Assessment of Colorado Streams (Johnson et al., 2016) to rapidly assess eleven variables, four of which (Flow regime, Sediment regime, Water quality, and Landscape) are watershed-scale and seven of which (Floodplain function, Riparian condition, Organic material, Morphology, Stability, Physical structure, and Trophic Structure) address reaches (see Appendix C for further discussion). Given the size of the study area and the focus on stream management, the on-the-ground rapid assessment focused on the lower reaches most impacted by ongoing water management. As the final step in Task 4, strategies were identified based on the needs found in the stream health assessment with a focus on the desired conditions and management goals provided by stakeholders (further described in Section 4).



Bird's-eye view of study area

Section 4 – Desired Conditions & Management Goals

From the core stakeholder advisory group meeting in February 2020 and the group's input during the SMP report prepration in summer 2020, desired conditions and management goals were developed within the context of the previously established overarching SMP goal:

> *"Collaboratively identify projects and management strategies in both St. Vrain and Left Hand Creeks that transition stakeholders from flood recovery to stream health projects that improve environmental conditions of the river while also meeting water users' current and future needs and are aligned with private property rights, public land and resource management plans, and the prior appropriation system."*

The general vision is outlined by topic or themes, with the understanding that actual implementation will address overlapping topics and will vary by on-the-ground conditions. Figure 4.1 depicts the major elements of the first phase of the SMP, as well as how implementation will lead to future refinement of the process. As illustrated, each element informs the next and is supported by ongoing, data-driven implementation and an adaptive management approach to continue the process forward. Descriptions of strategies and implementation are provided in Sections 6 and 7.

As previously noted, the SMP is organized around four main themes that were the focus of the evaluation: flow, habitat, water quality, and water management. Recreation, which is another important topic for the SMP, is addressed within each of the four themes. In this section, the desired conditions and management goals for each theme are defined.

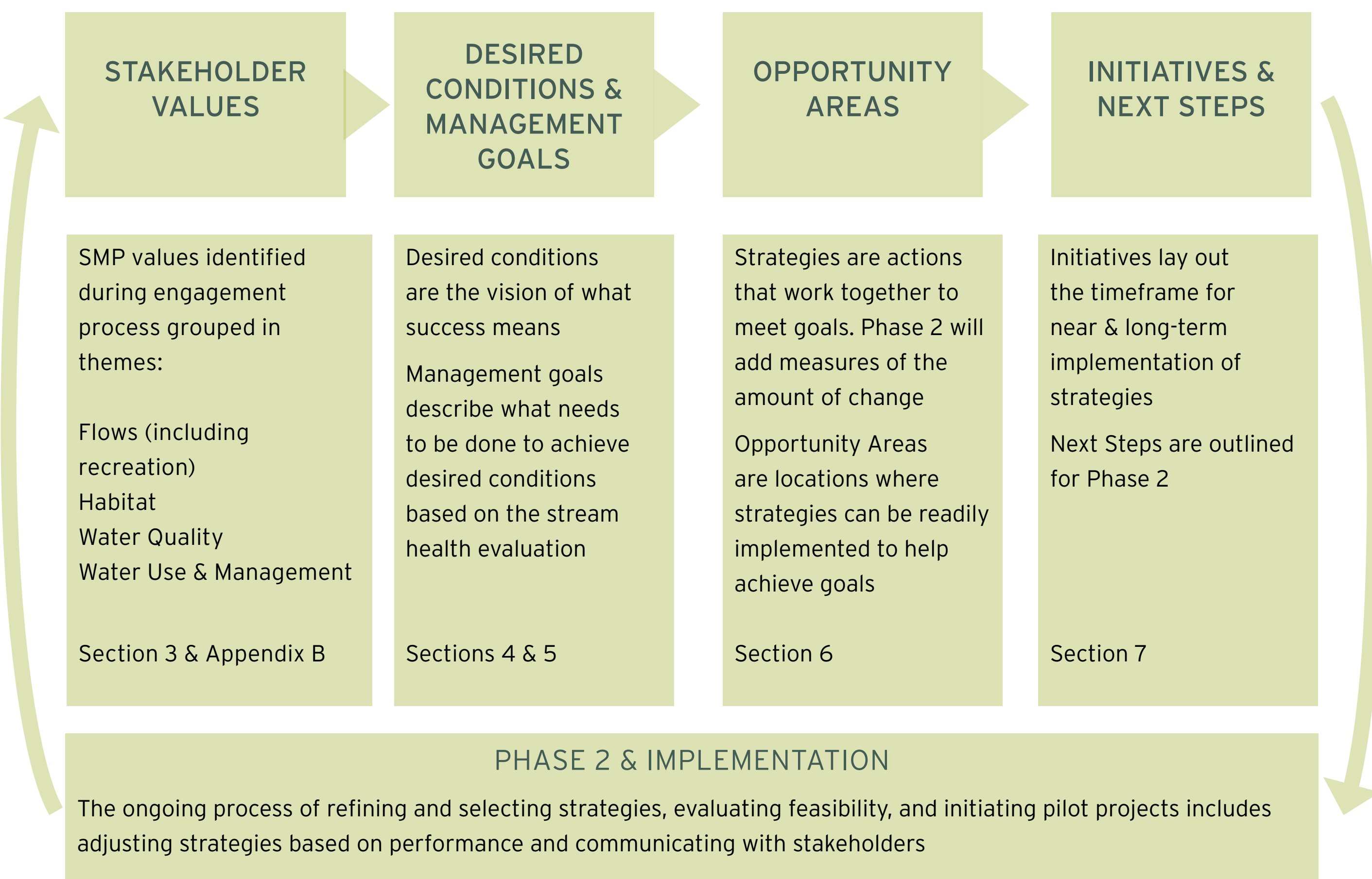


Figure 4.1– Relationship of desired conditions and goals to other parts of the SMP

4.1 FLOW

Desired Conditions: The desired conditions for streamflow are to achieve a flow regime that satisfies the needs of the natural environment, non-consumptive users, and consumptive users.

Achieving desired conditions depends on a range of flows needed to maintain flow-ecology relationships (e.g. for fish and riparian vegetation) and stream health through the year. Baseflows, particularly in winter and late fall, support fish survival by maintaining pool-riffle sequences and ensuring that saturated channel bottom (hyporheic) conditions persist for microbes and macroinvertebrate populations. High flows in spring are critical for floodplain inundation, recharging shallow groundwater, supporting a balanced sediment transport regime, maintaining channel morphology, supporting riparian native plant communities, and providing cues for fish spawning and recreation. Of particular importance is floodplain connectivity timing in relation to cottonwood regeneration in the spring, and summer and fall flows that support riparian growth and provide habitat for young fish as well as maintain water quality.

Specific flow patterns vary depending on the creek, reach and position in the watershed (as described further in Section 5). Figure 4.2 presents the typical annual flow patterns for a similar Front Range river system. The flow-related goal, presented below, reflects the need to tailor management strategies to address stressors based on an understanding of water rights administration, historical and natural flow conditions, and available opportunities based on the river condition and stakeholder interests.

Flow Management Goal:

1. Maintain baseflows and peak flushing flows in the creeks necessary to support ecological function and connectivity for native and sport fish, recreation, and diversions for beneficial use.

The above goal is used to identify strategies including potential Phase 2 topics, such as flow targets, discussed more in Sections 5 and 6.

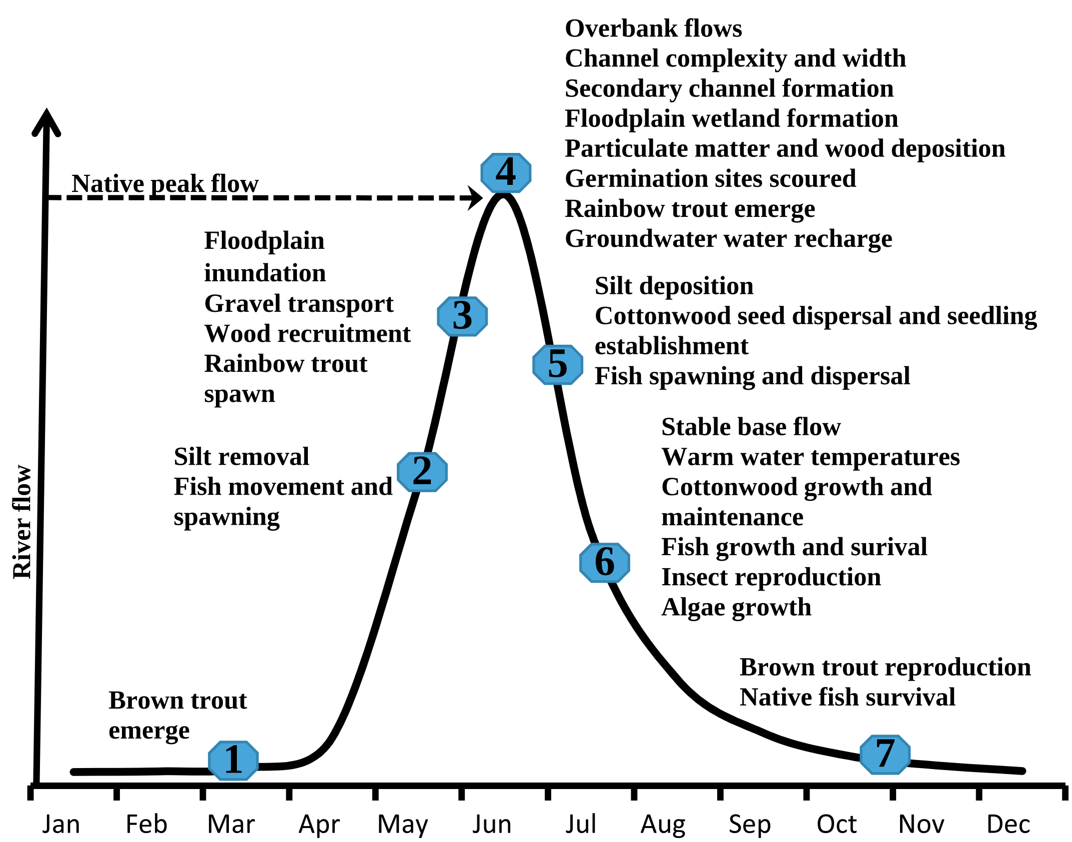


Figure 4.2– Example of hydrology calendar for Poudre River describing flows and timing of functions (Reprinted from Bestgen et. al., 2019)

4.2 HABITAT

Desired Conditions: *The desired conditions for habitat are to provide for diverse and resilient native plants and wildlife that, thrive in a network of riparian corridors and dynamic channels, with complex instream habitat features, and connected floodplains. These conditions will ideally be compatible with water rights, private property rights, public land and resource management plans.*

The SMP planning area holds an extraordinary amount of biodiversity because of its complex landscape, and as a result, maintaining habitat for plants and animals along the stream corridors depends on the interrelationships of many variables. High-functioning habitat depends on ecological processes and conditions, including floodplain connectivity, diverse and continuous instream habitat, dynamic and functional channel morphology and sediment regime, diverse native plants and animals, and adequate recruitment to sustain future populations (Figure 4.3). Desired conditions acknowledge the "working river"[1] that exists but also recognize the potential for added protections and improvements. In particular, there is growing awareness by scientists and resource managers that streams, riparian zones, and floodplains are integrated in their function and in their vulnerabilities (Baxter et al., 2005). Therefore, added emphasis on improved land management practices will be important (Arthington et al., 2006). Land management practices that improve habitat will also benefit water quality.

Habitat Management Goals:

1. Preserve and restore riparian and instream habitat for native species.
2. Allow natural processes to occur in appropriate locations[2].
3. Implement appropriate land and water management strategies to maintain and enhance habitats along creek corridors.
4. Increase instream and riparian connectivity for native species.
5. Control non-native invasive species.

Figure 4.3– Examples of interacting aquatic and riparian habitat elements

1. "Working river" is a general term that refers to the services a river provides to support human needs. In the Front Range this usually means consumptive uses for agriculture, municipal, and industrial. Working rivers are manipulated and managed. Healthy working rivers balance the human services and the natural ecosystem in a sustainable compromise.
2. Appropriate locations depend on the processes, site setting, and owner goals; for example, appropriate locations to enhance frequent overbank flooding include open space areas that would not increase risk to infrastructure.

4.3 WATER QUALITY

Desired Conditions: *The desired conditions for water quality are to meet or exceed standards set for public health, environmental concerns, and intended uses.*

Water quality pollutant standards are defined by state and federal regulations according to the designated use of a water body. Monitoring of stream water quality is conducted by various entities within the watershed. Widespread issues leading to restrictions on the use of creeks in the watershed are occurring due to abandoned mines, bacteria, and nutrient loading. Ongoing monitoring will take a concerted and coordinated effort by SMP stakeholders. Fortunately, local jurisdictions, the Left Hand Watershed Center, and the Keep it Clean Partnership, which includes many of the SMP stakeholders, have been tackling the issues for years and have developed monitoring plans and response actions to reduce impacts of sources of pollution that can serve as the foundation for the SMP to build on and support.

Water Quality Management Goals

1. Remediate known point and non-point sources of water pollution in the watershed.
2. Monitor pollutants from historic mine sites.
3. Rehabilitate excessively eroding and impaired creek banks and channels based on natural channel design concepts where possible.
4. Restore healthy forests and improve forest-creek connections to keep pollution out of waterways.
5. Limit new sources of water pollution.

4.4 WATER MANAGEMENT

Desired Conditions: *The desired conditions for water management are to achieve a balance among the needs of the natural environment, non-consumptive, and consumptive users.*

Most of the issues affecting water resource management and stream health extend beyond the boundaries of a single reach, landowner, or manager. As a result, improving management requires coordinated efforts by water rights holders and stakeholders. Irrigators in the basin have identified numerous needs and opportunities to address, such as coordination of financing and infrastructure improvement projects, which will help reduce barriers and be a catalyst for implementation.

Water Management Goals

1. Work with water rights holders to ensure their water supply needs are met and not interrupted, explore issues and concerns, and find opportunities for mutually beneficial management improvements.
2. Meet regularly with all stakeholders to discuss water management issues, potential solutions, funding opportunities, education and outreach, and other mutually beneficial opportunities.
3. Strive for a mutually beneficial balance between the needs of water users and the needs of the natural environment.

View of recreation along St. Vrain Creek through City of Longmont

Section 5 – Stream Health Evaluation Results

This section summarizes the ecoregional and watershed characteristics, flow analysis, and COSHAF results for major stream health variables. Results are subtotaled by stream mile in each zone. The Water Use and Management subsection 5.5 describes information collected as part of the demand analysis that evaluated gaps for agricultural water requirements and future municipal water needs. The final subsection describes remaining data needs.

5.1 ECOREGIONAL AND WATERSHED CHARACTERISTICS

To better understand stream systems, it is important to consider the characteristics of their watershed and ecoregion (described further below).

Ecoregional characteristics

Climate, topography, geology and soils interact in each ecoregion to shape water flow paths and patterns of plants, wildlife, and human uses. Figure 5.1 shows the distribution of the various ecoregions in the SMP study area, and Tables 1 and 2 summarize key characteristics. As shown, although the overall size of the ecoregions are evenly distributed, nearly half of the river miles are found in the canyon/foothills zone.

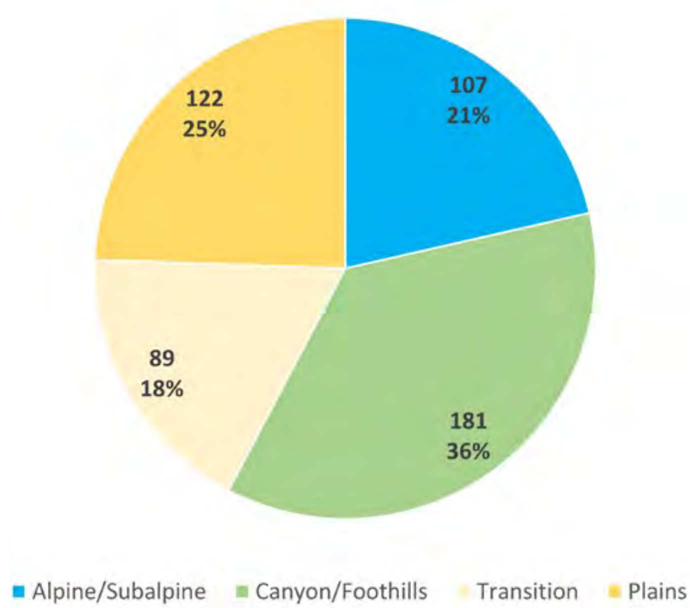


Figure 5.1– Area of Ecological Planning Zones in SMP Study Area(sq mi)

Table 1 Topography and Climate of the SMP Study Area

Ecoregional Zones	River Length, Miles (%)	Area, Square Miles (%)	Elevation range, (Feet)	Avg Annual Precipitation (inches)	Average Winter Minimum/ Summer Maximum Temperatures (°F)
Alpine/Subalpine[1])	35 (19%)	107 (22%)	9,500-13,000	18.0	16.5/75.2
Canyon/Foothills[2])	91 (49%)	181 (36%)	5,500-9,500	16.5	17.3/84.6
Transition[3])	32 (17%)	89 (18%)	5,000- 5,550	14.2	12.0 /87.0
Plains[4])	27 (15%)	122 (24%)	4,700- 5,000	14.7	17.7/90.0

NOAA historical data 1981-2010 for weather stations at: 1) Estes Park 3 SSE, GHCND:USC00052761; 2) Waterdale, GHCND:USC00058839 3) Longmont 2 ESE, GHCND:USC00055116 4) Greeley USC, GHCND:USC00053553.

Source: https://gis.ncdc.noaa.gov/maps/ncei/normals

Table 2 General Geologic Settings & Soil Characteristics of the SMP Study Area

Ecoregional Zones	Typical Geology	Typical Soil characteristics
Alpine/Subalpine	Gneiss, granite, glacial drift	Shallow, coarse gravel deposits, and rock outcrop complexes on steep slopes. Range of slopes: 3-80%
Canyon/Foothills	Predominately granite; sandstone in foothills	Shallow, coarse gravel to deeper loamy soils at toes of slopes Mountain slope soils. Range of slopes: e.g. 5-65%
Transition	Unconsolidated colluvial and alluvial deposits	Range of cobbly gravel and sand on terraces and fans to sand and clay loam floodplain soils. Range of slopes: 0-6%
Plains	Alluvial Deposits	Deep clay loam & sandy loam in floodplain. Range of slopes: 0-6%

Sources: Green, G.N., 1992 and USDA, 2008

Geology and soils affect the water flow paths, channel morphology and habitat. Briefly, starting in the alpine zone, shallow soils on steep bedrock direct water downslope into the alpine lakes and wet meadows found in the subalpine open valleys. Spring snowmelt in the mountains makes its way through these valley features, helping to moderate the release of water in each tributary. The hard granite of the canyons forms narrow valleys with relatively straight channel reaches and limited room for riparian vegetation. The canyons then start opening up through the foothills and into the transition zone. The flat alluvial deposits of the plains zone result in a winding, sinuous channel on the way to the South Platte River.

View of South St. Vrain Creek, characteristic of Canyon/Foothills

Watershed Characteristics/Overview

Watersheds have been mapped across the country at a range of scales using hydrologic unit codes (USGS HUCs). Of the 18 HUC sub watersheds in the SMP planning area (Figure 5.2), five of the largest basins make up 50% of the area: Firestone Lake-St. Vrain Creek, Outlet North St. Vrain Creek, McIntosh Lake-St. Vrain Creek, Headwaters North St. Vrain Creek, and Headwaters South St. Vrain Creek. Another major tributary to the St. Vrain, which is outside the study area, is Boulder Creek, which flows into St. Vrain just downstream of Longmont.

As the smaller drainageways flow into the main tributaries in the upper watershed, flow volumes increase, resulting in the creeks gaining flow. The creek corridors broaden as they enter the alluvial valleys in the transition and plains zones, and some water percolates to the shallow aquifer comprised of sand, gravel, and cobble deposits, where it is stored in the subsurface and flows back into the creeks as baseflow at a later time.

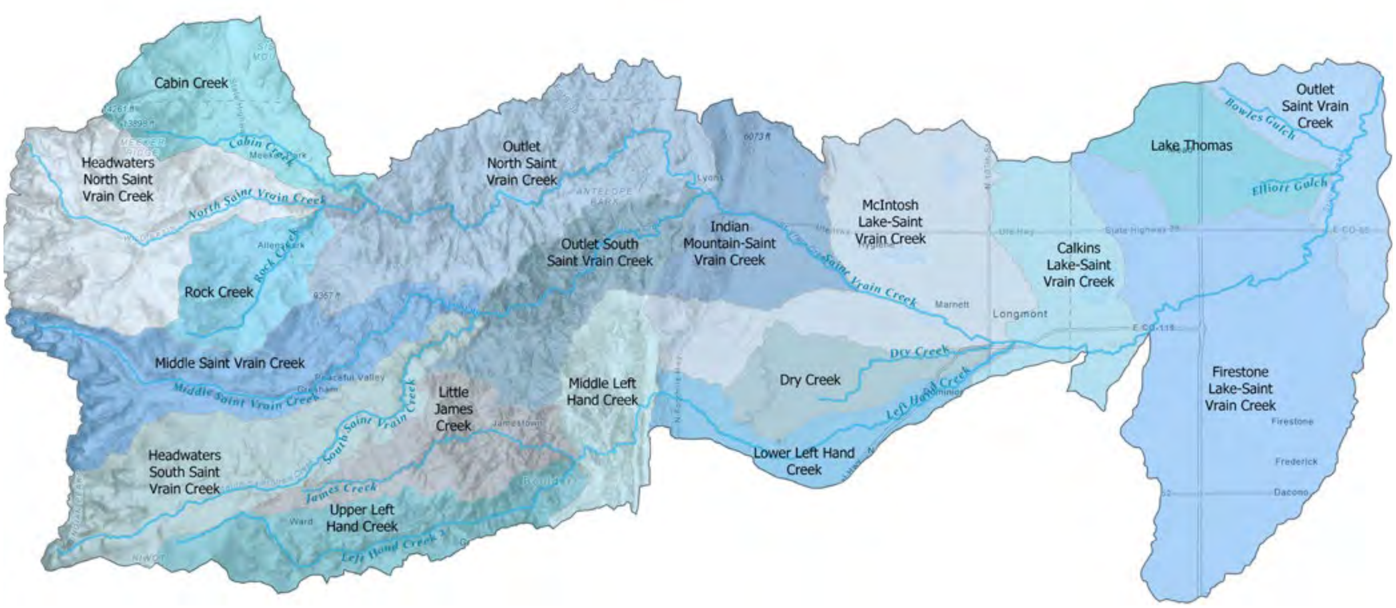


Figure 5.2– Subwatersheds (HUC12) in the SMP Study Area

5.2 FLOW REGIME

This section provides a summary of flow data compiled for the watershed. The first subsection summarizes general flow characteristics including mean annual flows, peak flows and low-flow patterns. The second and third subsections present summaries of flow alterations and considerations for key environmental and recreation flow targets. As would be expected, water management plays a major role in the existing flow regime, and Figure 5.3 shows locations of select diversions.

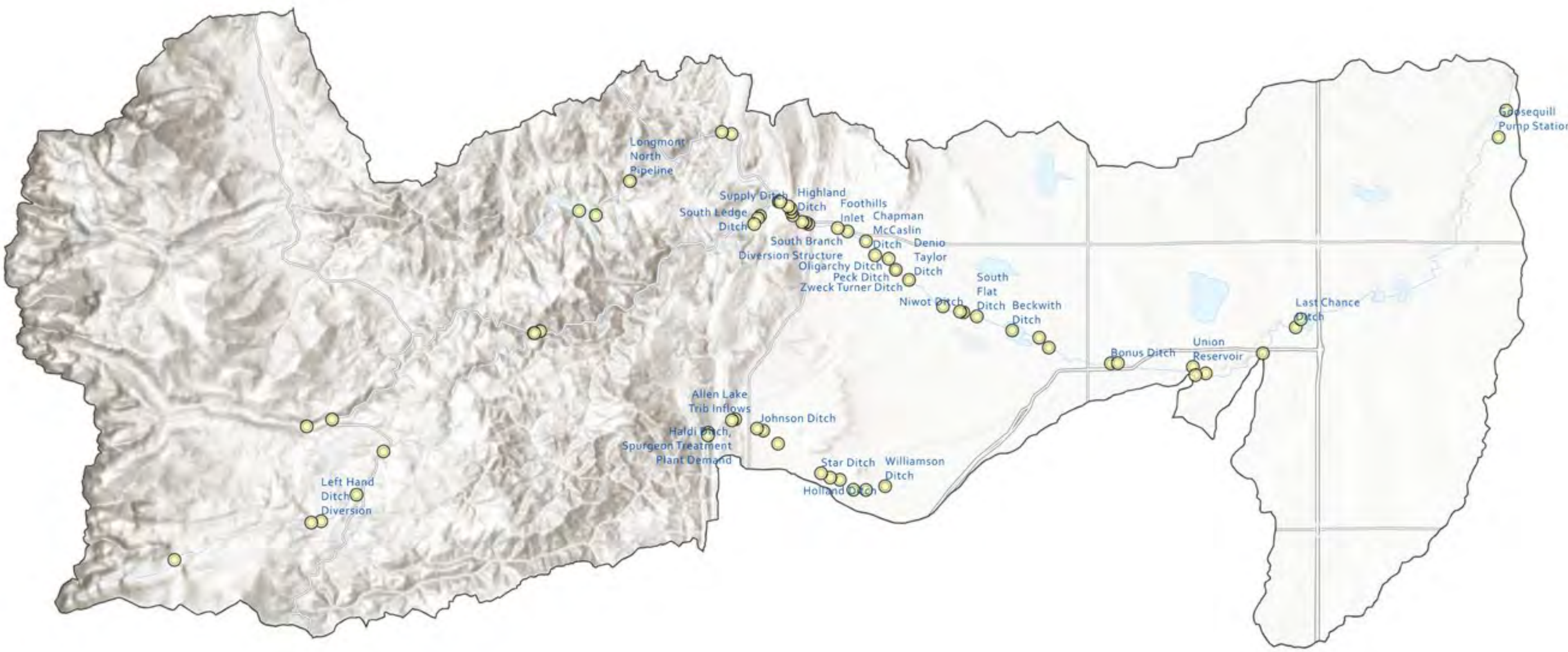


Figure 5.3– Location of select diversions in SMP study area

5.2.1 General Flow Characteristics

In spite of the extensive manipulation of flows throughout the creek system, flow patterns still generally reflect those that would be expected in this part of the Front Range - snow-melt driven creeks with peak flows occurring in the spring and low flows extending from late summer through winter. Year-to-year variation is typical, depending on depth of snowpack and rate of snow melt. Figure 5.4 shows the variability among example wet and dry years at one location. (Refer to Appendix C for further discussion of characterization of year types).

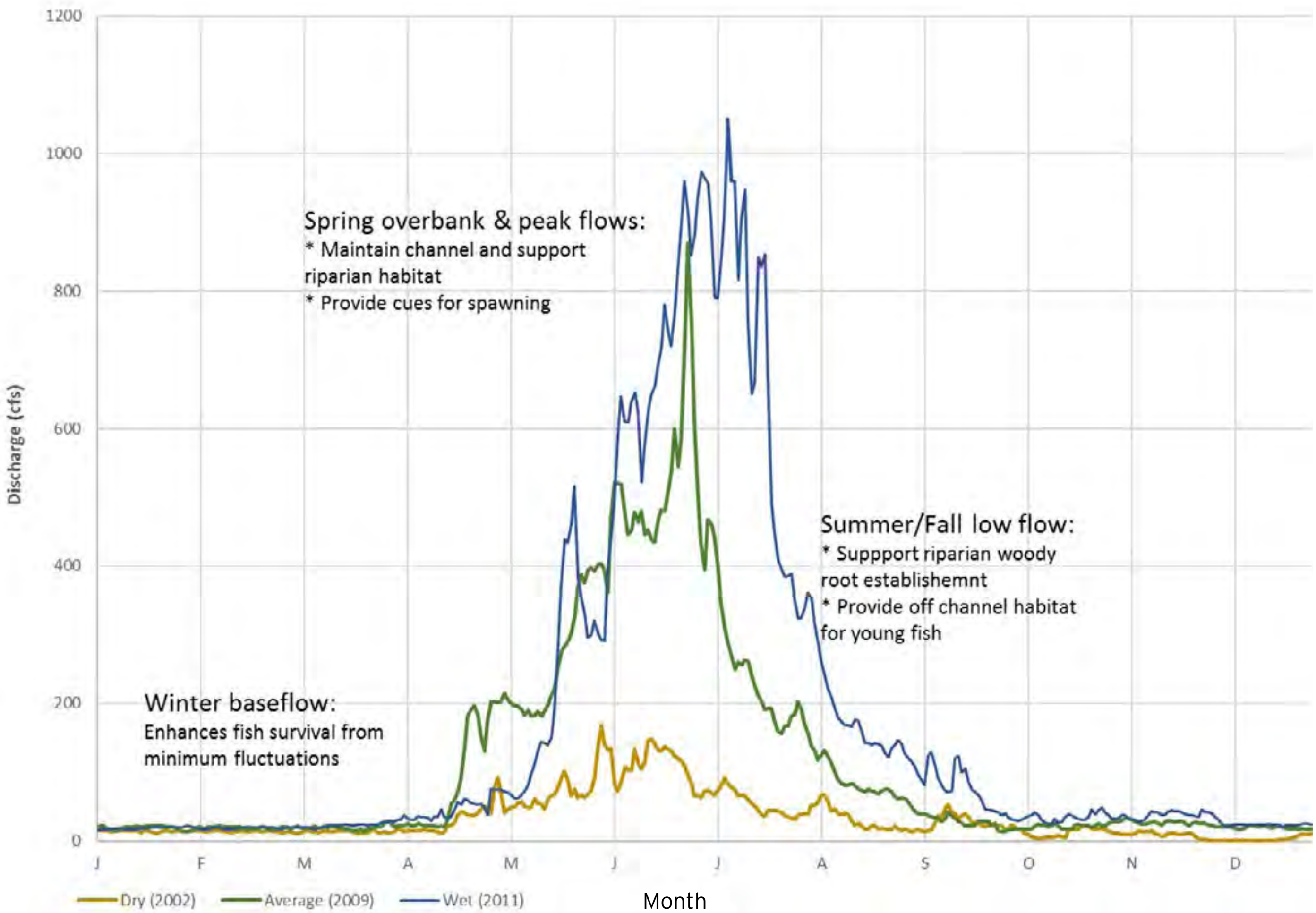


Figure 5.4– Average daily flows based on representative year types for St. Vrain Creek at Lyons.

Table 3 shows the range of flows for select gages including average annual minimum and maximum flows in cubic feet per second (cfs) and drainage areas from StreamStats records (USGS, 2018). Refer to Figure 3.2 for gage locations.

Table 3 General flow characteristics by gage and ecoregion. Refer to Figure 3.2 for gage locations

Ecoregional Zone	Location	WDID (Abbrev.)	Drainage area (sq mi)	Mean annual flow, cfs	Mean minimum flow, cfs	Mean maximum flow, cfs
Alpine/Subalpine	SOUTH SAINT VRAIN NEAR WARD	SSVWARCO	13	28	15	43
	MIDDLE SAINT VRAIN AT PEACEFUL VALLEY (at boundary with canyons zone)	MIDSTECO	17	59	2	358
Canyons & Foothills—North, Middle, South & Main Stem SVC	NORTH SAINT VRAIN CREEK BELOW BUTTON ROCK (RALPH PRICE) RESERVOIR	NSVBBRCO 504010	106	90	53	129
	SAINT VRAIN CREEK AT LYONS, CO	SVCLYOCO	216	127	46	222
	LEFT HAND CREEK NEAR BOULDER, CO	LEFCRECO	52	37	20	60
Transition-Mainstem	SAINT VRAIN CREEK AT HYGIENE, CO	SVCHGICO	223	84	--	--
	SAINT VRAIN CREEK BELOW KEN PRATT BLVD AT LONGMONT, CO	SVCLOPCO	370	125	--	--
	LEFT HAND CREEK AT HOVER ROAD NEAR LONGMONT, CO	LEFTHOCO	72	26	4	36
Plains--Mainstem	ST. VRAIN CREEK BELOW BOULDER CREEK AT HWY 119 NEAR LONGMONT, CO	SVCBBCCO	424	118	51	275
	SAINT VRAIN CREEK AT MOUTH NEAR PLATTEVILLE, CO	SVCPLACO	979	221	55	569

Source: USGS Stream Stats (accessed 2018)

Peak flows

Peak flow is the maximum statistically-derived flow in a given time period, which is an important measure of stream functions such as sediment transport, channel morphology, and riparian health. Annual peak flows typically occur during spring snowmelt, though as demonstrated by the 2013 flood, can also be caused by weather systems that stall over the watershed during other times of the year. In addition to the seasonal and year-to-year variability in peak flows, there is also wide variability in magnitude across the study area. Figure 5.5 shows the 1.5-year frequency peaks for different gage locations; they range from 187 to 1,970 cfs, with the highest peaks occurring below the confluence with Boulder Creek.

Mean minimum flow

Minimum flow is often used as an indicator of potential stress on aquatic organisms. There are many ways to look at low-flow patterns, such as daily, seven-day, or monthly averages. Seven-day minimum flows during low flow months, such as late fall and winter, are often used to characterize low-flow stream conditions because they are less impacted by short-term fluctuations that can influence one-day low flows. Figure 5.6 presents the seven-day minimum flows along with monthly flow averages for August, September and January at different gage locations. As shown, seven-day minimum flows are less than 10 cfs at five of seven gages, and all seven-day minimums are well below the lowest monthly means in January.

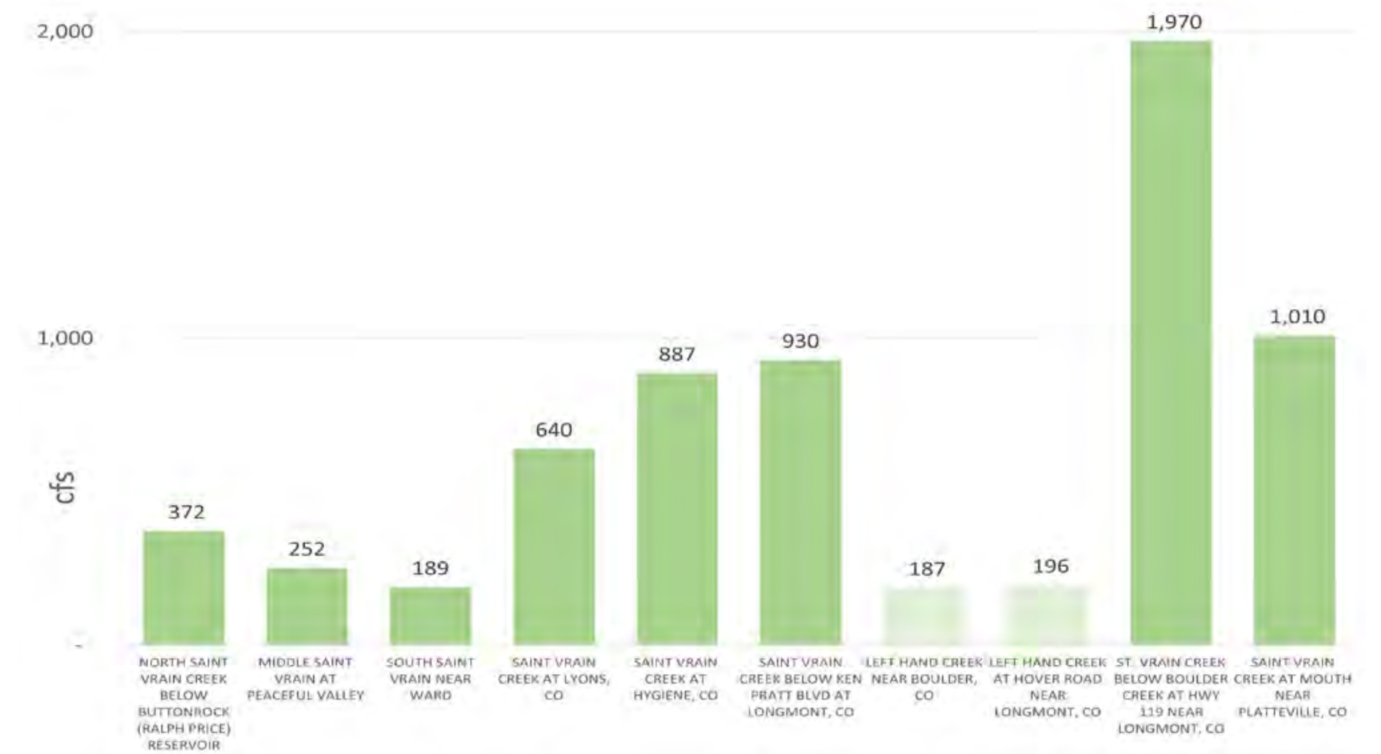


Figure 5.5– 1.5 year Peak flows (cfs) at select locations in the watershed

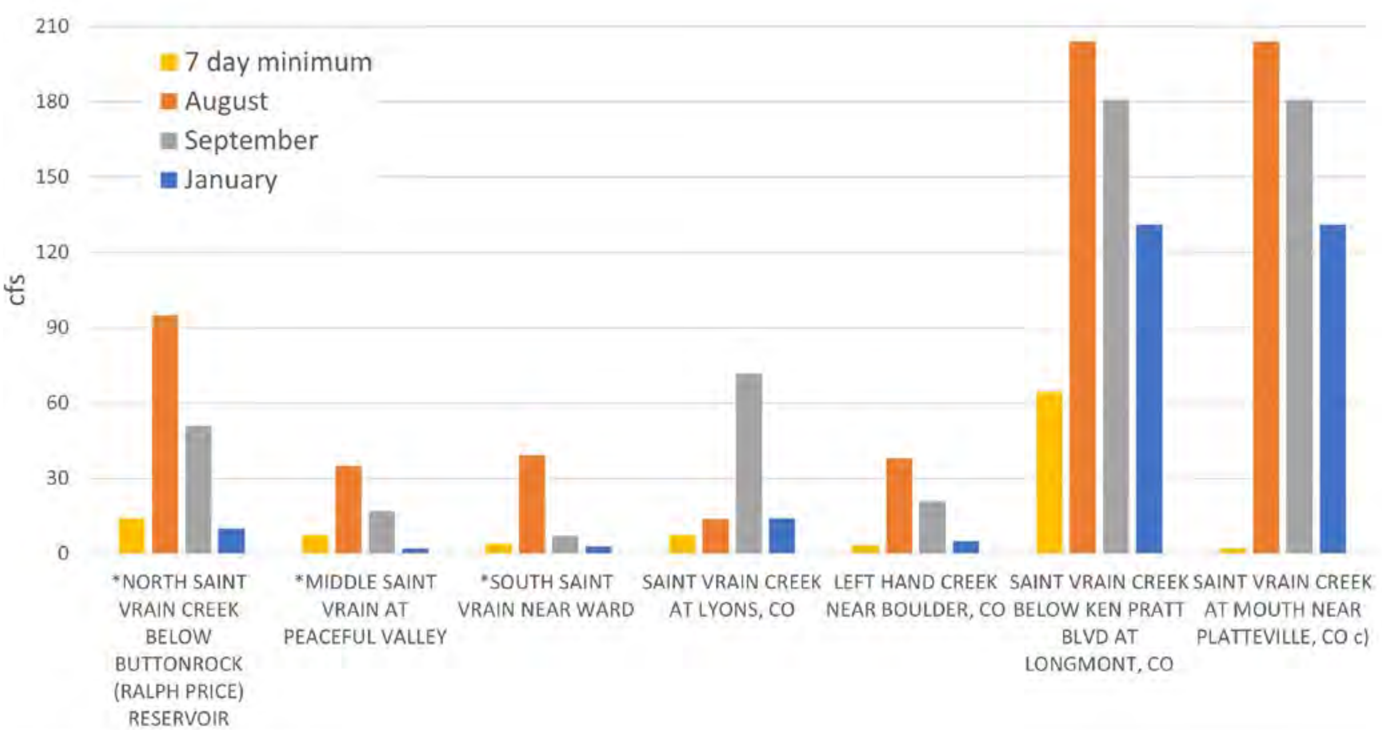


Figure 5.6– Seven-day minimum flows and mean monthly flows (Aug, Sept, Jan). Sources: USGS gage records,except for Middle St Vrain at Peaceful Valley and Left Hand Creek Near Boulder based on StateMod outputs: seven-day minimum data from USGS Stream Stats (Capesius & Stephens, 2009).

5.2.2 Flow-Ecology Alterations

Native habitat in St. Vrain and Left Hand Creeks evolved under natural processes, such as flooding, channel formation, sediment transport, and groundwater-surface exchange that are interrelated and fundamental to supporting the life and ecology of the corridor. Therefore, unmanaged (i.e., naturalized) flow patterns provide a baseline, starting point for understanding flow-ecology relationships when compared to existing conditions. The amount of change, or alteration, between flows for naturalized versus existing conditions helps identify areas of potential risk to native habitat and species. The flow evaluation looked at annual average flow, average flow during high-flow months, and average flow during low-flow months. (Refer to Appendix C for details on methods used to evaluate flow.) For this study, flow-ecology alterations were assessed using Colorado Decision Support System (CDSS) data and StateMod results to summarize changes in monthly flows under existing versus historic conditions.

In addition to CDSS and StateMod, the State of Colorado has described key environmental and recreation values that are identified in the South Platte Basin Implementation Plan and the Colorado Environmental Flow Tool (CWCB, 2019) for the St. Vrain Creek watershed. These sources were reviewed for information on flow ranges that are necessary to support native plains fish, wetlands, and recreational use[1].

1. Note that the CO Environmental Flow Tool for study area includes only one node (St. Vrain Creek at Lyons), so the current SMP evaluation provides additional detail based on an evaluation of 10 nodes in the study area.

Total Annual Average Flow Alterations

Total annual average flow in over half of the creek miles is relatively unaltered (88 miles, 52%) with low to minimal risk of impact to flow-ecology relationships, meaning that flows are similar to naturalized conditions (Figure 5.7). Eleven percent (18.2 mi) are considered to be moderate risk, and 24% (43.1 miles) are in the high- to very high-risk category due to total annual flow reductions. The remaining 12% of the reaches (21.2 mi) have increased flows relative to natural conditions, due to a variety of factors including diversions from one basin to another (such as to James Creek from South St. Vrain), contributions from wastewater treatment effluent, and timing changes due to upstream storage. As explained in Appendix C, reaches with increased flow were simply identified as such without being assigned a risk category.

As shown on Figure 5.8, all of the low risk reaches are in the upper watershed (alpine/subalpine or canyon/foothills zones) and the majority of the high to very high risk reaches for total average annual flow are in the transition and plains reaches in the St. Vrain Creek watershed[2], with the exception of South St. Vrain Creek below the diversion to James Creek.

2. Note, the StateMod flow analysis did not cover 16 miles of tributaries – Dry Creek, James Creek, Elliot Gulch and Bowles Gulch-- and therefore, the assessment of altered flows is focused on 170 miles out of the 186 miles in the study.

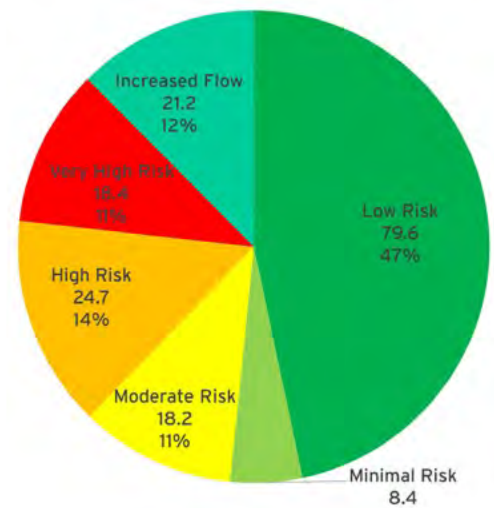


Figure 5.7– Ecological Risks associated wtih Total Annual Average Flow in SMP Study Area (Miles)

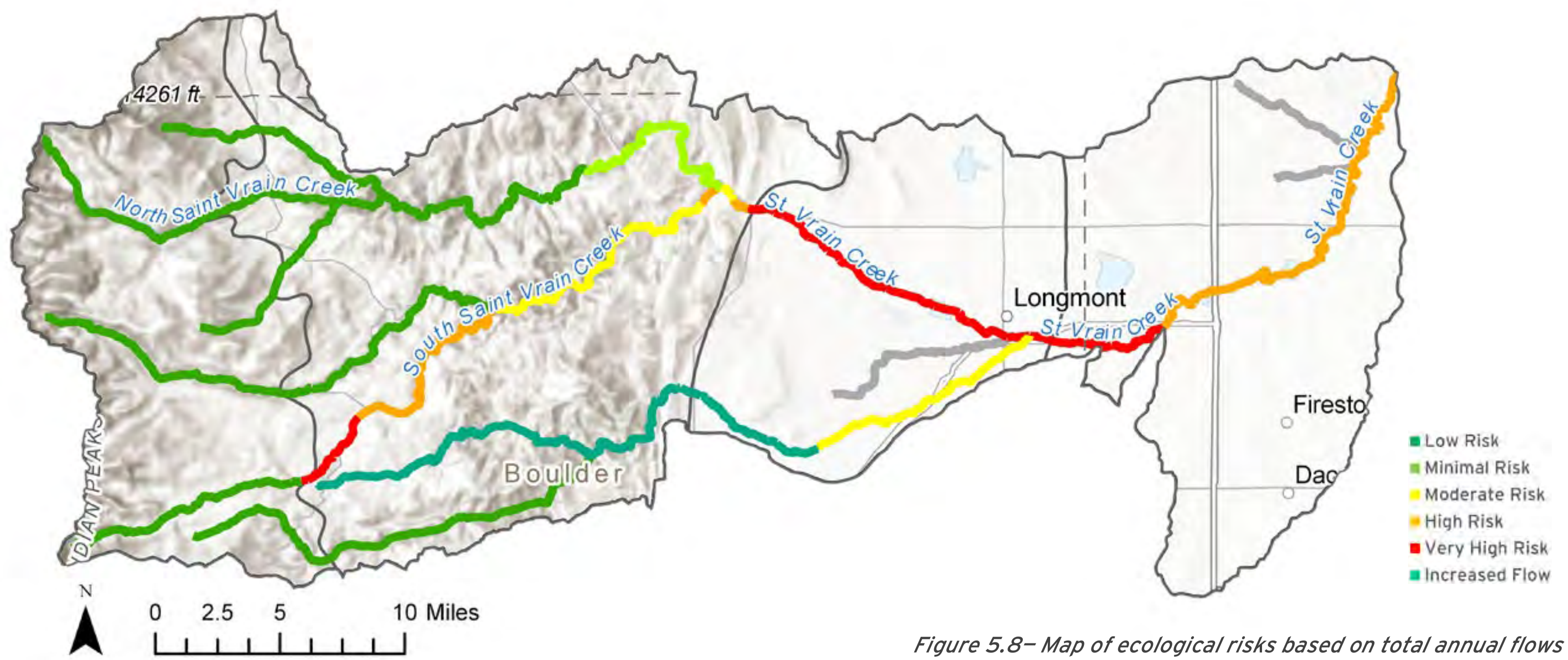


Figure 5.8– Map of ecological risks based on total annual flows

Average High-Flow Alterations

High flows support a number of flow-ecology relationships where overbank flows recharge the shallow alluvial groundwater and scouring peak flows create floodplain disturbances that reset successional processes suitable for regenerating cottonwood forests. High flows are also important for sediment transport maintenance of channel form. In the absence of these high flows, creek and riparian health are degraded and invasive species, such as tamarisk in the plains reaches, can become dominant.

High flows in May, June, and July in the alpine/subalpine and canyon/foothills zones (88 mi., 53%) are generally similar to naturalized conditions, with low to minimal risks (Figure 5.9). When looking at the entire length of creeks within the study area, about one-third of the creeks (51 mi, 30%) are in the high- to very high-risk categories for significantly reduced high flows during this 3-month period, indicating insufficient high flows to support healthy creek functions. As shown on Figure 5.10, of these 51 miles, 11 are downstream of the South St. Vrain to James Creek diversion and the remaining 40 miles are in the transition and plains zones. Most of the highly impacted reaches are in St. Vrain Creek (43 mi.). In Left Hand Creek, high flows are diminished and pose a high-flow ecological risk for about 8 miles below Williamson Ditch (just west of 63rd Avenue) to the confluence with St. Vrain Creek. Nine miles in the canyon/foothills zone are at moderate risk, and the remaining 21 mi have increased high flows due to inflow from one basin to another.

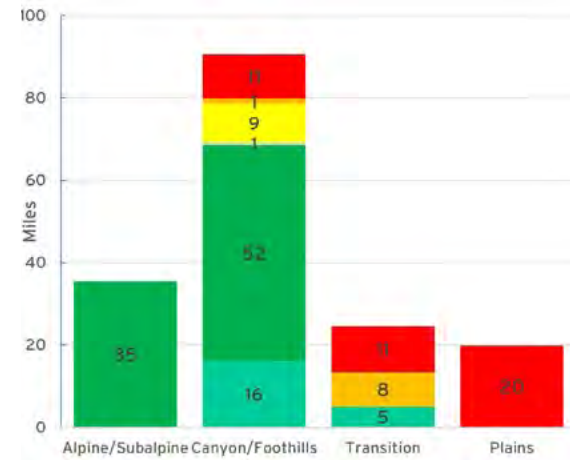


Figure 5.9– Ecological risk from high flows in SMP study area (miles)

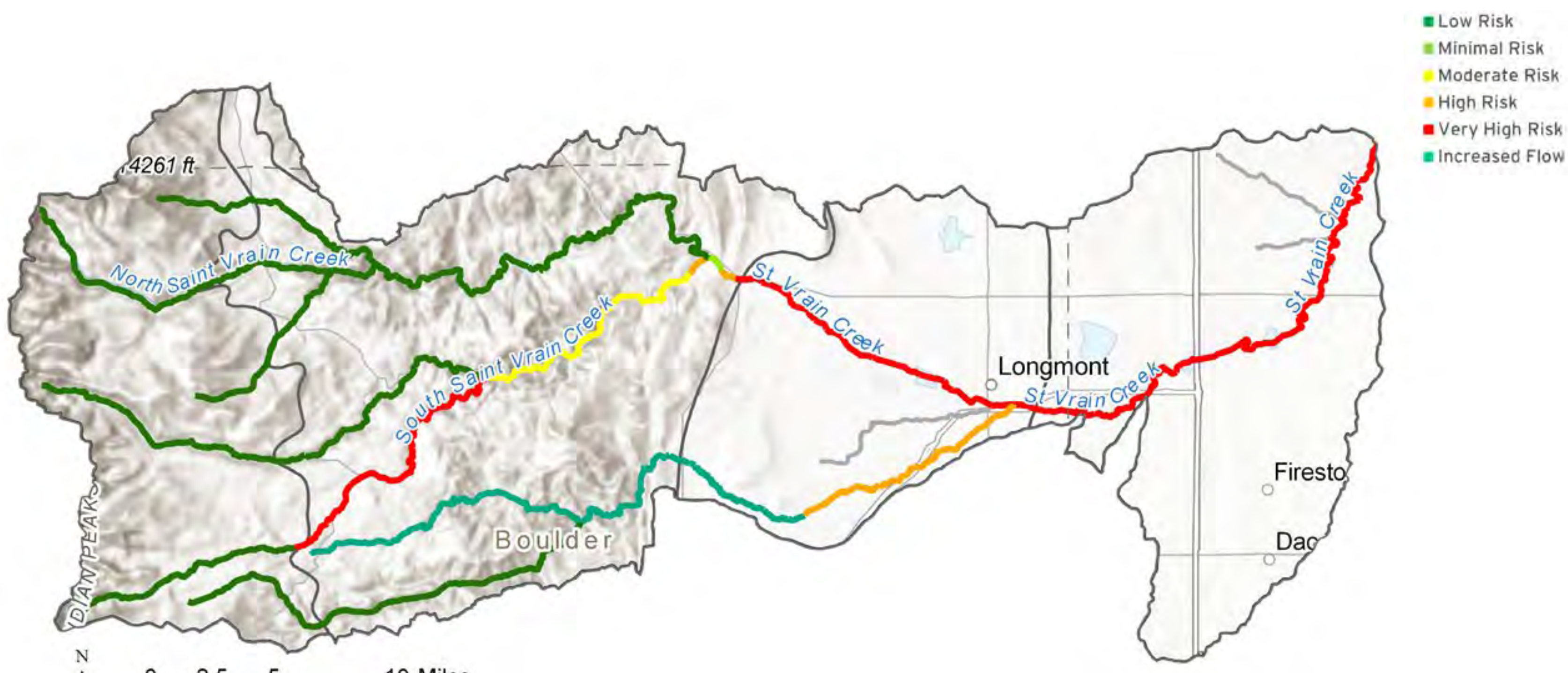


Figure 5.10– Map of ecological risks associated with high flows

Average Low-Flow Volume Alterations

During the low-flow months of December, January and February, the flow analysis found nearly two-thirds of the watershed (120 mi, 70%) is relatively unaltered and has low to minimal flow ecological risk (Figure 5.11). Thirteen percent (~21 mi) is in the high to very high ecological risk categories for low flows. Five percent (8 mi) is at moderate risk for impacts during the low-flow period, and 12% (~20 mi) have higher flows during the period as compared to natural conditions, likely due to the contribution of wastewater effluent and altered timing releases from upstream storage.

As shown in Figure 5.12, the significantly reduced low flows in St. Vrain Creek occur in approximately 16 miles, including about 3 miles in the transition zone, which are critical to the small native fish. In Left Hand Creek, low flows are reduced and at moderate to high risk from the Haldi diversion, (about 1/4-mile west of Route 36 near the mouth of the canyon, refer to Figure 5.3) to the confluence with St. Vrain Creek. See Figure 5.12.

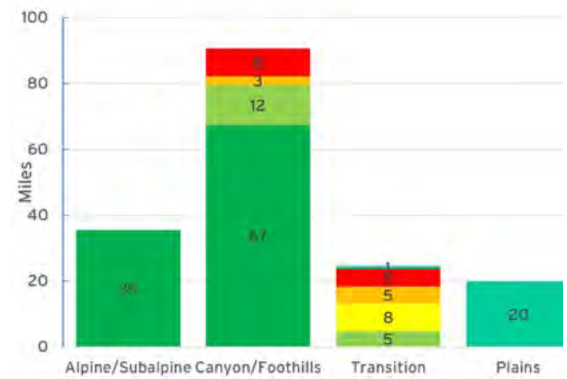


Figure 5.11– Ecological risk from low flows (Dec-Feb) in SMP study area (miles)

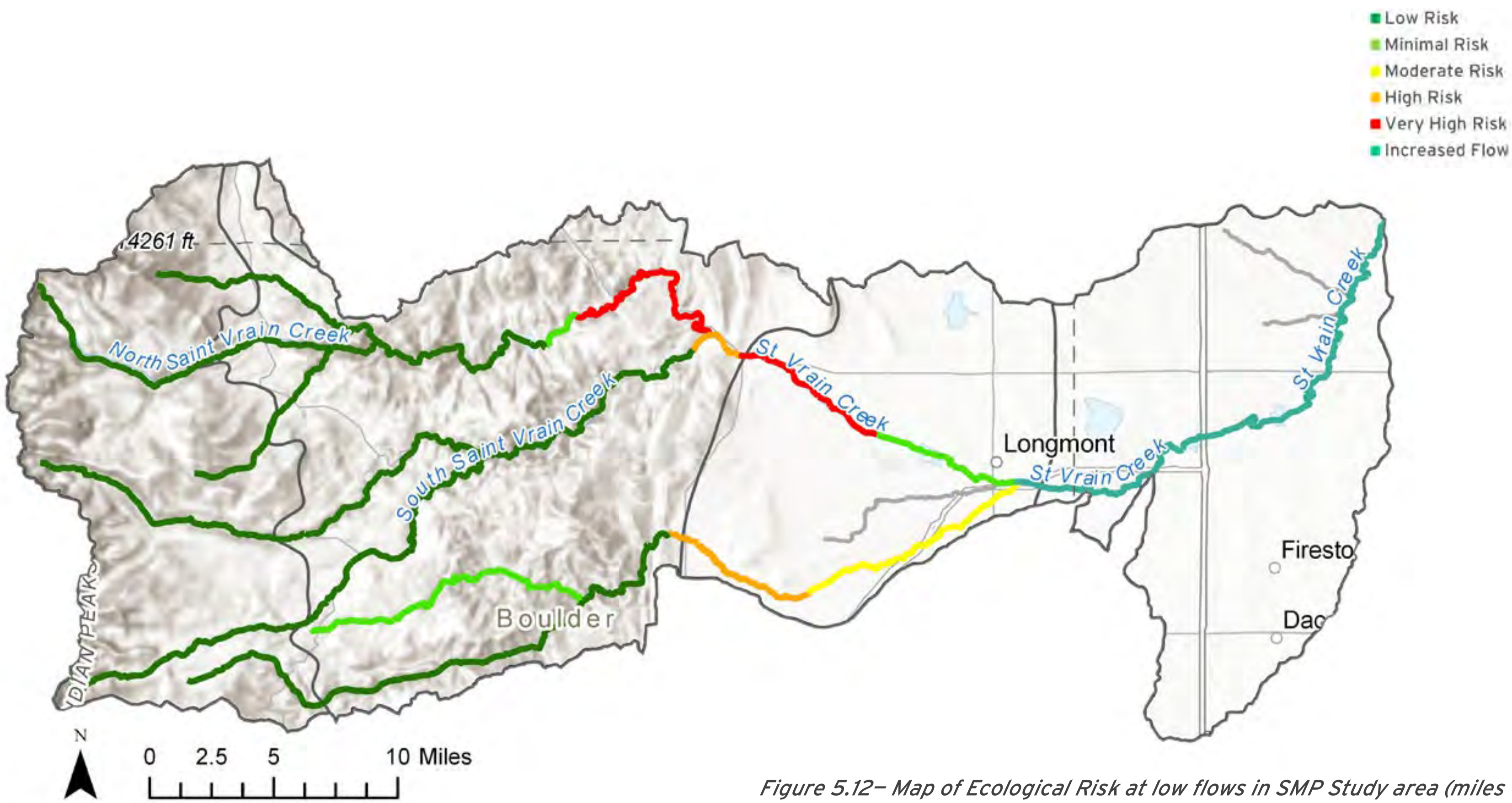


Figure 5.12– Map of Ecological Risk at low flows in SMP Study area (miles

5.2.3 Daily Point Flow Analysis Results – St. Vrain Creek

Northern Colorado Water Conservancy District's (Northern Water) daily point flow analysis for St. Vrain Creek was evaluated to better understand implications of low-flow patterns and to begin developing potential flow targets for future stream management. The analysis is based on average daily flows from 1980-2007. The SMP review focused on the reach downstream of Lyons, particularly between the Oligarchy and Niwot diversion structures, which has been identified as an important environmental segment based on CPW's historical observations of special status native fish species. (See Figure 5.3 for diversion locations). According to CPW staff, the limited historical data suggest that the Oligarchy Ditch represents the upstream limit of the special status fish species in the transition zone, and naturalized low-flow conditions can be considered a starting point for developing targets since fish survived and evolved under those conditions originally.

Northern Water's analysis provided daily average flow for existing conditions. Because natural conditions are not available on a daily timestep, average monthly flow (presented as average daily flow) per day was used from StateMod to provide the comparison to naturalized conditions. For the reach between the Oligarchy and Niwot diversion structures, StateMod only had one naturalized flow node located at the Denio Taylor diversion. However, the naturalized flow estimates between Lyons and Denio Taylor showed relatively insignificant variation (+/- 2%), as shown in Figure 5.13. Therefore, the naturalized flow estimates for St. Vrain Creek at Lyons can be considered fairly representative of naturalized conditions that would be expected downstream (above and below Oligarchy, see Figure 5.13).

Daily flow records help provide a more encompassing understanding of how discharges vary throughout a month under natural and existing conditions. The blue dashed line in Figure 5.14 represents monthly averages for naturalized conditions at Lyons (which as noted above would have been similar throughout the reach to the Denio-Taylor diversion). Northern Water's flow analysis at that same location in Lyons (green solid line) shows a generally good correlation between existing and natural conditions at the monthly scale. However, the daily variation within some months is significant, especially in the spring and late summer when daily flows are consistently increasing or decreasing. For example, in the month of July, the average natural flow per day is around 375 cfs, while the existing average daily flows drop from approximately 450 to 200 cfs, a change of over 50% (Figure 5.14).

Figure 5.13– Average monthly natural flows % change between Lyons gage and Denio Taylor diversion

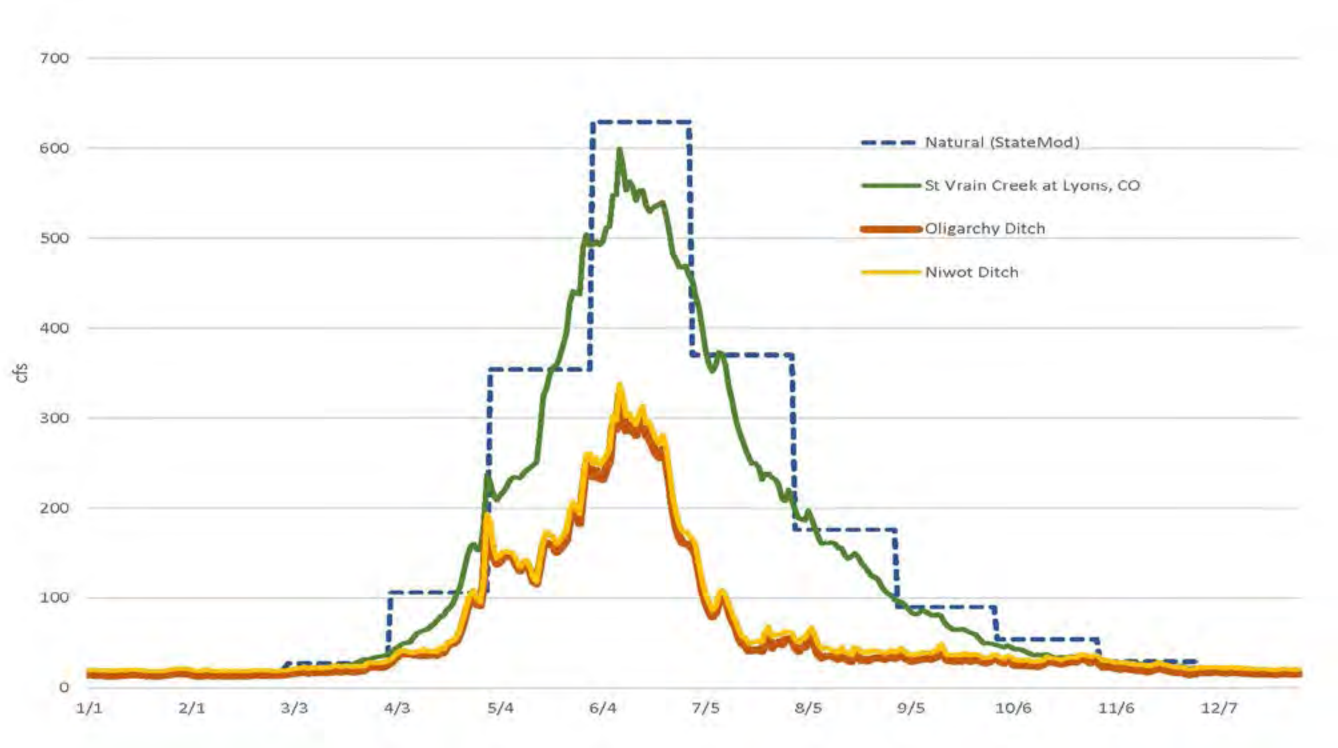


Figure 5.14– Average daily flows (cfs) from Lyons to Niwot Diversion (compared to monthly averages for naturalized conditions)

Figure 5.14 also shows the impact, or variances, between Lyons and downstream Oligarchy and Niwot Ditches (brown and yellow lines) compared to naturalized flows (blue line) due to the number of diversions in the reach (at ten nodes, supplying 24 ditches). The brown and yellow lines also show that there is negligible change in existing daily flows between Oligarchy Ditch (3.8 miles downstream of Lyons) and the Niwot diversion node approximately 2.75 miles further downstream (below Oligarchy).

To provide a clearer comparison of the low-flow conditions, Figure 5.15 focuses on the months of November through March. The daily flow has less variation during this time, showing that using monthly averages may be acceptable when evaluating the low-flow months. Average monthly flow for natural conditions during the months of December, January, and February are very similar, for example, and could be grouped together with an overall average of 17 cfs in those months.

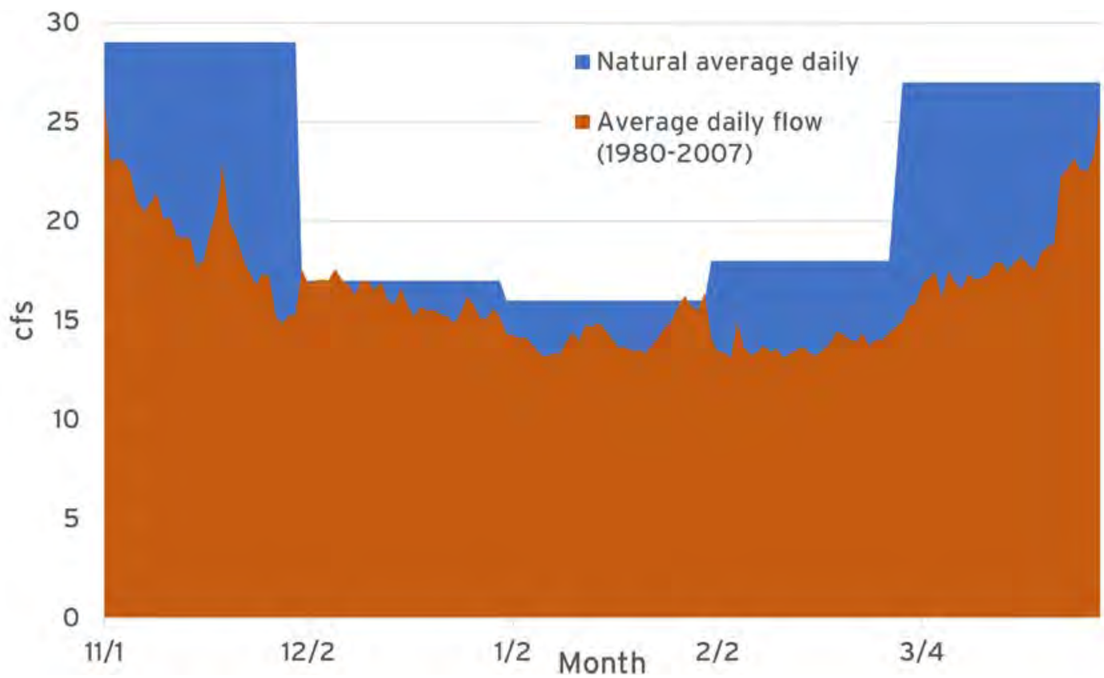


Figure 5.15– Zoomed in view of November to March average daily flows compared to naturalized flows on St. Vrain Creek below Oligarchy Ditch

Another consideration when developing flow targets is the variation in conditions between wet and dry years. Figure 5.16 shows daily flows downstream of Oligarchy during average, wet, and dry years along with the average monthly natural flow. The data show that the volume of supplemental water needed to meet future flow targets will vary year to year, which can diminish to zero in wet years.

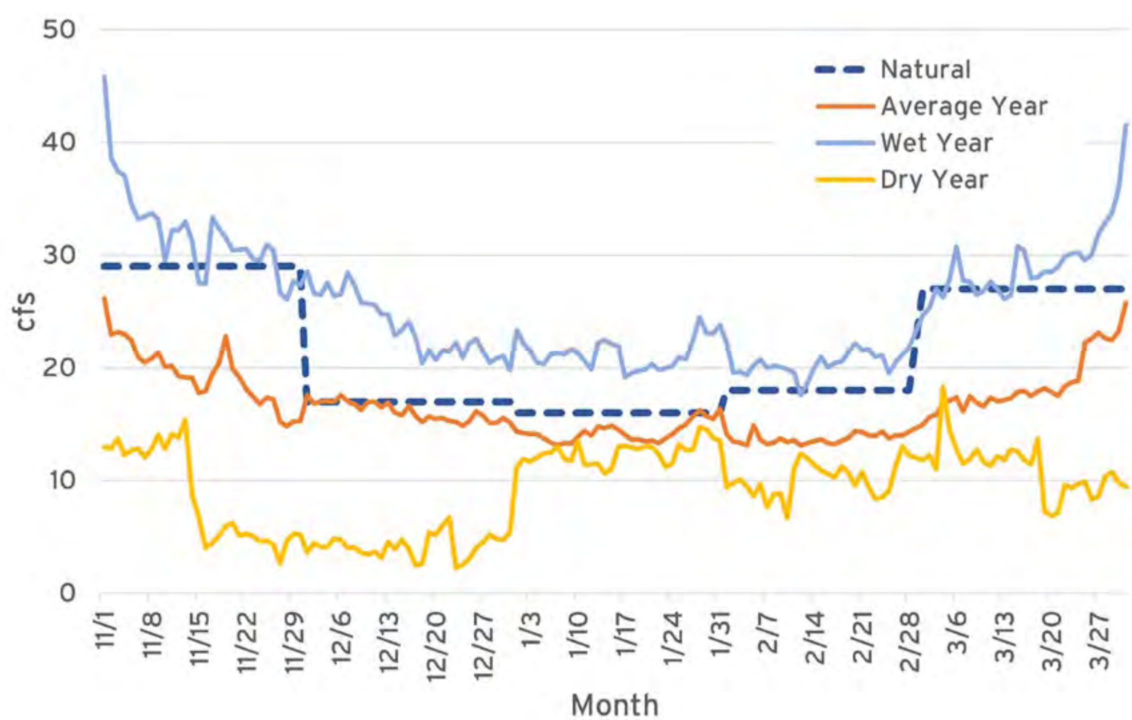


Figure 5.16– St Vrain Creek below Oligarchy Ditch average daily flows Fall-Winter by year type (cfs)

Zero Flow Days

In addition to understanding low-flow patterns, the Northern Water's point flow analysis includes information on zero flow days (days when the average daily flow is zero) at each node within the segment covered by the analysis (Figure 5.17). As would be expected, days with no flow have a significant negative impact on aquatic habitat. Three diversions between Lyons and Longmont experience zero flow days from five to thirteen times per year on average (refer to Appendix E). Six of the diversions in the segment are identified as priority CPW fish passage locations (see Section 5.3.2). In addition, two diversions – Pella/Peck and Niwot, shown on Figure 5.3 – will sweep the river to help ensure delivery of water for senior rights, resulting in dry-up points downstream of the structures.

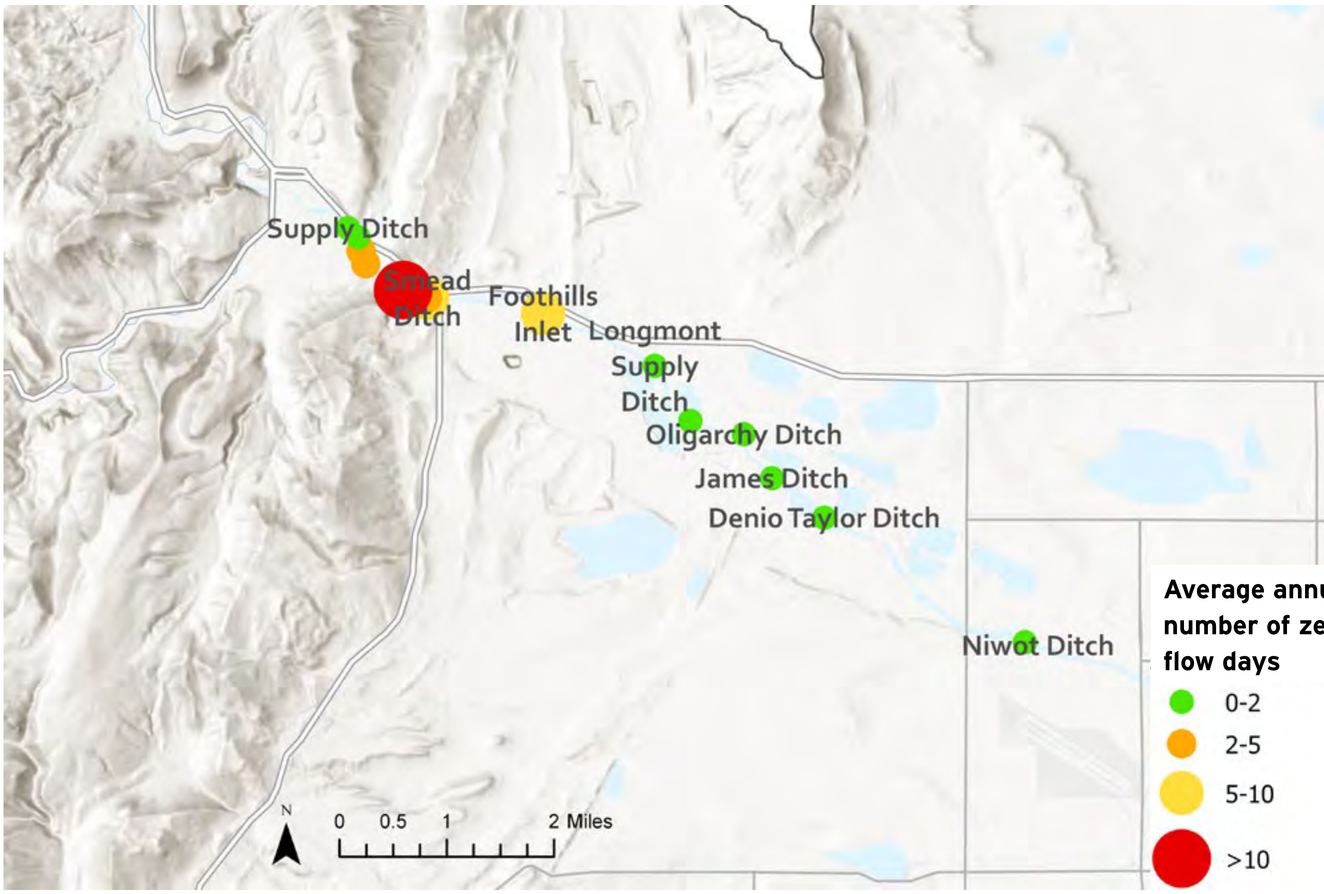


Figure 5.17– Zero Flow Days (average number of days per year)

5.2.4 Flow Summary & Preliminary Targets

Low flows are important for supporting sensitive native small fish in transition reaches, and as shown by the analysis described above, these flows are currently characterized as posing "high to very high ecological risks" in parts of the transition zone due to significant variance from naturalized conditions. The preceding discussion provides the foundation for developing preliminary flow targets, which need to be more fully evaluated by a group of experts in Phase 2. For example, as noted above, 17 cfs (based on monthly averages from December to February) is the average naturalized daily flow from StateMod in St. Vrain Creek below Oligarchy Ditch, which could be used as a starting point to approximate an acceptable baseflow in this reach. Using that example and rounding up to 20 cfs as a year-round baseflow target, Figure 5.17 shows the daily gap or difference between average daily flows from the recent past to demonstrate how a target for baseflow can inform discussions about timing and magnitude of enhanced streamflow needs.

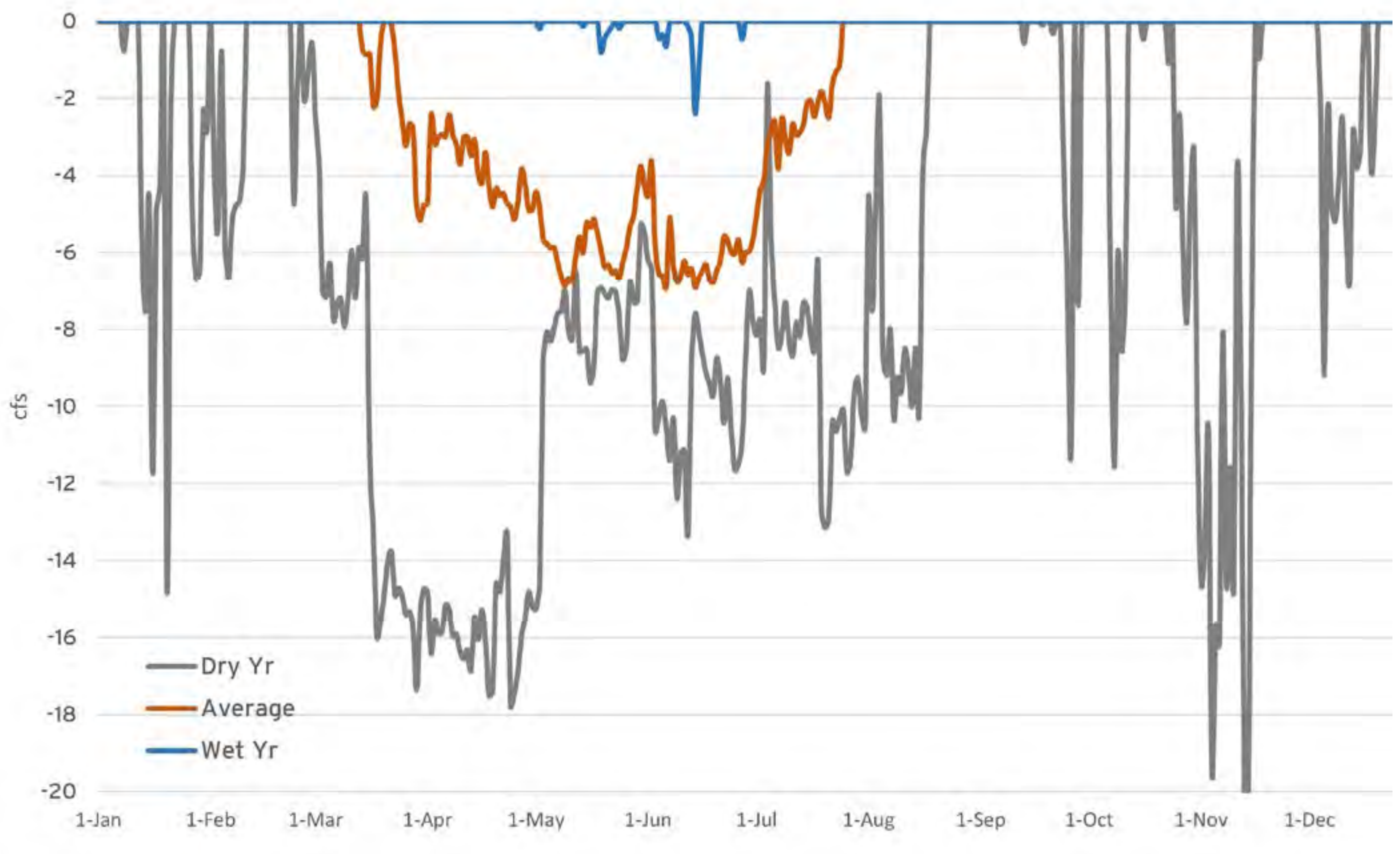


Figure 5.18– Daily flow gap (cfs) in reach below Oligarchy Ditch (based on 20 cfs example flow target)

Setting preliminary targets for high flows should take into consideration reaches with riparian habitat that is at high to very high ecological risk, as demonstrated in the plains zone and potentially South St. Vrain Creek. Other water management and recreational inputs (discussed more in Section 5.5.4) should also be considered as well. Issues such as these will be more fully developed in Phase 2.

5.3 HABITAT CONDITIONS

Evaluation of habitat conditions included review and mapping of CPW data for amphibian, reptile, fish surveys and fish passage priorities; wetland mapping (National Wetland Inventory NWI and Boulder County); Preble's meadow jumping mouse information (USFWS 2018[3]) ; supplemental riparian cover mapping by Biohabitats; previous reports (Biohabitats 2011 and USFS 2019), and the COSHAF field observations. Current habitat conditions were also assessed by examining riparian and wetland habitat, aquatic habitat, as well as other stream health indicators (sediment, channel morphology and floodplain). Aquatic habitat conditions included physical structure of the river for macro-scale features (pools, water depth, wood, bank features) and micro-scale features (sediment deposition, algae) as well as observations of biotic structure and organic material.

3. The occupied range of Preble's Meadow jumping mouse in Boulder County, which includes portions of St. Vrain Creek, is considered a significant potential recovery location (USFWS 2018). The purpose of the Recovery Plan is to lead to the eventual delisting of the species based on sufficient stability and management programs.

5.3.1 Conservation Targets

Conservation targets are species, biological communities or ecosystems that are the focus of habitat planning. Plant and wildlife species conservation targets were identified for the project by zone (see inset box).

Information was also compiled on stressors or risks that are known to increase habitat vulnerability including:

- Water management and flow alterations from reservoirs, raw water pipeline and diversions
- Future flow demands
- Climate change
- Diseases
- Water quality pollutants from mining waste, wastewater, excess sediment loading
- Invasive species
- Forest fire risks
- Road development and recreation pressures
- Land use management impacting multiple river functions

Observations of key stressors and considerations for improvements by zone are listed below.

- Stressors to wildlife in the alpine/subalpine zone are mainly climate change, fire potential, increasing recreational usage, invasive species and diseases. Water quality impairments on Left Hand Creek are also occurring from abandoned mining. Public land partners would benefit from added focus and capacity (staff or funding) to further improve recreational and forest management, update monitoring, and do the outreach that is necessary for successful adaptive management.
- Stressors in the canyon/foothills zone are mainly fire potential (see Figure 5.19), water quality impairment from abandoned mining, roadway and infrastructure impacts to riparian areas, recreation pressures, water temperature issues (potential) downstream of Button Rock Dam, and fish passage issues at diversion structures. Similar to in the alpine/subalpine zone, public land managers are struggling to keep up with the increased number of visitors. At Ralph Price Resevoir at Button Rock Preserve, which is one of the City of Longmont's primary reservoirs, the Longmont Times-Call recently reported (Spina, 2019) that *"Historically, visitors use ranged as low as 5,000 to 7,000 people annually, but in 2018, annual visitation surpassed 60,000 people."* Opportunities include providing fish passage, improving riparian forest and fish habitat especially downstream of Button Rock, restoring channels and floodplains, and improving recreation management. Additionally, enhanced beaver ponds and meadows can potentially add water quality and flood attenuation benefits.

Conservation Targets

Basinwide Ecosystems, Plant Communities & Species

- Perennial streams & ephemeral streams
- Ponds & lakes
- Wetlands: emergent, wet meadows and shrublands
- Riparian woody shrubland/forests & upland buffers
- Eight rare plant species
- Riparian birds including raptors & migratory species

Upper Watershed

Upper – Overall

- Beaver
- Northern leopard frog & western boreal toad
- Coldwater fish: Brook and Brown trout
- Macroinvertebrate communities
- Other county-identified critical wildlife habitat

Alpine / Subalpine

- Hudsonian emerald dragonfly, Rocky Mountain capshell and lake chub
- Greenback cutthroat trout (potential)

Canyons/Foothills

- Tiger salamander, Western/striped chorus frog
- River otter habitat (MSV, SSV, LHC, James Creek)

Lower Watershed

Lower – Overall

- Northern leopard frog (SVC & LHC), Couche's spadefoot (LHC) & native snakes
- Macroinvertebrate communities

Transition

- Small native fish species of concern
- Boulder County critical wildlife habitat incl. Preble's Meadow Jumping Mouse

Plains

- Warm water habitat for diverse native fish species

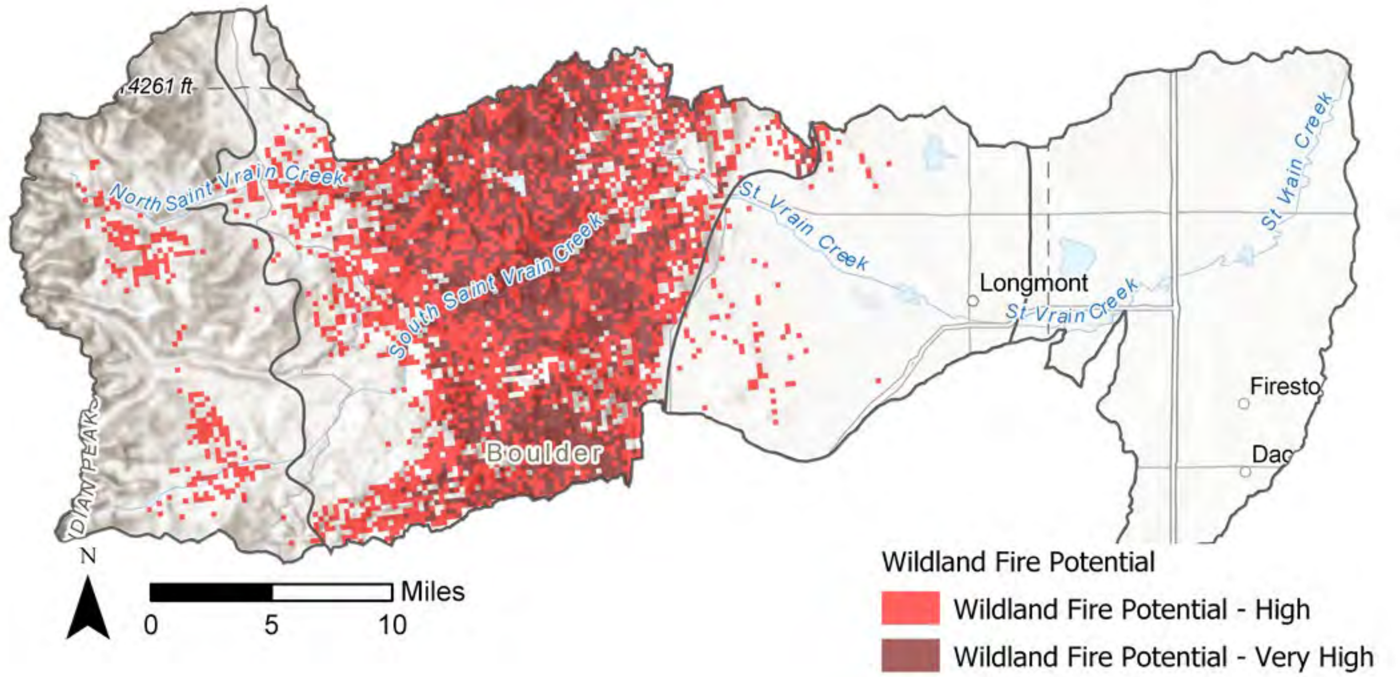


Figure 5.19– High and very high forest fire risk in the watershed (LANDFIRE data set, details in Appendix A.)

- The transition zone is the most developed and urbanized; hence stressors here are many and varied. The main impairments to habitat are highly altered flows including dry-ups, altered channels and vegetation, reduced floodplain connectivity, fish passage barriers and poor physical fish habitat. Opportunities to improve stream conditions include increasing riparian width and wetland construction in target locations, fish passage, floodplain restoration, non-native species control, enhancement of native species structure, and diversifying instream channel habitat for aquatic species.
- Stressors in the plains zone are mainly flow alterations, lack of riparian and aquatic habitat, fish passage, altered channels and floodplain connectivity. Opportunities in the plains reaches could be achieved by removing channel constraints, enhancing floodplain connectivity, and increasing riparian width, ensuring fish passage opportunities, and non-native species removal.

5.3.2 Wetlands & Riparian Habitat

To identify the potential to reduce habitat stressors, within the realities of the modified landscape, the SMP assessed plant communities in the riparian corridors, instream habitat features, and floodplain connectivity. Indicators of wetland and riparian habitat health within the buffer include overall size or extent; native plant cover, diversity, structure, and evidence of regeneration; and extent of non-native species. Assessment of riparian conditions included the following techniques:

- Classification of riparian land cover within the corridor using a combination of aerial analyses, between the canyon/foothills and the plains zones.
- Quantification of riparian land cover within the creek corridor, which includes a 1/4-mile creek buffer on either side of the channel, as this is also the area that contains 80% of the Federal Emergency Management Agency (FEMA) 100-year floodplain.
- An intersection analysis of hydrogeomorphology and wetland occurrences in the corridor.
- Observations of condition based on width of riparian vegetation, incidence of non-native crack willow (*Salix fragilis*), and age classes of native cottonwoods ranging from seedlings to decadent.

Extent

Of the approximately 3,260 acres of historically mapped wetlands in the creek buffers, more than 40% were mapped in the plains, and the remaining wetlands were evenly distributed across the other zones (Figure 5.20). About one-third of the mapped wetlands are open water (pond, lake or riverine), 40% are freshwater forest/shrub and 25% are freshwater emergent wetlands (70% of which occur in the plains).

There is a strong relationship in the upper watershed between landforms (hydrogeomorphologic valley types) and wetland areas. Most wetland and riparian areas within the 1/4-mi buffer (65%) are mapped in "high energy open" valleys (Figure 5.21). Thus, open valley types can be used as a good indicator of opportunities for wetland protection and restoration in the upper reaches.

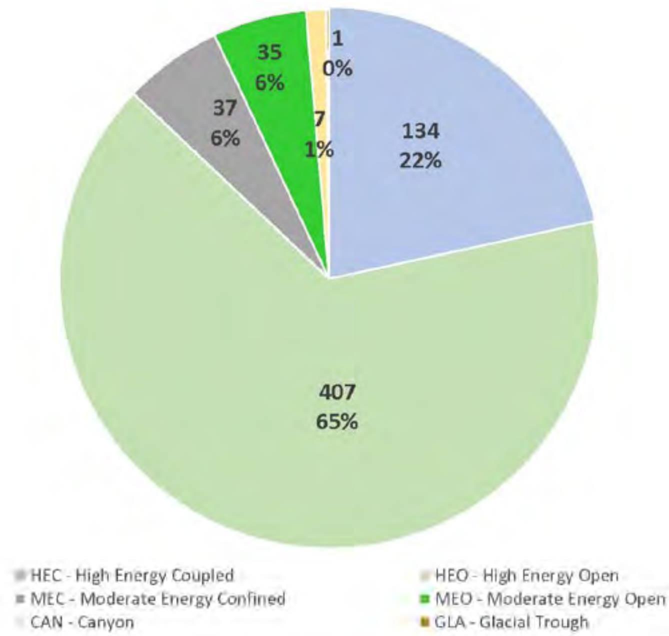


Figure 5.21– Distribution of wetlands in upper watershed by valley type (pre 2013 flood, acres)

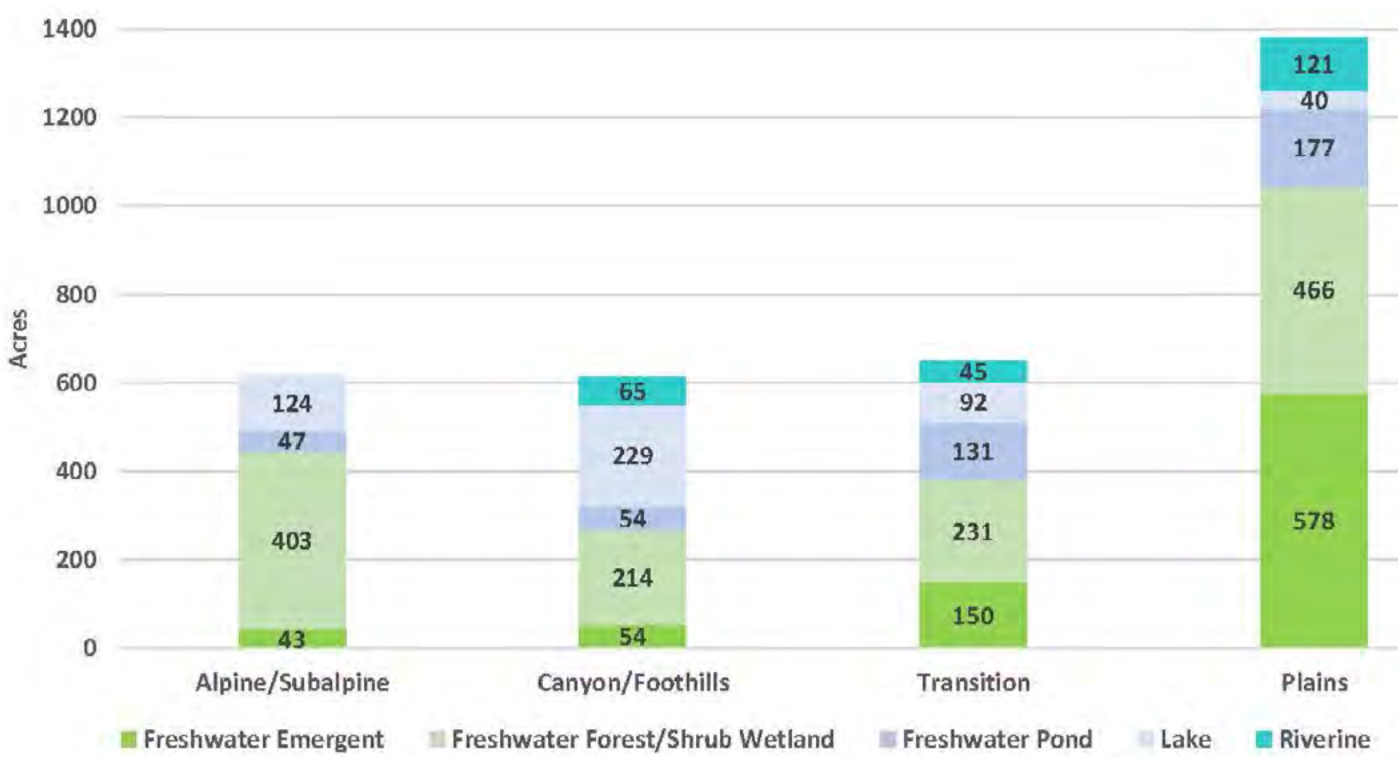


Figure 5.20– Wetlands by ecoregion pre-2013 flood (acres)

Riparian Cover and Structure by Ecoregion

Riparian cover and structure naturally vary by zone. Figure 5.22 shows tree canopy acreage was highest in the canyon and foothills. Agricultural riparian lands were highest in the transition zone. The transition zone also had the highest diversity of cover types compared to canyons/foothills or plains reaches. Another important indicator of habitat quality is impervious surface, which is associated with degraded riparian conditions from excess runoff and channel confinement. Paved areas are highest in the urban reaches in the transition zone, where they account for 24% of the 1/4-mi buffer, highlighting the need for green infrastructure and other best management practices in these areas.

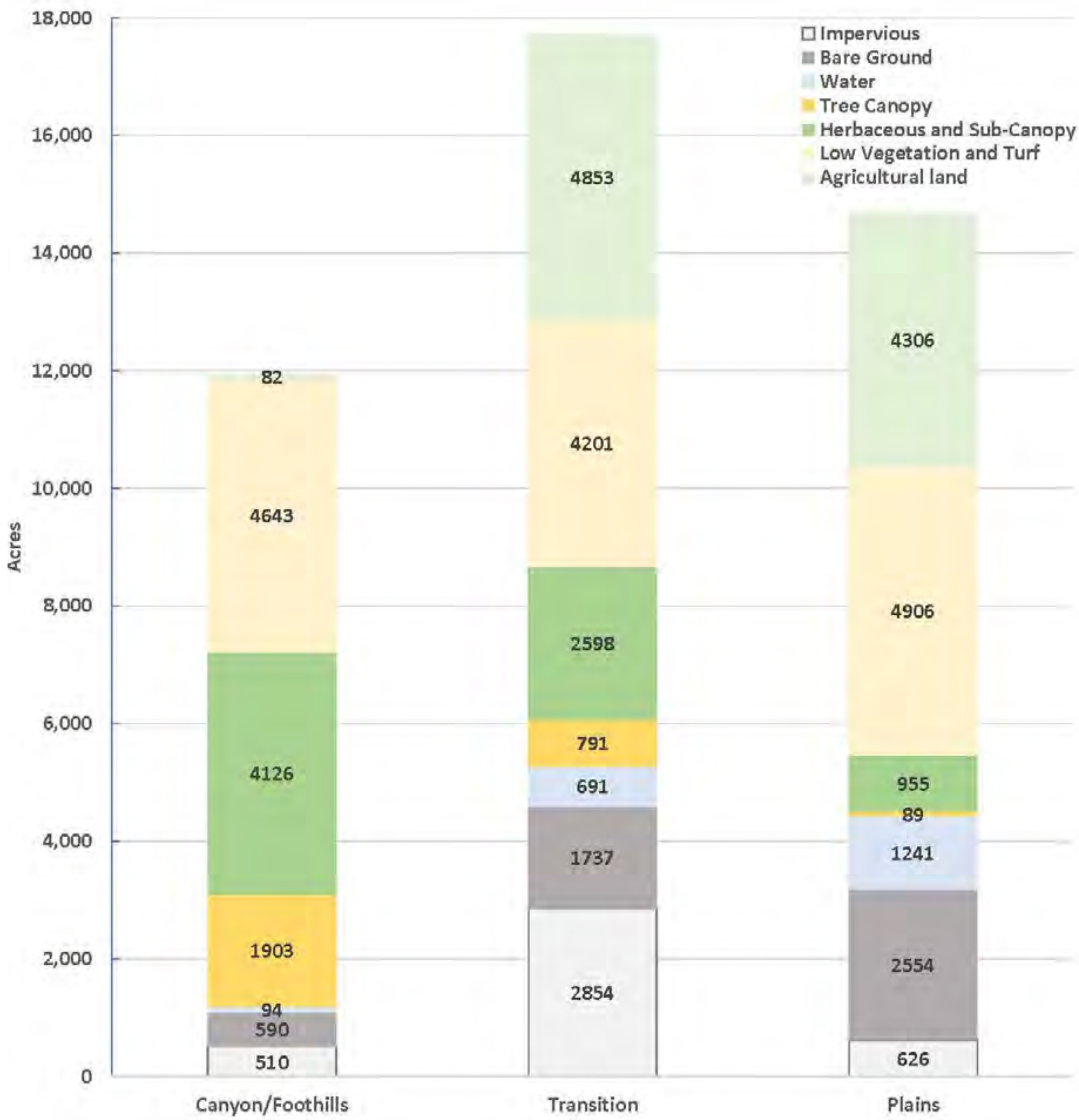


Figure 5.22– Riparian vegetation cover in 1/4-mi buffer for Canyon/Foothills to Plains (acres)

A transition reach along St. Vrain Creek was highlighted as a potential reference reach by County staff (west of North 63rd) where riparian cover was in particularly good condition (see aerial images in Figure 5.23).

Figure 5.23– Representative reach with good riparian condition (width & structure) and floodplain connectivity in SV22 located between Chapman McCaslin Ditch and Foothills outlet, downstream of Western Mobile property. Upper left aerial view of the reach, lower left inset is location, and image on right shows view of vegetation elevation or canopy structure with darker green indicating taller trees and lighter color indicating grasslands (or open water in upper right corner).

Riparian Observations

Observations of riparian condition included vegetation diversity and structure (plant community heights), presence and extent of invasive species and native cottonwood recruitment as well as related ecological functions such as bank stabilization and floodplain dissipation. The findings are summarized in Figure 5.24 in terms of ecological risk, i.e., the vulnerability of the riparian habitat because of impaired ecological processes and stressors such as adjacent land uses and management. About 45% of the observed riparian areas are classified as having high ecological risk due to narrow riparian vegetation, over 50% non-native crack willow cover, cottonwoods of a single age class with some decadence, and little to no new cottonwood recruitment (Figure 5.24). These higher-risk riparian areas occur more frequently at lower elevations in the transition and plains.

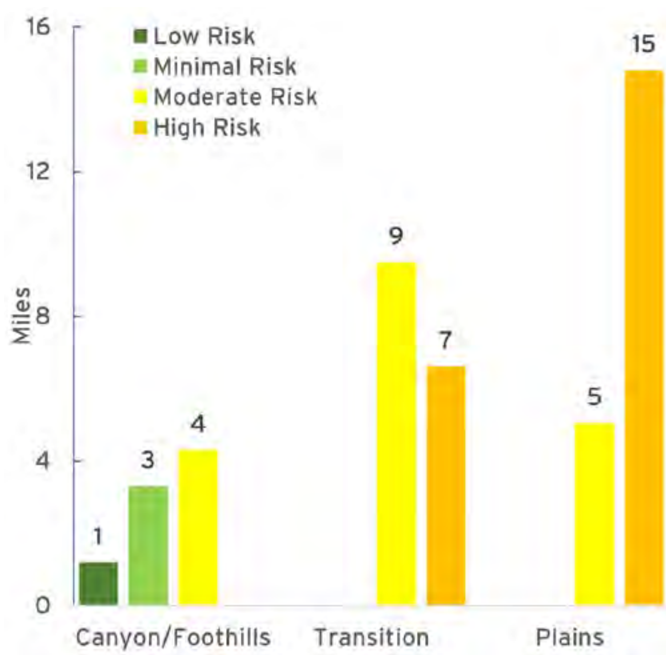


Figure 5.24– Riparian Condition Summary (miles shown at top of column.)


View upstream of fish passage barrier on St. Vrain Creek

5.3.3 Aquatic Habitat

Aquatic habitat zones in the study area span cold water trout streams and lakes in the upper watershed to warm water reaches and lakes in the plains. Condition information was provided by CPW as well as from the rapid assessment and included indicators of presence/absence, native and non-native distribution, physical conditions, and habitat features.

Table 4 presents a list of five small native fish species identified by CPW as present or having historic range in St. Vrain Creek. CPW staff identified the transition reach from Oligarchy Ditch to Niwot Ditch as the most important habitat for these species based on historical sampling. A study of losses of small native fish noted, "pool drying or predation by terrestrial vertebrates when the fish are restricted to shallow drying pools" as likely causes (Scheurer and Faust, 2002). In addition to predation by terrestrial vertebrates, the regular escape of predatory fish from reservoirs and the confinement of non-native fish such as brown trout below dams increases direct predation on native fish. Other factors limiting the successful foraging and breeding of small native fish include:

- Lack of proper flow conditions and seasonal timing for migration
- Deficiency of functional riparian conditions to buffer and support aquatic habitat
- Inadequate flushing flows that create a cemented substrate and reduce breeding habitat
- Degradation of water quality from increased pollution leading to decline in macroinvertebrates, a critical food source
- Reduction in natural oxbows and backwater habitat for off-channel rearing

Table 4 Focal Species for Small Native Fish in Transition Zone

Species (adult size)	Status	Habitat Zone
Common shiner *Luxilus cornutus*	State Threatened, Tier 1. Recently extirpated (no observation since 2013). In South Platte basin, the St Vrain is 1 of only 2 creeks with Common shiner	Warm Water and Transition
Plains topminnow *Fundulus sciadicus* (1.5-2.5 inches)	State Tier 1, Declining locally, in S Platte and globally	Transition
Brassy minnow *Hybognathus hankinsoni* (2.5 to 3.0 inches)	State Threatened , Tier 1	Warm Water and Transition
Northern Redbelly Dace *Phoxinus eos*	State Endangered, Tier 1	Warm Water and Transition
Stonecat *Noturus flavus*	State Special Concern (not a statutory category), Tier 1	Warm Water and Transition

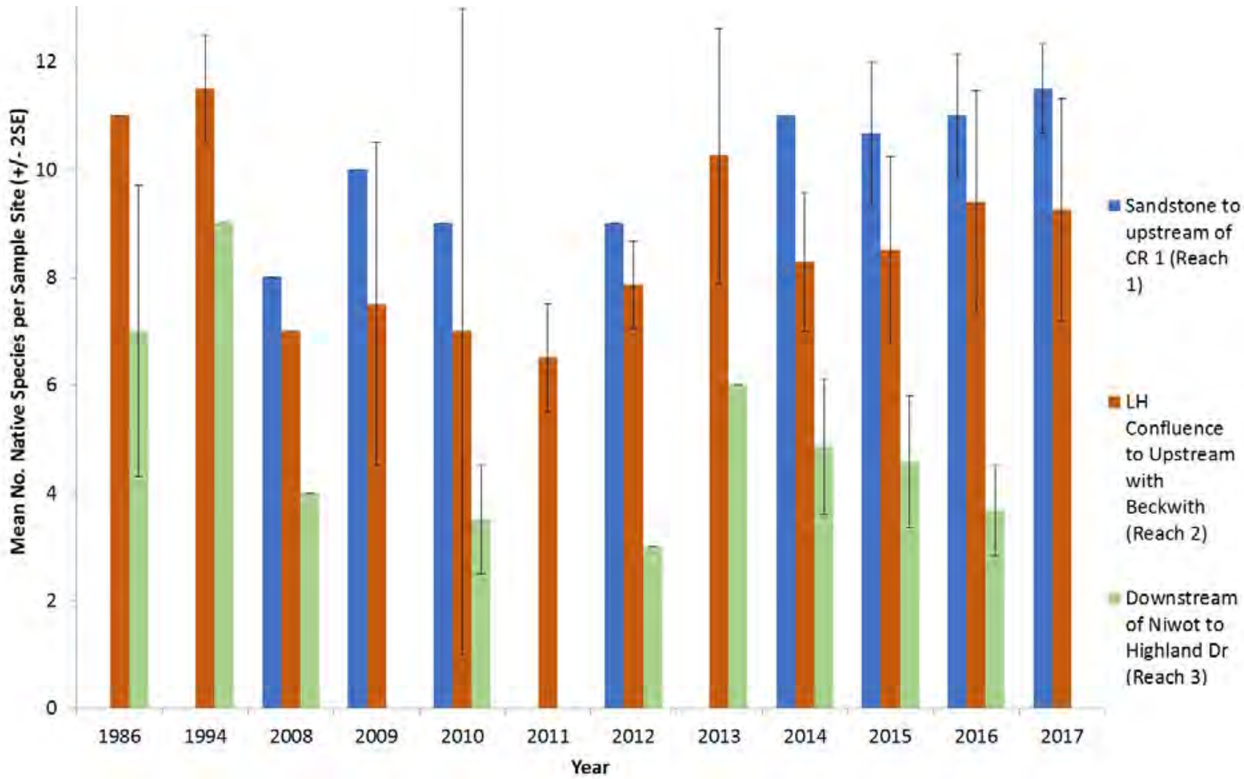


Figure 5.25– Mean number of native fish in CPW samples 1986-2017

CPW also has prepared 12 years of report cards (from 1986 to 2012) based on native species richness in select reaches of St. Vrain Creek and lower Left Hand Creek. The results show the downstream reaches are generally more consistent in native species richness compared to the upstream transition reach on St. Vrain Creek where there has been an overall decline (Figure 5.25)[4].

Physical assessment of aquatic habitat conditions indicated moderate- to high-risk conditions in the transition and plains reaches (Figure 5.26). One of the most significant aquatic habitat impacts is from diversion structures that fragment habitat, block sediment transport, impair channel evolution, and inhibit fish passage.

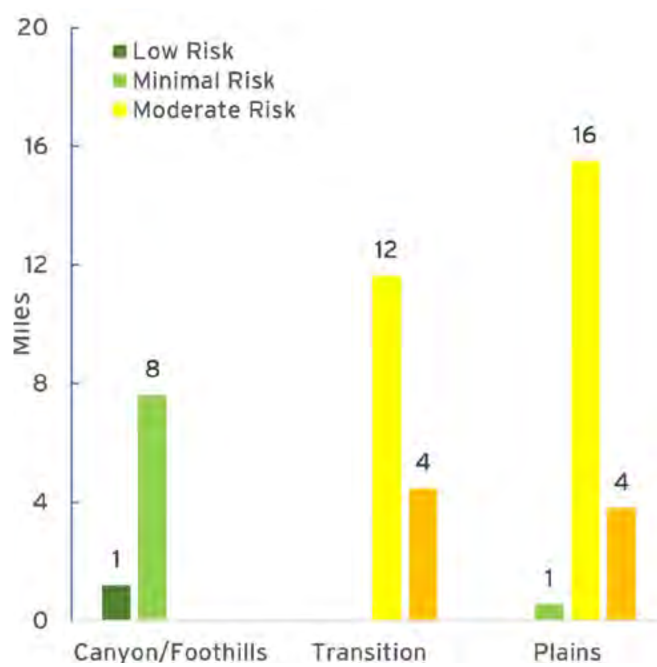


Figure 5.26– Aquatic habitat- physical conditions (miles shown at top of columns)

4. Note CPW reach numbers do not correspond to SMP reaches.

As shown in Figure 5.27, the Left Hand Watershed Center has identified eight diversions as providing total barriers to fish passage. On St. Vrain Creek, ten diversions have been identified as priorities for fish passage by CPW.

Other aquatic habitat considerations are the prevalence of aquatic nuisance species and other invasives including predatory fish such as largemouth bass. Populations of predator species have been fluctuating throughout transition reaches, and additional evaluation of the extent of these impacts is recommended for Phase 2. Other potential improvements were identified in the City of Longmont's Riparian Corridor Protection Plan as described below.

"Specific habitat improvements that could benefit the brassy minnow (Hybognathus hankinsoni), the Iowa darter (Etheostoma exile), the northern redbelly dace (Phoxinus eos), include enhancing backwater habitats with aquatic vegetation, especially back water habitats that are connected to cold spring seeps."(Biohabitats, 2011)

5.3.4 Other Stream Health Indicators

Sediment, channel morphology and floodplain connectivity all play interconnected roles in stream health and habitat conditions as summarized below.

Sediment Regime

A functioning river balances the transport of water and sediment. In most cases, sediment helps maintain the geometry and aquatic habitat of a river, and the sediment regime reflects the amount and timing of sediment supply and the ability of the system to transport materials unimpeded by barriers.

In the upper watershed, the steep gradient results in generation and transport of sediments except where valleys broaden and gradient decreases, which causes deposition to occur in the floodplain. In the lower watershed, under natural conditions, the creeks would include both transport and deposition reaches. Due to channelization and incision, however, many of the lower watershed reaches are now sediment sources as well as transport reaches due to accelerated erosion and disconnection from the floodplain (except where channel structures disrupt sediment transport and cause deposition to occur).

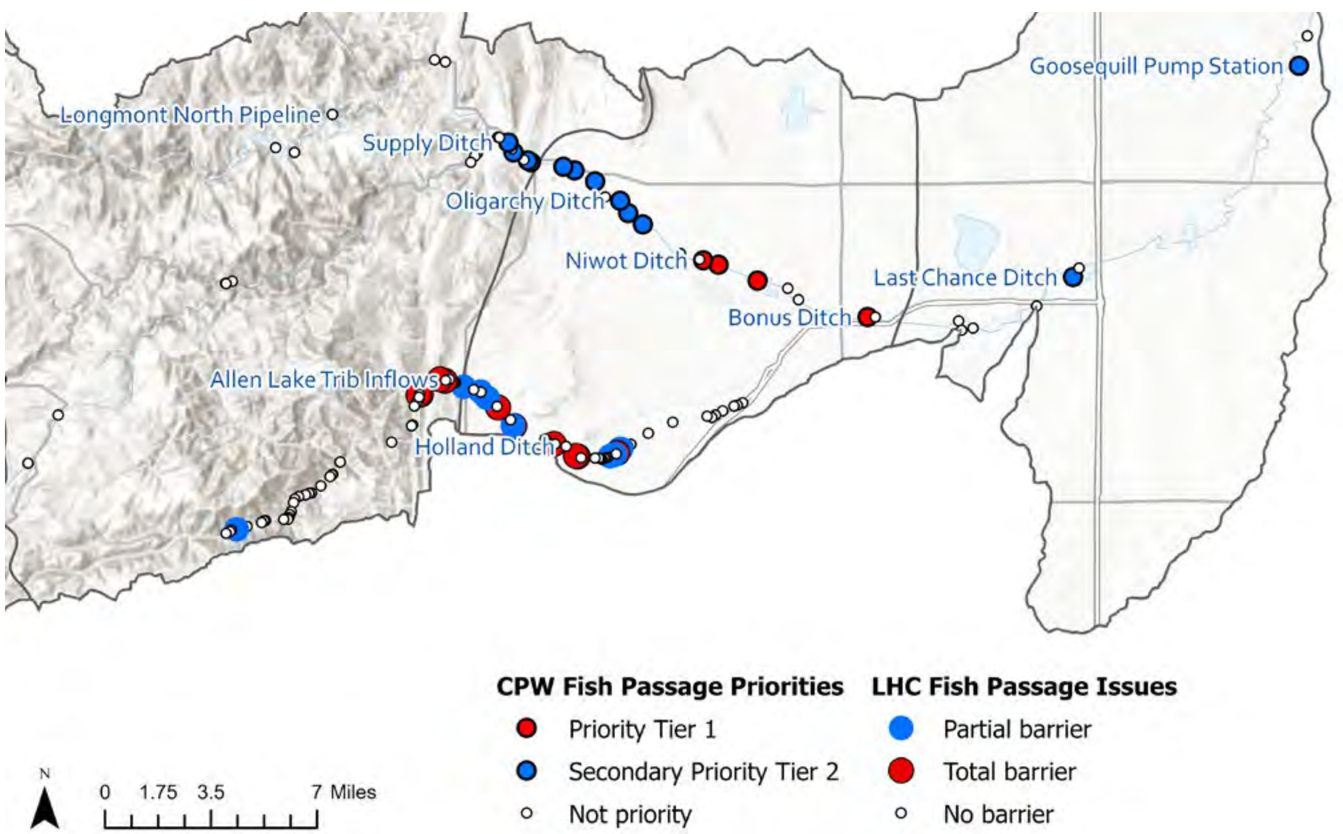


Figure 5.27– Select diversions with potential opportunities to improve fish passage

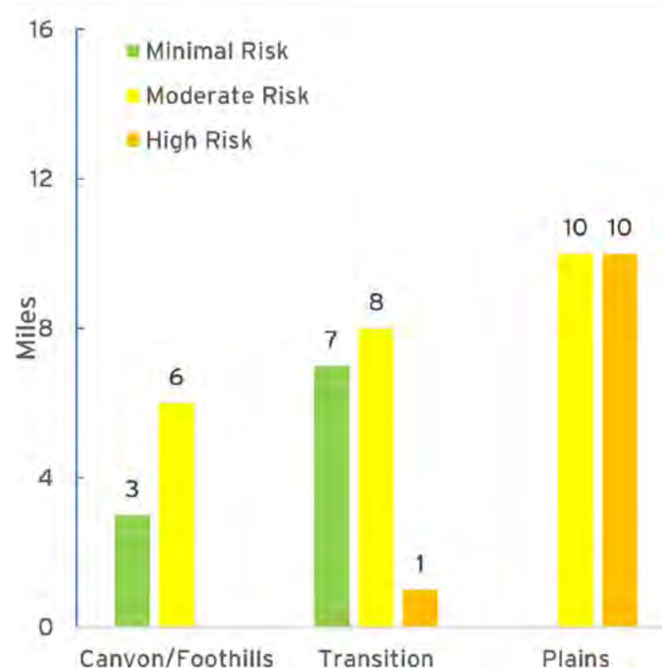


Figure 5.28– Sediment regime condition on St. Vrain and Left Hand Creeks (miles sown at top of column).

The stream health assessment found that the majority of reaches in the lower watershed had moderate to high ecological risk for sediment regime. The plains reaches were in the poorest condition (Figure 5.28) due to excessive bank erosion and sediment associated with runoff from agricultural lands.

Geomorphic Condition

Hydrogeomorphic data were reviewed from USGS for the upper watershed, watershed plans (particularly post flood geomorphic assessments), and COSHAF observations. Overall, stream morphology has been less altered in the upper watershed compared to the lower watershed. The creeks in the upper watershed (alpine/subalpine and canyon/foothills) are mostly high gradient, confined, boulder/cobble step/pool systems. There are some reaches where the glacial valley produces a wide, lower gradient, meandering system with floodplains and the opportunity for beaver ponds.

Creeks in the lower watershed (transition and plains) are mostly moderate to low gradient, meandering, riffle/pool systems. Many of these reaches have been channelized for gravel extraction, roads, agriculture, and other uses, such that they have minimal meandering and minimal access to a floodplain when flows exceed mean annual peak flow. In the plains reach where St. Vrain Creek has maintained some of its meanders, poor land use practices have led to channel downcutting and accelerated bank erosion with minimal access to a floodplain during high frequency flood events. Assessment results for canyons, transition and plains zones are summarized in Figure 5.29.

The risks to stream health relate to oversimplification of the channel geometry, especially loss of deep pools and meanders, which limit aquatic and riparian habitat. Channelization and downcutting lead to oversimplification of the channel due to high shear stressors in the channel. High shear stress is created when frequent flood events cannot access the floodplain. The unnaturally deep flows produce high shear stress which tends to homogenize the channel profile. Instead of steep riffles and deep pools, the channel becomes one long, low gradient riffle with some shallow pools. This homogenization of the channel degrades aquatic habitat, which is dependent on a highly diverse channel. Further degradation of aquatic habitat occurs when riparian trees are removed causing a loss of complexity, carbon, and shade to the channel. Incised channels also lead to degraded riparian conditions and the loss of natural oxbows and backwater habitat through lower groundwater tables and infrequent flooding.

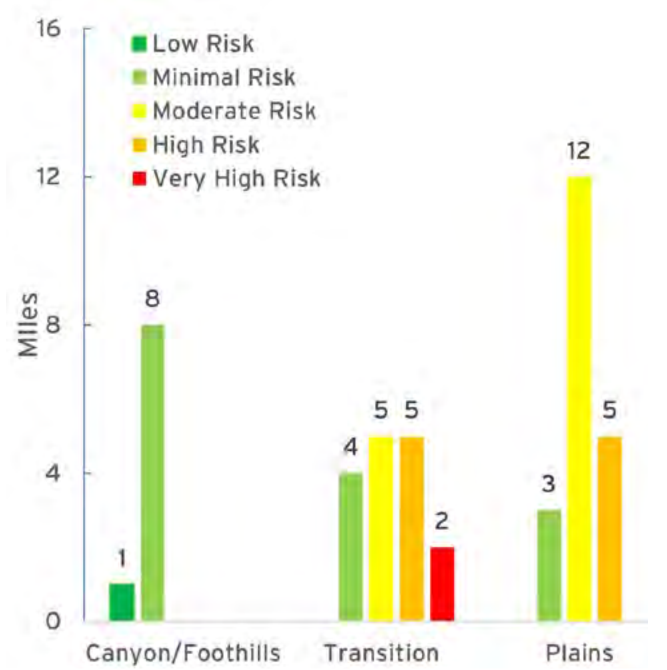


Figure 5.29– Morphology Condition on St. Vrain and Left Hand Creeks (miles shown at top of column)

Floodplain Condition

Floodplain connectivity is a critical variable because overbank flows are key to supporting both aquatic and riparian habitat as described in the previous subsection. The SMP evaluated floodplain connectivity and thus floodplain condition, based on channel entrenchment. The more entrenched the channel the less connected it is to its floodplain and the more at risk the floodplain condition.

Most reaches were found to be entrenched, with only lower frequency flows (10-year flows or greater) accessing the floodplain[5]. In some locations, adjustments from the 2013 flood, such as the case of St. Vrain Creek downstream of Longmont, created a new floodplain inside of breached gravel pits. The lack of frequent floodplain connectivity is a negative impact for many different reasons. One such reason is because it allows encroachment of invasive species, which in turn hardens the banks and reduces the effectiveness of channel-forming processes. In addition, without regular inundation, maintenance and regeneration of most native riparian species is reduced. As a result, the assessment found high- to very-high ecological risk in 18 miles of the creeks due to floodplain conditions, with the highest-risk conditions in the transition and plains zones.

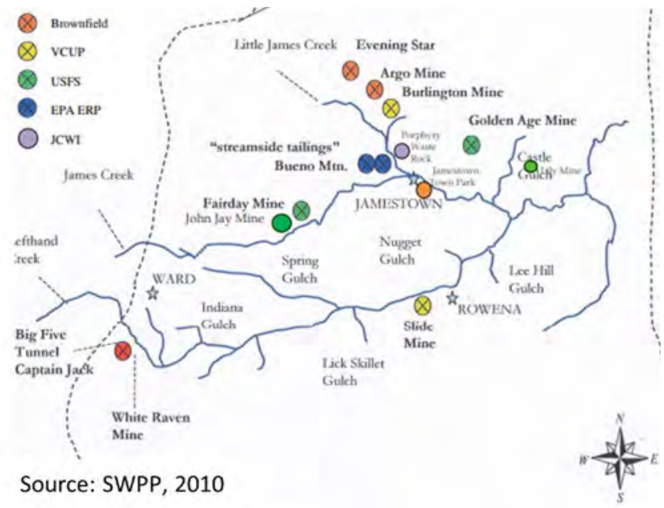


Figure 5.31– Mine reclamation projects in Left Hand Creek watershed

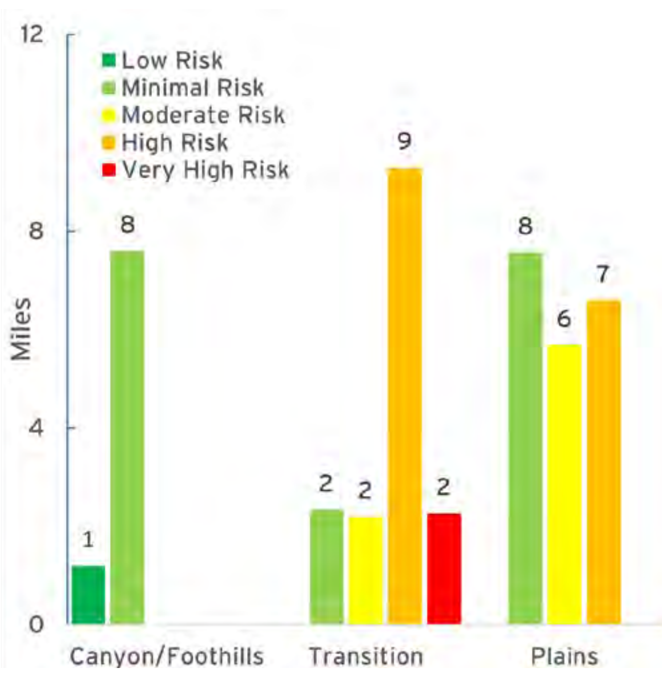


Figure 5.30– Floodplain Condition on St Vrain and Left Hand Creeks (miles)

5.4 WATER QUALITY CONDITIONS

Water quality information was compiled from a variety of sources. The Colorado Department of Health and Environment (CDPHE) water quality data on 303d[6] segments for impairments and Total Maximum Daily Loads (TMDL), Left Hand Water District Source Water Protection Plan (SWPP), Keep it Clean Partnership's (KICP) watershed reports, benthic macroinvertebrate index (BMI) sampling results, and EPA's abandoned mines and hazardous waste sites were reviewed and provided the basis of the watershed-wide evaluation of issues and impacts. Interviews with representatives of the Keep it Clean Partnership were also conducted for additional data input. Numerous sources of potential pollution are described in detail in the SWPP. Metals and pH, nutrients and E. coli are the primary water quality issues in the watershed as described below.

5.4.1 Metals Pollutants

Past mining sites, shown in Figure 5.31, have resulted in metals pollution including mainly copper, cadmium, and zinc, with some reaches also having high amounts of lead, manganese and iron[7]. Of the 80 mining sites mapped in EPA's database in the study area, all but 10 are found in the Left Hand Creek watershed, and as expected, the majority of the mining sites (94%) are located in the canyon/foothills zone.

5. Note, Alpine/Subalpine zone conditions were not assessed due to limited impacts from alterations as well as generally narrower extent of natural floodplains.
6. 303(d) refers to the list of impaired and threatened waters that have been identified and reported to EPA (CDPHE, 2017).
7. Arsenic, selenium and temperature are also elevated in many of these reaches; however, the state is in the process of developing updated standards for these and other constituents, e.g. to account for natural variations.

As shown on Figures 5.32 and 5.33, about 53 miles have metals and low pH outside of recommended levels for beneficial uses, with the majority in Left Hand Creek.

The state information on impaired waters (mapped in Figure 5.33) includes segments with Total Maximum Daily Loads (TMDLs) as well as impairments which do not require a TMDL (4a-4c[8]). TMDL's are the "maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL is essentially a plan, usually based on monitoring information and scientific modeling that describes how pollutant loads coming from various types of sources must be reduced in order to meet water quality standards" (EPA 2020). Implementation of the TMDL for non-point sources, such as acid mine drainage, can occur in several ways, e.g., voluntary, citizen-led or state-funded plans under the EPA "319" grant program.

Figure 5.32– Reaches with metals impairment by creek and ecoregion (miles)

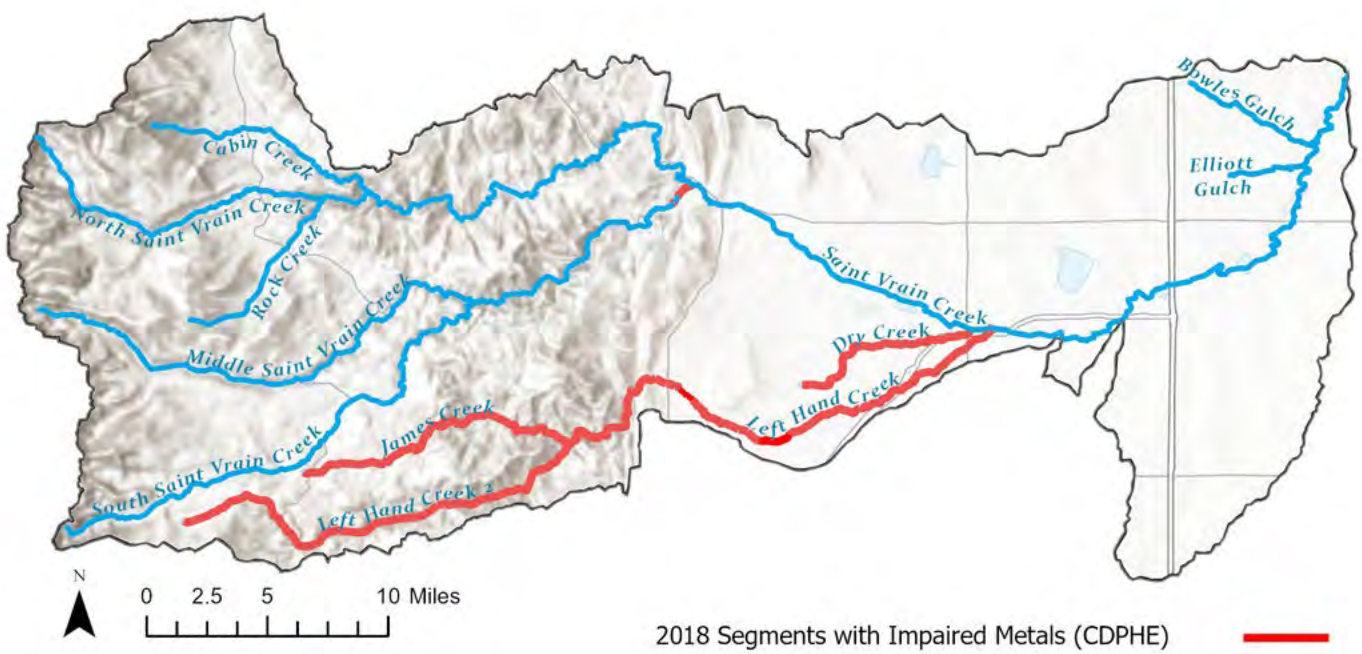


Figure 5.33– Map of metals and pH impairments by creek and ecoregion

8. Category descriptions include: 4a - TMDLs have been completed but uses are not yet attained; 4b - other required control mechanisms are expected to address all waterbody-pollutant combinations and will attain water quality standards in a reasonable period of time; 4c - the impairment is not caused by a pollutant.

The Keep it Clean Partnership's 319 Watershed Plan summarizes the status of creek conditions and priorities. The plan lists the following stakeholder concerns relating to metals: *"a) attainment of applicable stream standards through reducing pollutant loading to streams, and b) improving understanding of the current metals mass balance in the Left Hand Creek sub watershed and addressing elevated metals due to legacy mining impairments, in accordance with the LWOG (2005) implementation plan (Appendix F)"* (KICP 2015)

5.4.2 Organic and Nutrient Pollutants

Elevated bacteria (E. coli, a fecal indicator) has been reported on a widespread basis in the lower watershed. The reaches include approximately 37 miles in St. Vrain and Dry Creeks in the transition zone and the remainder in St. Vrain Creek in the plains zone. (Figure 5.34). The reach downstream of the Longmont Wastewater Treatment Plant (WWTP) to St. Vrain State Park is also high in ammonia. High nutrients are also associated with algae concerns (chlorophyll-a).

Captain Jack Mill Cleanup, Emergency Response and Removal

» In October 2018 CDPHE and EPA determined that a release of contaminated water originating from a mine tunnel at the Captain Jack Mill Superfund site likely was responsible for a fish kill reported Oct. 22 in the upper portions of Left Hand Creek.

» Field monitoring and the results of water samples collected at various locations along Left Hand Creek indicate water discharging from the Big Five tunnel was more acidic and contained higher levels of heavy metals than in previous water samples. The high acidity and heavy metals, coupled with the seasonal low flows in Left Hand Creek, resulted in water quality impacts approximately five miles below the superfund site.

» *Following reports of the fish kill EPA, in coordination with CDPHE, is conducting an emergency response and has implemented a temporary treatment system to treat acid mine drainage water from the Big Five tunnel prior to discharge to Left Hand Creek. Initially, sodium hydroxide was used to neutralize the water and remove the dissolved metals as solids. In early December 2018 a lime-based treatment system was mobilized to the site and has been treating water since. Temporary treatment conducted under this emergency response will continue to manage the mine pool while additional modifications are made to improve the in-tunnel treatment system.*

Source: https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0800892#Status

Additionally, KICP stakeholders noted the need for verification of status of Voluntary Clean Up (VCUP) implementation at the Burlington Mine. The KICP Plan includes implementation efforts including developing an enhanced monitoring program for Left Hand and James Creeks, reprioritization of projects, and working to secure funding for priority mine areas. The Left Hand Creek Source Water Protection Plan (2010) provided similar implementation recommendations including working with USFS and Division of Mining and Safety to create and maintain an inventory of sites and status of reclamations, as well as characterization from active mines, ongoing creek monitoring, and participating in reviews for mine reclamation activities. As evidenced by the 2018 fish kill from the Captain Jack Mine (see inset box), heavy metals in the Left Hand Creek watershed continue to pose a significant challenge to stream health.

There are multiple potential sources of bacteria and nutrient pollutants, which include wastewater treatment plants, septic systems, agricultural and urban/suburban stormwater runoff. Note, the state recently started a 10-year plan[1] for establishing nutrient standards (nitrogen and phosphorous) for lakes and streams, which will be adopted in 2027 and will need to be integrated into future water quality planning in the watershed. Implementation efforts in the Keep it Clean Partnership's 319 Watershed Plan (KICP 2015) focused on E. coli as a priority and included source identification, and best management practices for source control to reduce loading. Keep it Clean Partnership's Watershed Plan (2015) noted stakeholders are also concerned about planning for upcoming regulation of nutrients. *"In 2015, standards for total nitrogen, total phosphorus and chlorophyll-a were adopted in Regulation 38 for certain stream segments upstream of WWTP discharges, in accordance with "interim nutrient values" adopted in Regulation 31. These interim values for nutrients may be adopted as stream standards within the next 10 years downstream of WWTP discharges."*

1. https://www.colorado.gov/pacific/cdphe/WQ-10-Year-Roadmap

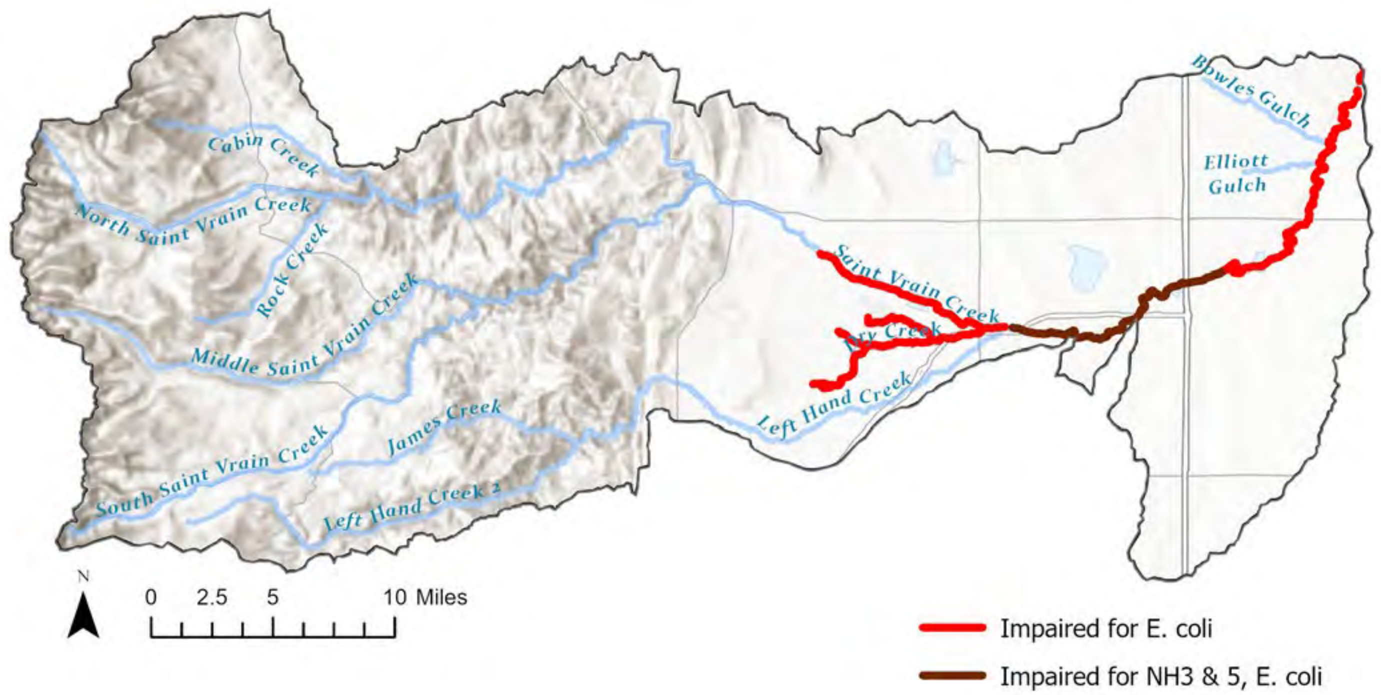


Figure 5.34 Organic and nutrient impairments. Organic pollutants are bacterial and nutrients include phosphorous and nitrogen.

5.4.3 Other Water Quality Issues & Gaps

CDPHE's 2018 listing for temperature is based on reports in the literature of the negative effects of warming in summer and winter on cold water species such as trout. Temperature was reported to be a potential issue for aquatic life in the North St. Vrain Creek reaches downstream of Button Rock Dam (for aquatic life) and in South St. Vrain Creek just above the confluence. The listings of the North St. Vrain and South St. Vrain Creek segments indicate that warming trends exceeded the allowable amounts (as number of degree days) in these reaches. Temperature is one of the constituents undergoing CDPHE review as part of their 10-year road map. In addition to regulated pollutants, sediments are another new water quality concern due to related maintenance issues. SMP Stakeholders noted that sediment deposits are an issue at the Haldi intake on Left Hand Creek and the South Ledge diversion on South St. Vrain Creek for example.

Benthic macroinvertebrate index (BMI) is a biological indicator of water quality for aquatic life, and attainment of Colorado standards is based on the multi-metric index (MMI) method. BMI sampling has been conducted in various creeks in the watershed for the past several years, and results have continued to find conditions impaired for aquatic life in parts of St. Vrain Creek and Left Hand Creek, although positive trends have been reported (Left Hand Watershed Center, 2020). Because the cause of the poor BMI scores is unknown, ongoing monitoring by the Left Hand Watershed Center and Keep it Clean Partners and further investigations are needed to better assess the role of possible contributing factors.

Data on other possible pollutants such as pesticides or emerging contaminants (pharmaceuticals, caffeine, hormones etc.) were not reviewed as part of the current study. However, USGS studies in Boulder and across the country are finding increasing evidence of loading of pharmaceuticals downstream of wastewater treatment plants and accumulation in fish. The 2015 Watershed Plan noted that emerging contaminants are a growing concern of the KICP stakeholder group.

5.5 WATER USE & MANAGEMENT

A complex network of reservoirs, diversions, and ditches support the agricultural, municipal and industrial water users in CO Division of Water Resources (DWR) Division 1, District 5[2]. Interviews were conducted with the District 5 Water Commissioner, water rights holders, and irrigation company representatives to collect preliminary information on current conditions and opportunities. In addition, several of the diversion structures were visited including the Highland Ditch,

2. See straight line diagram in Supplemental Resources on District website.

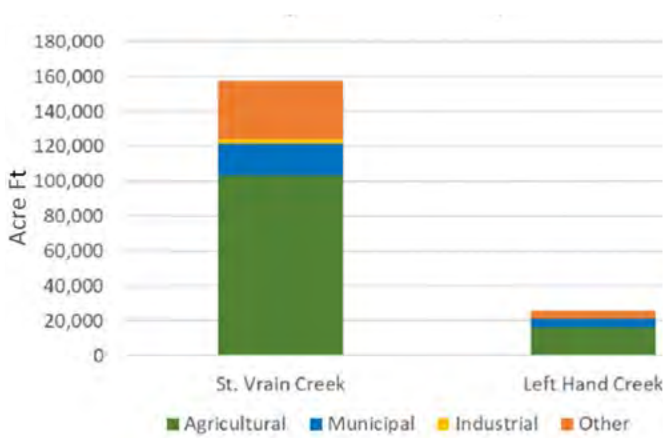


Figure 5.35 Average annual diversion by basin 2000-2012 (includes C-BT deliveries)

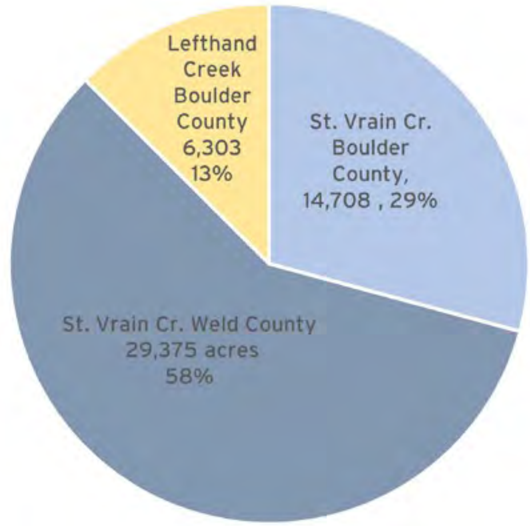


Figure 5.36 Irrigated acreages by water and creek

Foothills Inlet, Niwot, South Flat, Oligarchy, Bonus, Beckwith, South Ledge and several owned by Left Hand Ditch Company on Left Hand Creek during the stream health assessment. Full structural evaluation of the diversions were beyond the scope of Phase 1; however, stakeholders provided some initial input on infrastructure challenges and opportunities (including Left Hand Watershed Center's fish passage assessments previously noted) that will be further evaluated in strategic opportunity areas in Phase 2.

Agricultural water use accounts for the majority (over 65%) of the demand in the basin. As shown on Figure 5.35 and Table 5, "Other" is the second largest "diversion" category in StateMod, which includes reservoirs with mixed water uses, which could not be accurately quantified as either municipal or agricultural. This category also includes municipal water that may be used for augmentation, evaporative losses from reservoirs, and two diversions from one stream to another (refer to Appendix D).

Over 65 diversion structures are included in the StateMod analysis conducted for the study area. Approximately 40 ditches have senior water rights with decrees between 1863 to 1877. Refer to Appendix D for additional details.

Table 5 Summary of Average Annual Diversions in StateModel (2000 -2012) in Acre Feet

Reach	Agricultural	Municipal	Industrial	Other	Average Diversion
St. Vrain Creek	103,491	17,825	3,088	33,205	157,609
North Fork	*39*	*8,538*	*0*	*0*	*8,576*
South Fork	*1,857*	*1,794*	*0*	*14,521*	*18,172*
Mainstem (w/S. Branch)	*101,596*	*7,493*	*3,088*	*18,684*	*130,861*
Left Hand Creek	16,462	4,341	0	4,902	25,706
St. Vrain + Left Hand Creeks Total	119,953	22,167	3,088	38,107	183,315

5.5.1 Agricultural

Total irrigated lands in the St. Vrain and Left Hand watersheds cover 50,400 acres that are supplied by about 50 ditches. Figure 5.36 shows the distribution of acres by creek and county. As shown in Figure 5.37, of the irrigated agricultural lands, 66% are supplied by two ditches – Highland Ditch and the Supply Ditch (based on CDSS data, details in Appendix D).

The main crops in the basin are alfalfa and grass, as well as barley and some corn and sugar beets. The vast majority of farms in the basin use flood irrigation for alfalfa and grass, with sprinkler systems only used on a small minority of the farms (CDSS Irrigated Lands, 2018 data set).

Irrigation Water Requirement

To estimate potential agricultural water gaps, the irrigation water requirement (IWR) was developed using the state's Consumptive Use Model by calculating the difference in IWR and the amount of water diverted to the irrigated lands in different scenarios (Appendix D provides additional detail). The analysis found that annual IWR for the project area is 87,200 acre feet (AF) on average, and ranged from 63,845 AF (1961, wet year) to 116,941 AF (2012, dry year).

To identify the existing frequency and locations of potential agriculture water gaps, the IWR was compared to CDSS diversions per irrigation structure assuming a delivery/ditch loss of 20% and an on-farm irrigation efficiency of 60%. The results found 16 of the 47 irrigation structures did not have sufficient diversions to meet the IWR in average years including two large diversions-- Highland Ditch (with a gap 26,000 AF) and Supply Ditch (3,700 AF gap). Along the Front Range, large irrigation ditches are frequently short on an annual basis and as a result often supplement their supplies from system storage. For example, Highland Ditch irrigated lands receive supplemental water supplies from McIntosh Reservoir, Highland Reservoirs 1-3, Carter Lake, and Foothills Reservoir. Ditches in Northeast Colorado have access to supplemental water supply via the Colorado-Big Thompson (C-BT) trans basin project. Locally, many water right holders also have access to C-BT, including those under the Highland and Supply ditches.

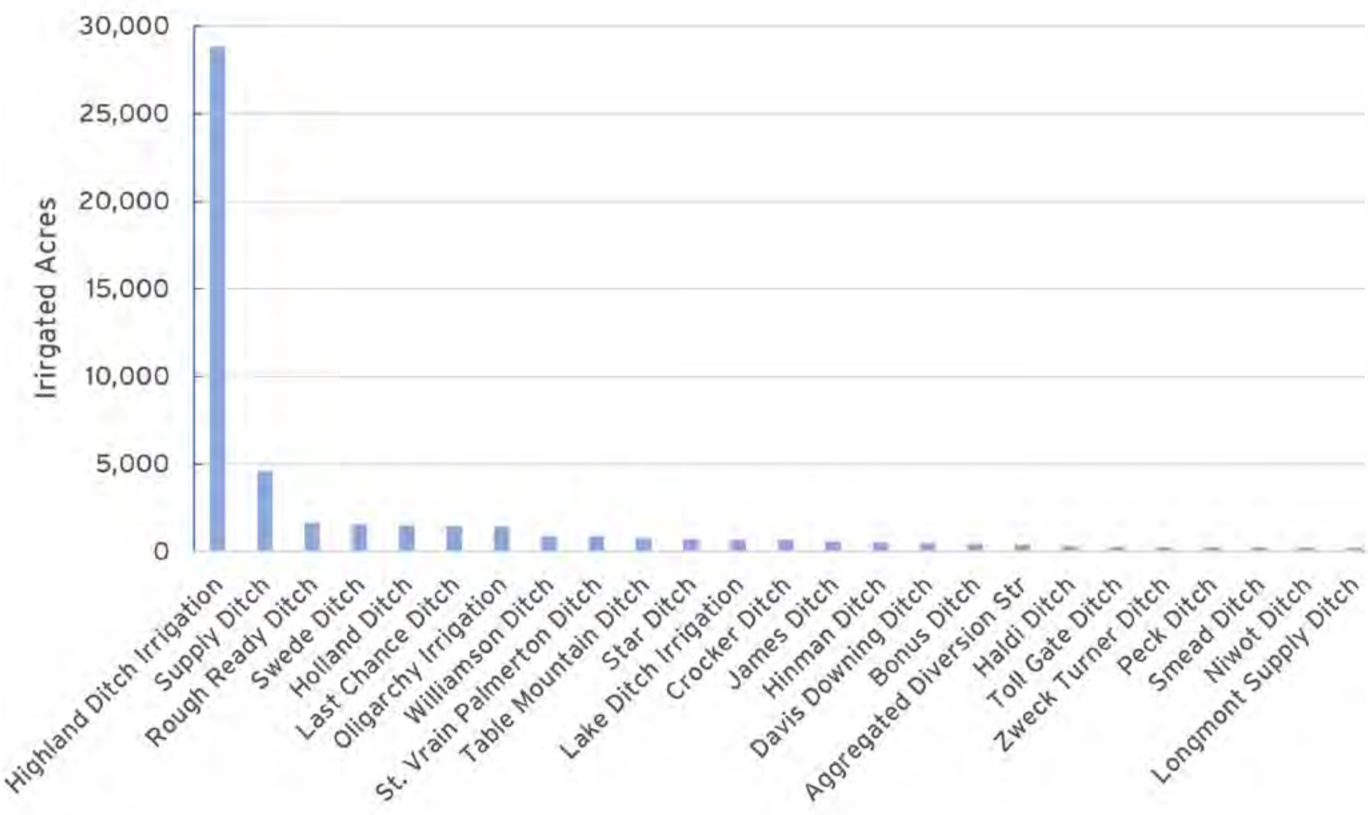


Figure 5.37 Top 25 ditches (Based on >200 acres irrigated land)

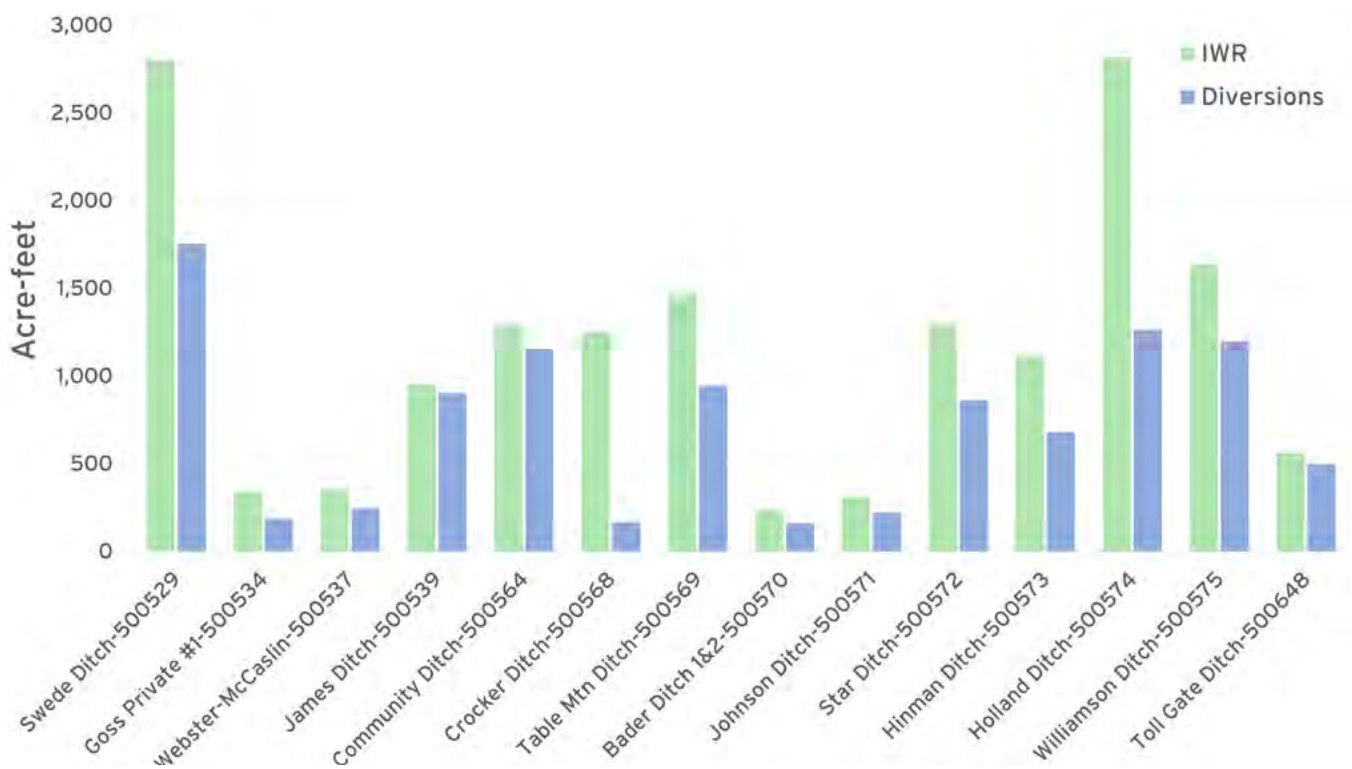


Figure 5.38-Ditches with irrigation water requirement shortages excluding Highland and Supply Ditches

Excluding Highland and Supply Ditches, the estimated Agricultural Water Gap is about 6,100 AF per year (on average). This gap is associated with 14 structures shown in Figure 5.38, all of which are in the transition zone, with the exception of about 25 acres supplied by Lake Ditch located on the eastern edge of the foothills (Figure 5.39). Of these potentially water-short acres, 2015 irrigated lands data show that 88% are alfalfa and grass, most of which are flood irrigated. It was not determined if these lands may receive supplemental water supplies from sources outside the St. Vrain and Left Hand watershed.

5.5.2 Municipal & Industrial Demands

In the St. Vrain and Left Hand Creek watershed, there are currently five municipal water service providers and four water service districts. Municipal water service providers include the City of Longmont, Town of Lyons, Town of Firestone, Town of Frederick, Town of Ward, Town of Jamestown, and Town of Dacono. Water service districts include the Left Hand Water District, Little Thompson Water District, Longs Peak Water District, Central Weld County Water District, and Allenspark Water and Sanitation District (see Figure 5.40).

Representatives from municipal and district water providers within the study area were interviewed to gather information regarding existing and future domestic demands and gain insight regarding how municipal water providers are planning to meet increased demands in the future. The following sections provide a high-level summary of the information provided by each municipal water provider. A visual summary of this information is included in Figure 5.40.

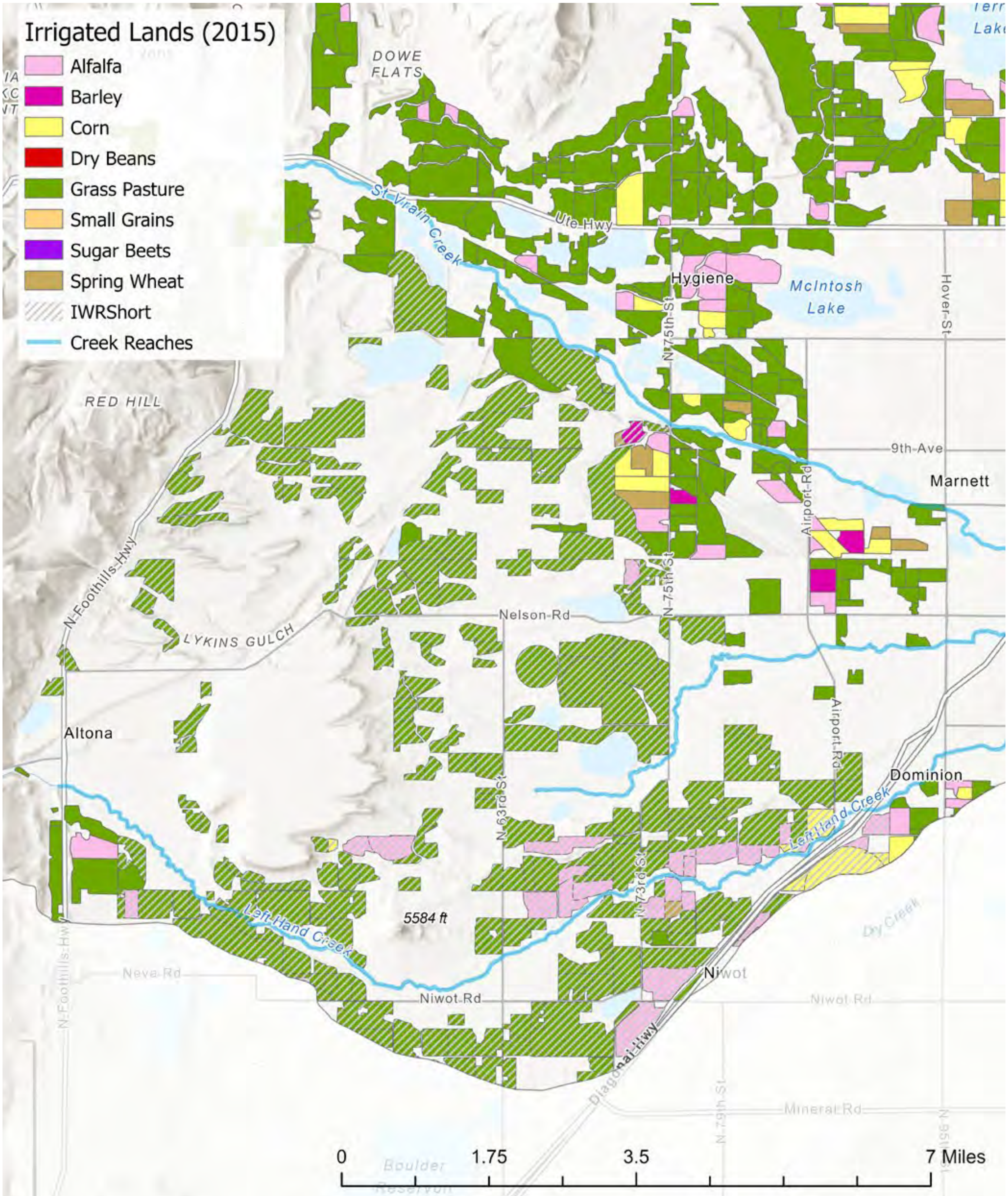


Figure 5.39 Irrigated acreage serviced by ditches with IWR shortages

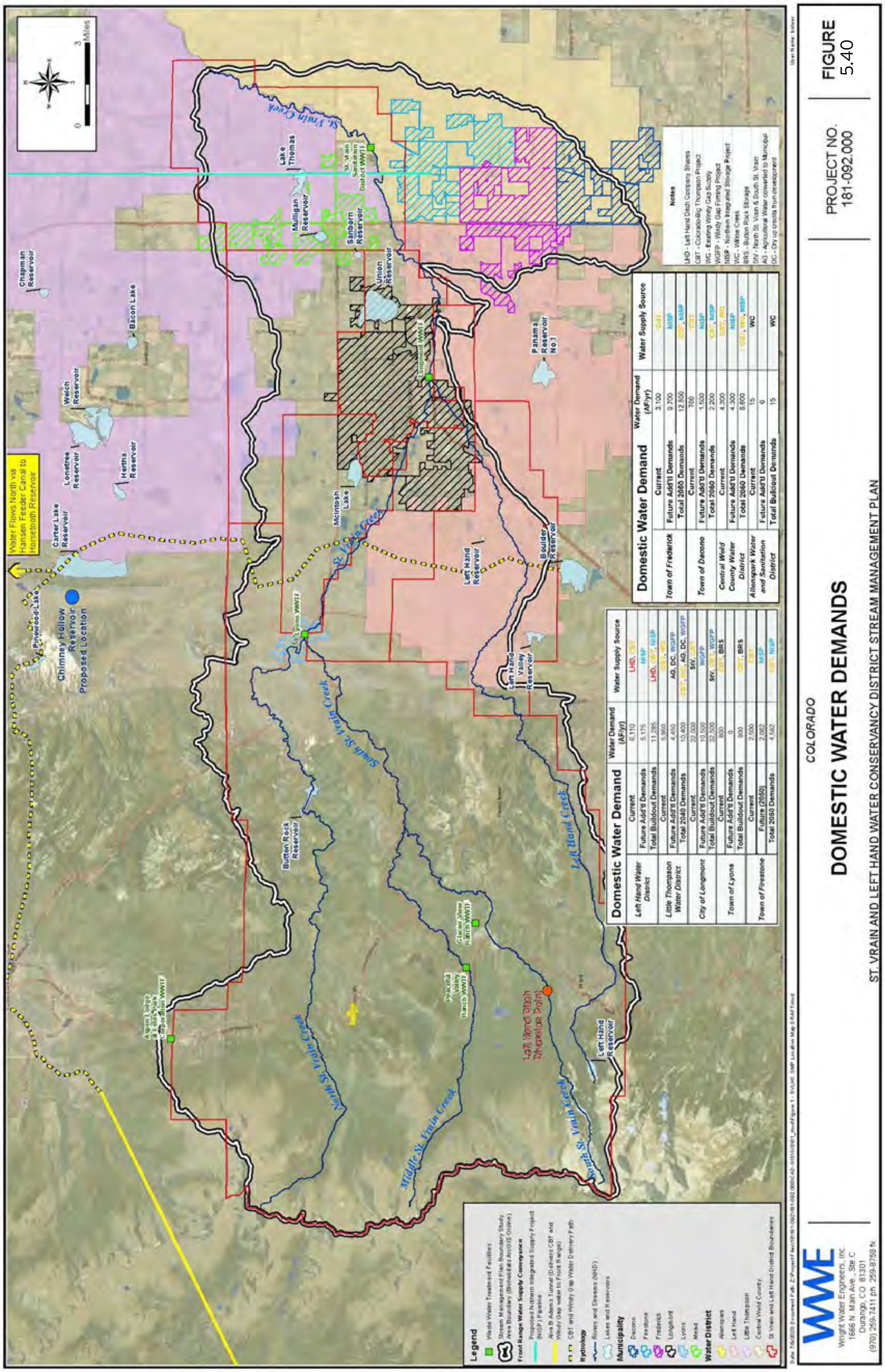


Figure 5.40 Domestic water demands

City of Longmont (Longmont)

Longmont provides water service to a population of approximately 94,000 and provides water treatment services to the Town of Lyons (Jacobs, formerly CH2MHill, 2017) within its service area. Longmont's existing raw water demands are approximately 22,000 AF per year (Jacobs, formerly CH2MHill, 2019). In 2019, Longmont updated its Water Demand Evaluation to include considerations for revised land use based on the Envision Longmont comprehensive plan, which updated population growth scenarios, historical water demand trends (which include water conservation trends), climate impacts, and more stringent water rights administration(Jacobs, formerly CH2MHill, 2019). The 2019 Water Demand Evaluation estimates an annual future raw water demand of approximately 32,500 AF per year, or approximately 10,500 AF more than existing demands.

Longmont's existing water supply system is complex. Longmont diverts water at Button Rock Dam (Ralph Price Reservoir, an on-channel reservoir on the North St. Vrain Creek) and at the Oligarchy Ditch into Union Reservoir. (Figure 5.41). Longmont also diverts water at its North Pipeline, South Pipeline and the Highland Ditch. The types of water rights diverted at these pipelines may be several different sources, including direct flow water rights, changed agricultural water rights (diverted by exchange), C-BT water (diverted by exchange from the St. Vrain Supply Canal), or releases from Button Rock Dam. In addition, Longmont takes delivery of C-BT directly from a pipeline from Carter Lake or directly out of the St. Vrain Supply Canal. C-BT is delivered through the Carter Lake pipeline or directly from the St. Vrain Supply Canal, as a result this water never enters St. Vrain Creek.

Longmont's current water rights portfolio can meet a raw water demand of 28,750 AF (Jacobs, formerly CH2MHill, 2019). After full build-out of its existing water rights portfolio, Longmont can meet a water demand of approximately 30,500

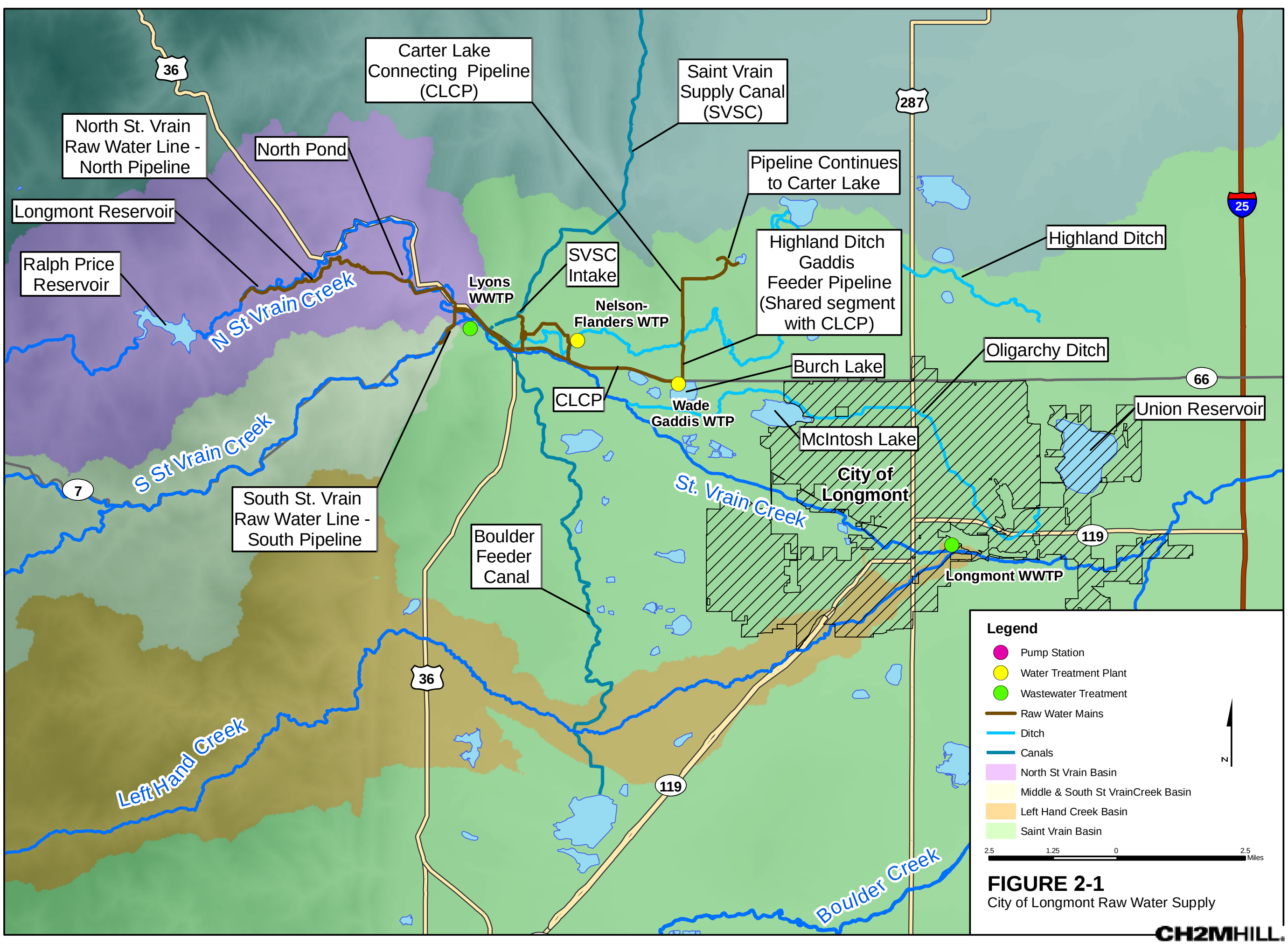


Figure 5.41 City of Longmont raw water supply system (Reprinted from CH2MHill 2017)

AF (Jacobs, formerly CH2MHill, 2019), or approximately 2,000 AF less than projected future demands. To address this gap, Longmont is participating in the Windy Gap Firming Project and continuing efforts to improve efficiencies within their system (Jacobs, formerly CH2MHill, 2019).

Left Hand Water District (LHWD)

The LHWD provides water service to approximately 8,390 Single Family Equivalents (SFEs) within its service area (LHWD, 2020). For planning purposes, the 2014 Master Plan estimates a demand of 650 gallons-per-day (gpd) per SFE equating to an existing annual demand of approximately 6,110 AF per year. Under full build out conditions the LHWD is expecting to service approximately to 15,500 SFEs (LHWD, 2020) equating to an annual estimated future demand of approximately 10,400 AF per year. This corresponds to an increase of 6,150 AF between now and full buildout conditions which are expected to occur in or around 2040.

The LHWD's current water supply sources include Carter Lake via the St. Vrain Supply, Boulder Feeder Canal System, and shares in the Left Hand Ditch Company. To meet future demands, LHWD is a project participant in the Southern Water Supply Pipeline Project II to supply additional C-BT water to LHWD, City of Boulder, Town of Berthoud and Longs Peak Water District. The LHWD is also a participant in the Northern Integrated Supply Project (NISP) with an expected annual yield of approximately 4,900 AF per year, if permitted.

Little Thompson Water District (LTWD)

In 2018 the LTWD delivered approximately 5,950 AF to its 8,000 service taps within its service area (LTWD, 2019). In year 2040, annual water demand in the LTWD is expected to increase to approximately 10,400 AF per year, or approximately 4,450 AF more than existing demands (LTWD, 2019). The LTWD is the primary water provider for the Town of Mead (LTWD, 2019).

Currently the LTWD's relies exclusively on C-BT water to meet existing demands. The LTWD has approximately 6,228 AF of firm yield C-BT water (LTWD, 2019). To meet future demands the LTWD developed the following strategies outlined in their 2019 Water Efficiency Plan:

- LTWD will file a change of use application in water court for their shares in local ditch companies to enhance their firm water supplies, as necessary.
- Firm and enhance the supply of the LTWD's Windy Gap project water through storage in Dry Creek Reservoir.
- Central Weld County Water District (CWCWD)

Currently the CWCWD relies exclusively on C-BT and Windy Gap project water and owns approximately 5,000 AF of storage rights in Dry Creek Reservoir. To meet future demands the CWCWD is participating in NISP with an expected annual permitted yield of approximately 3,500 AF per year.

Allenspark Water and Sanitation District (APWSD)

The APWSD provides approximately 15 AF of water per year within its service area boundary. Approximately 1.56 AF of the 15 AF delivered is depleted[3]. The APWSD service area is currently at full build out, and no additional demands are expected in the future. The APWSD water supply is from surface water diversions off Willow Creek (APWSD, 2020).

Town of Lyons (Lyons)

The Town of Lyons is currently nearing full build out with an annual service area demand of approximately 800 AF (Town of Lyons, 2020). Lyons currently has enough firm water supplies to serve approximately 1.5 times its current population. There is a possibility for future development in Apple Valley, however development in this area is not expected to occur within the next 50 years.

Lyons relies exclusively on C-BT project water and water ownership reserves in the Ralph Price Resevoir for municipal demand. Lyons has a large irrigation water demand, currently met by the Lyons Ditch #1, the Palmerton Ditch, and the Rough and Ready Ditch.

Lyons also benefits from water that is delivered to St. Vrain Creek via the St. Vrain Creek Supply Canal to help maintain recreational attractions including boating and trout fishing.

Town of Firestone (Firestone)

Firestone's current water demands are approximately 2,500 AF per year (LRE Water, 2020). Firestone is currently projecting an annual water demand of approximately 4,582 AF per year by 2050, or approximately 2,082 AF more than existing demands (LRE Water, 2020).

Firestone relies on C-BT and Windy Gap project water to meet existing demands. Firestone's 2020 Water Action Plan outlines a variety of planned water supplies and infrastructure projects to meet future demands including:

- is a NISP participant with an expected annual permitted yield of approximately 1,300 AF per year.
- Changing Firestone owned water rights to municipal use and developing plans for augmentation.
- Development of wells and wellfields in the St. Vrain Creek alluvial aquifer with plans for augmentation.

3. Depletion refers to "the loss of water from surface water reservoirs or groundwater aquifers at a rate greater than that of recharge" Waskom and Neibauer, 2012

- Securing raw water storage in Firestone Reservoir No. 1, Firestone Reservoir No. 2, Central Park Reservoir, and potentially Dry Creek Reservoir.
- Securing new water rights in the St. Vrain Creek basin.

Town of Frederick (Frederick)
Frederick's current water demands are approximately 3,100 AF per year (Town of Frederick, 2020; Harvey Economics, 2017). Frederick is currently projecting an annual water demand of approximately 12,800 AF per year by 2060, or approximately 10,718 AF more than existing demands (Town of Frederick, 2020; Harvey Economics, 2017).
Frederick currently relies exclusively on C-BT project water to meet existing demands with an estimated firm yield of approximately 3,200 AF (Harvey Economics, 2017). To meet future demands Frederick is participating in NISP with an expected annual permitted yield of approximately 2,600 AF per year. Frederick also has Windy Gap water that is not firmed or currently in use and is exploring options to make use of this Windy Gap water to supply their service area. According to their 2011 Water Conservation Plan Frederick also has a policy in-place to acquire native water rights on lands irrigated primarily by Boulder Creek and Idaho Creek within its planning boundary. However, at the time of their 2011 Water Conservation Plan's development, the Town did not believe treating these native water rights to potable standards was economically feasible. Instead they are using raw water irrigation until such a time when treating the water becomes economically viable or when the native water rights can be exchanged for higher quality water upstream.

Dacono
Dacono's current water demands are approximately 700 AF per year (Town of Dacono, 2020; Harvey Economics, 2017). Dacono is currently projecting an annual water demand of approximately 2,200 AF per year by 2060, or approximately 1,500 AF more than existing demands (Town of Dacono, 2020; Harvey Economics, 2017). Dacono currently relies exclusively on C-BT project water to meet existing demands with an estimated firm yield of approximately 1,112 AF (Harvey Economics, 2017). To meet future demands Dacono is participating in NISP with an expected annual permitted yield of approximately 1,250 AF per year.

Municipal and Industrial Demands Summary
It is understood as populations increase and the demand on water increases there will be changes and adaptions to meet future demands. Transmountain water is providing reliable sources of water for future growth scenarios and should be monitored as transmountain projects come on line. Creative solutions for management of these water sources should be explored to look for multiple benefit solutions that not only provide water for consumptive uses, but also keeps water in the creek system to benefit recreation and the environment. Also, as time progresses, water efficiency practices are increasing, and continued adaption and innovation should be encouraged to manage the increased demand on water resources. The impacts of climate change on the system should also continue to be evaluated and addressed.

New development in Firestone

5.5.3 Other Water Rights

Other water rights in the basin include decrees related to reservoirs, instream flows, wells, gravel pits and recreation.

Reservoirs & Lakes

CDSS data show 291 reservoirs in the planning area (not including inactive or historical reservoirs). Of these, two main reservoirs, Ralph Price and Union, are the largest and serve as upper and lower "buckets" respectively, in Longmont's system. Figure 5.42 presents the other reservoirs in the system with greater than 1,000 AF absolute decreed volume. In addition to the regulated reservoirs, there are numerous mountain ponds as well as farm irrigation ponds in the watershed. In total, the open water areas mapped in the watershed cover over 5,000 acres. As presented in Figure 5.43, most of these water bodies are in the plains zone, where evaporation rates are higher than in the upper watershed, and evaporative losses from climate change are expected to increase as temperatures continue to warm in the future.

Instream Flows

Twenty-one instream flow (ISF) water rights[4] were appropriated in the upper portions of the watershed between 1979-1995. Of the approximately 107 miles of SMP reaches[5] with ISF rights, about 21 miles are on North St. Vrain Creek, 12 miles are on Middle St. Vrain Creek, 27 miles are on South St Vrain Creek, 9 miles are on Left Hand Creek, 7.5 miles on James Creek, and the remainder are on St. Vrain Creek tributaries.

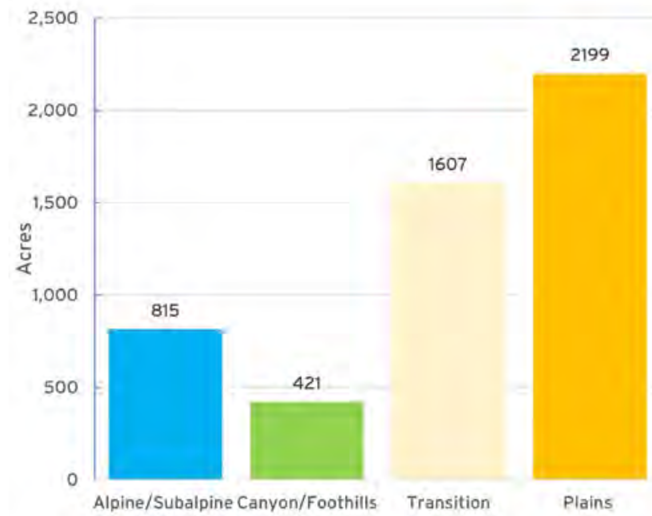


Figure 5.43 Reservoir and lakes, surface area (acres) by SMP zone (with zone elevation in ft)

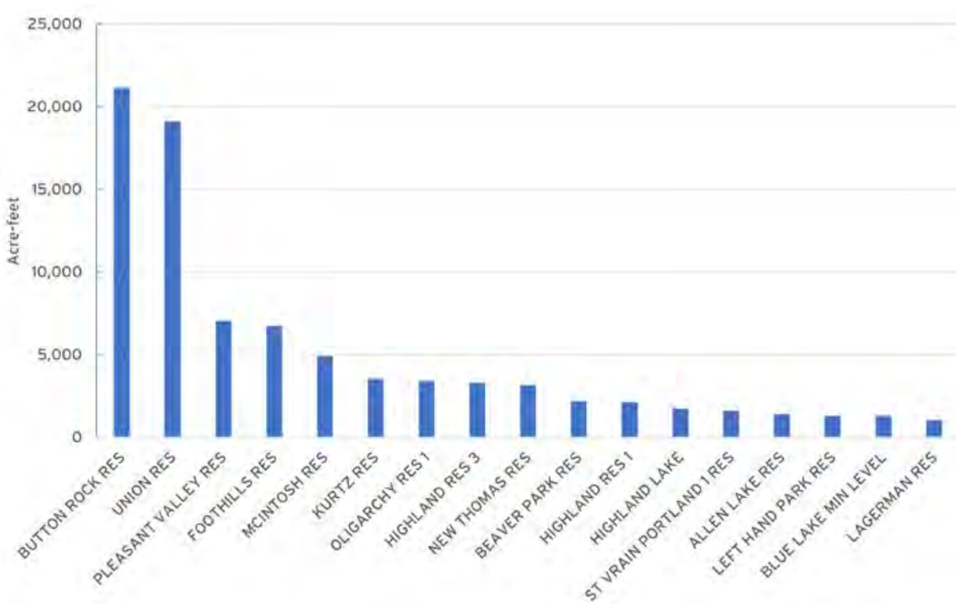


Figure 5.42 Storage capacity of reservoirs (with absolute decreed volumes >1,000 ac ft)

4. Note Little Mitchell Lake 1 and 2 water rights are decreed for lake volumes, not included in the above discussion.
5. Note, the District 2020 Business Plan reports ISF segments cover 256 miles, the difference between miles reported here from GIS data and the District's value are possibly due to using stream mile (starting points) rather than segment lengths.

Figure 5.44 Waterways with instream flow water rights

Table 6 Summary of Instream Flow Rights in the Watershed

Case No.	Waterway	Appropriation Date	Miles	Type	Status	Historic Calls
78W9378	Beaver Creek	07/11/78	3.4	New Appropriation	Decreed	-
87CW0289	Beaver Creek	12/11/87	2.5	New Appropriation	Decreed	-
79CW0199	Cabin Creek	03/14/79	4.8	New Appropriation	Decreed	-
79CW0001	Cabin Creek	09/19/78	3.7	New Appropriation	Decreed	-
78W9377	Coney Creek	07/11/78	3.3	New Appropriation	Decreed	-
87CW0293	Horse Creek	12/11/87	2.2	New Appropriation	Decreed	-
95CW0262	Hunters Creek	07/24/95	4.6	New Appropriation	Decreed	-
78W9379	James Creek	07/11/78	7.6	New Appropriation	Decreed	-
86CW0301	Lefthand Creek	09/05/86	4.9	New Appropriation	Decreed	-
86CW0342	Lefthand Creek	09/05/86	4.1	New Appropriation	Decreed	-
78W9361	Middle St Vrain Creek	07/11/78	3.5	New Appropriation	Decreed	-
87CW0281	Middle St Vrain Creek	12/11/87	8.2	New Appropriation	Decreed	-
87CW0288	Mitchell Creek	12/11/87	1.3	New Appropriation	Decreed	-
87CW0282	North St Vrain Creek	12/11/87	10.2	New Appropriation	Decreed	-
78W9363	North St Vrain Creek	07/11/78	10.8	New Appropriation	Decreed	-
87CW0280	Roaring Fork Creek	12/11/87	1.5	New Appropriation	Decreed	-
87CW0278	South St Vrain Creek	12/11/87	9.3	New Appropriation	Decreed	-
78W9362	South St Vrain Creek	07/11/78	15.5	New Appropriation	Decreed	10/24/2016
87CW0283	South St Vrain Creek	12/11/87	0.8	New Appropriation	Decreed	-
95CW0261	South St Vrain Creek	07/24/95	1.1	New Appropriation	Decreed	-
79CW0002	Tahosa Creek	09/19/78	4.5	New Appropriation	Decreed	-

Wells

The CDSS database includes 443 constructed wells in the SMP planning area, but 20% of these are monitoring wells which are not used for groundwater withdrawals. Of the 357 remaining wells, 328 (92%) are household and domestic wells (some of which include secondary uses for stock), and the remainder are for other purposes including irrigation, commercial, industrial, oil and gas, and temporary uses. Most of the wells (61%) are located in the canyon/foothills zone. Although all the wells are listed in "unknown aquifer," the vast majority of well depths are less than 100 ft in the transition and plains zones, suggesting they are likely withdrawing from the South Platte alluvial aquifer. Most of the well records did not include yields.

Gravel Pits

Over 30 gravel pits are listed on the straight-line diagram for DWR's Division 1, District 5 which oversees administration of water rights. All the pits are located along the St. Vrain Creek (see Figure 6.3). And most of the pits are unlined and still operational. The former pits on City property at Dickens Farm have been retrofitted with access and features to allow recreation (flat water kayak, fishing etc.) Following closure, several pits are slated for storage which requires lining. As plans for lining progress, impacts to the river should be considered and planned for, as lining pits creates a local barrier for groundwater/surface water interactions and, depending on the location, can alter groundwater discharge to support baseflow.

St. Vrain and Left Hand Water Conservancy District (District)

The District has several water rights which are potential assets for improved flexibility for stream management[6]. These are summarized below.

- *Coffintop Decree.* Coffintop Reservoir, or more specifically, the decreed conditional water storage rights for the reservoir (called the Coffintop Decrees), is still a focus of the District. However, the reservoir's final design and location are likely going to be vastly different from the original design and location. Though it would require a water court process, the District may choose to move the Coffintop Decrees to a series of alternative off-channel storage sites, which are sometimes referred to as a "string of pearls". To achieve the needs of the basin, conversations regarding water storage should be geared toward discussing Creek Improvement Facilities (CIFs), rather than storage. CIFs are different from storage because they are multiuse, do not affect federally regulated wetlands or water bodies, make water delivery more efficient, and mitigate for increased climate uncertainty. There is potential for several CIFs within the basin. In-series, this "string of pearls" can provide ISF, recreational flows, and improved efficiencies for domestic and agriculture water delivery.
- *Gravel Pit Agreements.* Between the period of 1974 and 1988, the District entered into 13 sand and gravel pit augmentation agreements (Agreements). Although each of the Agreements is unique, generally the Agreements identify the amount of native water restricted or transferred to the District. If transferred, the District may have flexibility to allow the water to be left in the stream as a formal or informal instream flow.

Recreation In-Channel Diversion (RICD)

The state of Colorado allows water rights to be adjudicated for minimum flows for reasonable recreation activities, and the City of Longmont has a RICD right for 350 cfs (May 1-June 15) and lower flows March 1-October 31) for the reach downstream of the Highway 287 bridge.

5.5.4 River Recreation Uses

Boating

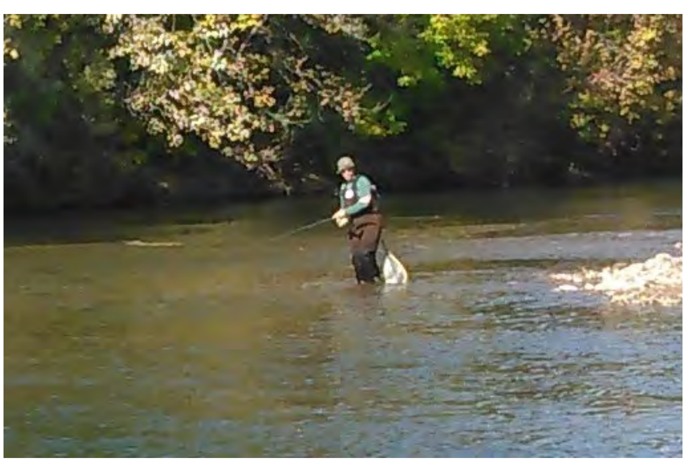
American Whitewater contributed to the SMP process by providing input on boaters' streamflow preferences for boating and specifically by developing a baseline Boatable Days assessment for the planning area. (Refer to Appendix F for full report.) The purpose was to understand flow conditions related to recreational boating and educate stakeholders about the SMP. The process included a web survey to assess flow acceptability of different users based on skill level and types of boating and rafting. The results helped to define flow ranges as lower acceptable, optimal and upper acceptable, and then based on those ranges the number of boatable days were evaluated in different year types (wet, dry and average). The study used two approaches for characterizing years: in one method where sufficient data were available, representative years were selected from historical data with 2018 (dry), 2016 (average), and 2015 (wet); and the second method derived year types statistically.

6. Note: Legislation recently passed in the state provides direction on two options for the District to explore 1) voluntary loans to the state to preserve instream flows (HB1157) and augmentation of instream flows through state acquisition of water rights (HB1037). See also Section 6.

Based on its findings, American Whitewater recommended using the Laverne M. Johnson Park (Lyons Whitewater Park) as a consideration in recreational planning and future decision making. The number of boatable days in each acceptability category at Lyons varied depending on the method used. But overall, the analysis found that the total number of boatable days (sum of lower acceptable, optimal, and upper acceptable) at Lyons Whitewater Park ranged from 45-49 in dry years, 65-67 in average years, and 89-90 in wet years (see Appendix F for more details). In addition to the boatable days analysis, American Whitewater reported the following priority issues were identified by survey respondents: enhanced flows in North St. Vrain and South St. Vrain Creeks, removal of boating hazards, river access improvements and continued operation of stream gages.

Fishing

Because stakeholders and the community identified the importance of recreational fishing in the watershed, a fishing survey was developed to collect additional information on user skills, frequency of use, and experiences related to flows. The results are preliminary and should continue to be evaluated. Nevertheless, survey respondents most often noted adequate minimum flows for fishing in canyon reaches at 10-25 cfs or 25-35 cfs. Many survey respondents felt that a main management priority should be improving the quality of aquatic habitats to specifically support native fish species. Respondents also felt that improved riparian habitat quality would improve their fishing experience. Some fishing survey respondents noted that preference in management given to boaters and casual recreationists (swimmers, tubers, etc.) can decrease the quantity and quality of available fish. Though further exploration of the topic is warranted, this information provides a starting point for understanding recreational fishing uses, which can continue to be refined in Phase 2 and during development of projects in opportunity areas.



5.5.5 Preliminary Infrastructure Assessment & Stakeholder Input

A preliminary assessment of infrastructure needs was based on interviews with the District 5 Water Commissioner and stakeholders and supplemented by site visits. An overarching theme that emerged was that financing and planning for stream and infrastructure improvements are currently not coordinated among entities. This has created added financial, maintenance and regulatory burdens, delivery inefficiencies, and further habitat degradation.

An initial list of general needs is presented below; however, Phase 2 of the SMP will assess feasibility and evaluate which of these can be integrated with other project goals to achieve multiple benefits. The following ideas for infrastructure and management related improvements were identified by stakeholders:

- Improve flood protection, particularly to reduce flood risks to smaller water rights/landowners
- Reduce ditch maintenance needs from sediment and debris through gate improvements and multi-objective fish passage retrofits
- Strategically increase the number streamflow gaging stations to improve real-time monitoring and water administration along the creeks. Specifically, additional gaging stations at select locations including the Highland Diversion (with flow bypass), between the Oligarchy diversion and Airport Road, and South St. Vrain at Old St. Vrain Road bridge
- Reduce impacts of dry-up points
- Improve fish passage. Ten diversion structures on St. Vrain Creek are identified as priorities for fish passage by CPW, and eight diversions on Left Hand Creek are identified as presenting total barriers. Fish passage maintenance assistance was also noted as a need
- Improve water delivery efficiencies through coordinated management of "The String of Pearls" creek improvement facilities, or CIFs, to provide instream flows, recreational flows, and deliveries for domestic and agriculture water supplies
- Improve US Army Corps of Engineers permit coordination for infrastructure projects
- Collaborate with the owners of Union Reservoir to investigate the potential for multiple benefits on the proposed reservoir expansion.
- Consider alternative designs and management or diversion structure retrofits at several locations along

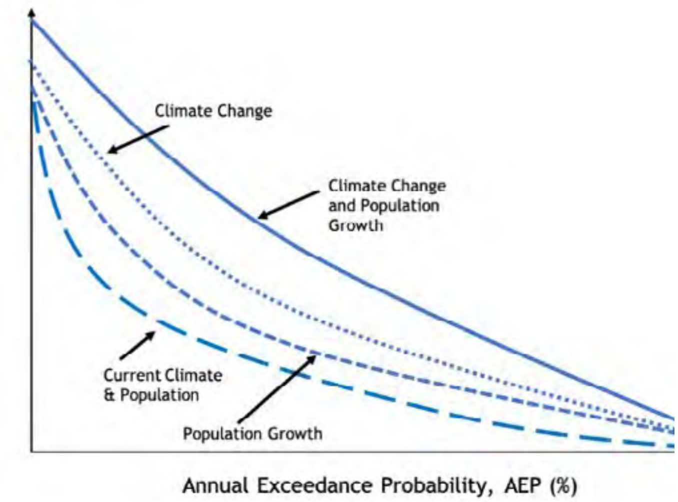


Figure 5.45 Future Avoided Cost Explorer, CWCB 2020

the creeks where impediments prevent travel of aquatic species

- Further green water system efficiency improvements to better manage irrigation on crop land
- Provide conveyance flexibility/exchanges and improve conveyance efficiency and increase conveyance to downstream users
- Develop augmentation plan for recreation and environmental needs
- Create storage agreements
- Improve policy coordination and possible safety improvements for example tie-offs on diversion structures for first responders during high water rescues
- Increase on-farm irrigation changes to improve efficiencies
- Create financial incentives and technical assistance opportunities
- Investigate the potential to combine diversion structures and the feasibility of completing such a change in water court
- Reduce safety concern from low head dams

5.6 DATA NEEDS SUMMARY

Monitoring and data collection are a continuous process and should be an expected component of future work. Because rivers and creeks are complex, it is often hard to disentangle the factors that influence health in any given year. Therefore, long-term datasets and action thresholds are a key part of stream management planning.

Five priorities for data collection emerged from the SMP that will support a better understanding of flow-ecological risks and stressors including improved data on climate, biological indicators, flows, water quality, and infrastructure. These vary in the timeframe of collection, but each requires sustained effort. The main topics for these data needs are listed below.

- **Climate change** impacts on the river are uncertain, but increasing temperatures are expected to have an overall negative impact on water storage, water quality, and stream health by increasing evapotranspiration and evaporation. Therefore, integrating collection and evaluation of climate data in the basin will be important moving forward and will need to be combined with biological data, population trends and other risk of damages information (See Figure 5.45). Risks from increased forest fires should be included in the evaluation, and funding opportunities such as the Peaks to People Water Fund should be reviewed.
- **Biological indicators** need to be agreed upon early and inventoried to establish common baselines for assessing long-term success of aquatic habitat and native riparian and wetland plant and animal recruitment and resilience. A program for more routine wildlife data collection and processing and sharing of trends for select fish, benthic macroinvertebrates, amphibians, and birds should be instituted. Suitability of viable beaver habitat should be included in the follow-up assessment of the restoration potential of opportunity areas in the upper watershed.
- **Flow ecology** relationships need to be better understood to characterize continuous flow conditions, flow depths, wetted area extent, floodplain inundation, sediment transport patterns and vegetation responses among other variables. Given the wide range of ecological characteristics across the basin, additional study should be focused on opportunity areas where flow improvements are anticipated. The South St. Vrain in particular, merits further investigation. Stakeholders suggested convening subject matter experts for targeted scientific feedback of goals in Phase 2.
- **Water quality** impairments from E. coli need more detailed monitoring to better understand sources in key locations, in addition to increased understanding of metals issues from mining and related needs noted in the 2015 Watershed Plan.

- **Infrastructure** evaluations will help identify additional opportunities for improvements. These could include specifics on headgate condition, repair history and needs, channel migration opportunities and sedimentation issues, habitat quality, and community outreach and education opportunities. Additionally, more detailed information is needed to better understand how planned water management changes, including infrastructure upgrades and conveyance to meet water demand gaps, agricultural land retirements, and water storage--including gravel pit lining—could influence the creeks. Additional input is also needed on locations where flood protection and restoration can reduce flood risks to smaller water rights/landowners while achieving other stacked environmental benefits.

Note that some stakeholders who were not available to participate in Phase 1, such as the National Park Service, may have additional data which should be reviewed as available and incorporated into future SMP phases and projects.

View of Left Hand Creek post-flood road repair and restoration project

Section 6 – Strategies

This section presents a range of strategies, which are actions with a common focus, to address needs identified by stakeholders and the stream health evaluation. The strategies listed in Section 6.1 are linked to desired conditions and management goals for each of the main themes identified by stakeholders. Possible locations where strategies may be applied are presented as Opportunity Areas in Section 6.2. Section 7 presents Initiatives that describe near-term and long-term action items to help managers plan for implementation and Phase 2.

6.1 RECOMMENDED STRATEGIES

Strategies focus on leverage points where actions can readily achieve change and create significant improvement often with multiple benefits. As subject experts involved throughout the process and using information offered by the stakeholders, the strategies in Table 7 are recommended by the Biohabitats team as topics that warrant more detailed investigations to reach the goals. These should be discussed and agreed upon early in Phase 2 and as necessary be refined to include more detail on timing and quantifiable measures for specific projects. A list of possible initiatives for near and long-term implementation is presented in Section 7.2.


Beaver dam analog example on Left Hand Creek

Table 7 Recommended Strategies

<table>
<tr><th>Strategies Recommended for Further Evaluation by Goal</th><th>Potential Phase 2 Topics</th></tr>
<tr><td colspan="2">FLOW GOALS:
1. Maintain baseflows and peak flushing flows in the creeks necessary to support ecological function and connectivity for native and sport fish, recreation, and diversions for beneficial use.</td></tr>
<tr><td>Select Tools to Enhance Streamflow
• Alternative transfer methods[1]
• Voluntary loans to the state[2]
• Instream flow rights[3]
• Augmentation of instream flows through state acquisition of water rights
• Reduce demands and increase efficiencies
• Recreational In-Channel Diversions (RICDs)</td><td>Preliminary flow targets warrant further study by a group of subject matter experts during Phase 2. Specifically:
Low flows: establish baseflows targets in reaches with high to very high ecological risks (refer to Section 5.2 for the technical starting point).
High flows: establish flow targets for reaches with high to very high ecological risks managed to improve channel-forming processes. Reach-specific target amounts and timing to be studied based on historical flow data.
Continuous flows: prioritize diversion structure upgrades to allow for bypass to maintain and improve habitat for recreation and native fish by preventing dry ups and ensuring safe passage.
Identify alignment within acceptable recreation flows and target ecological flows to prioritize.</td></tr>
<tr><td>Investigate reservoir operation agreements
• Cooperative/voluntary agreements
• Coordinated release timing</td><td>Work to develop reservoir operation agreements for St. Vrain reservoirs that encourage flexible and updated management, including increased flexibility and coordination to time releases and reduce ecological risk while meeting decreed water rights.</td></tr>
</table>

1. Alternative transfer methods: "a variety of approaches such as option agreements and short-term leases to meet various water supply needs in ways that minimize permanent reductions in irrigated agriculture and associated socio-economic and ecological externalities." https://cwcb.colorado.gov/focus-areas/supply/alternative-transfer-methods
2. Temporary loans to the state instream flows can be used to preserve and improve environmental flows per "Rules Concerning The Colorado Instream Flow And Natural Lake Level Program 2 CCR408-2
3. Instream flow water rights are appropriated by the Colorado Water Conservation Board to preserve the natural environment to a reasonable degree, including flows between designated points on a strea

<table>
<tr><th>Strategies Recommended for Further Evaluation by Goal</th><th>Potential Phase 2 Topics</th></tr>
<tr><td colspan="2">HABITAT GOALS
1. Preserve and restore riparian and instream habitat for native species.
2. Allow natural processes to occur in appropriate locations.
3. Implement appropriate management prescriptions and uses to maintain and enhance habitats along creek corridors, including for sport fishing in opportunity area
4. Increase instream and riparian connectivity for native species, and control non-native invasive species.</td></tr>
<tr><td>Restore floodplain, riparian and aquatic habitat
• Buffer management education programs like the Good Creek Neighbor policy
• Improve streambanks and floodplain, e.g., through raising channel inverts and reconnecting floodplains
• Improve channel forming processes</td><td>To support robust, self-sustaining riparian areas, a group of subject matter experts should be formed to study and develop restoration plans for numerous areas. Specifically:
Develop plans to restore entrenched and degraded channels to improve access to an active and healthy floodplain during high-frequency (1- to 5-year) flow return intervals.
Develop plans to restore pool and riffle habitat forming processes in opportunity areas (e.g., to reduce embeddedness, maintain pools, and enhance backwater channels).
Design development for process-based restoration of riparian and wetland habitat in opportunity areas</td></tr>
<tr><td>Protect wetland and riparian buffers
• Conservation easements
• Floodplain management agreements
• Technical assistance programs for vegetation management
• Education and outreach for buffer management</td><td>High-quality riparian, wetland, and aquatic habitat areas, identified as focal protection locations, are designated and include open valleys and beaver ponds and large wetlands/riparian areas in the upper watershed. Specifically:
Develop management agreements to protect focal areas and buffers from development, recreation impacts, fire threats, invasive species, and other stressors.
Research and monitoring efforts are funded to better understand trends in disease, climate change and habitat conditions.
Best practice guidance and incentive programs</td></tr>
</table>

<table>
<tr><th>Strategies Recommended for Further Evaluation by Goal</th><th>Potential Phase 2 Topics</th></tr>
<tr><td colspan="2">WATER QUALITY GOALS
1. Remediate known point and non-point sources of water pollution in the watershed, including historic mine sites.
2. Monitor pollutants from historic mine sites
3. Rehabilitate eroding and impaired creek banks and channels based on natural channel design concepts where possible
4. Restore healthy forests and improve forest-creek connections to keep pollution out of waterways
5. Limit new sources of water pollution</td></tr>
<tr><td>• Increase project implementation
• Implement 2015 Watershed Plan including E. coli inventory
• Increase implementation of BMP demonstration projects & education and outreach
• Restore severely eroding banks
• Enhance water quality monitoring
• Increased monitoring of metals in Left Hand Creek
• Increased benthic macroinvertebrate sampling in St. Vrain Creek transition zone
• Develop rapid response network
• Define system of reporting
• Establish team of experts</td><td>To improve water quality throughout the basin, a group of subject matter experts should be formed in Phase 2 to identify and study pollutant sources to reduce impacts. Specifically:
Develop BMPs through education to improve water quality runoff from urban and agricultural sources.
Develop partnerships to improve forest health and the connectivity of forests to the riparian corridors.
Identify the root cause of sediment inputs to the creeks and identify barriers to adequate sediment transport.
Further develop monitoring programs for impaired creek reaches with the goal of improving water quality parameters (metals, pH, E. coli, and nutrients) such that they meet or trend toward compliance with state and federal standards.
Develop a rapid response network and system for reporting for contamination issues and events.</td></tr>
</table>

Strategies Recommended for Further Evaluation by Goal	Potential Phase 2 Topics
WATER USE & MANAGEMENT 1. Work with water rights holders to ensure their water supply needs are met and not interrupted, explore issues and concerns, and find opportunities for mutually beneficial management improvements. 2. Meet regularly with all stakeholders to discuss water management issues, potential solutions, funding opportunities, education and outreach, and other mutually beneficial opportunities. 3. Strive for a mutually beneficial balance between the needs of water users and the needs of the natural environment.	
Improve diversion structures, ditches, and irrigation systems • Streamflow gaging • Fish and boat passage • Diversion structure enhancements and improved management • Increase on-farm irrigation efficiencies	Improving water management throughout the basin will require a coordinated effort amongst water managers. The following potential improvements were identified during the Phase 1 assessment and require further investigation and planning: Install additional streamflow gaging stations at select locations including Highland Diversion (with flow bypass), also between Oligarchy and Airport Rd. Provide conveyance flexibility/exchanges and improve conveyance efficiency. Coordinate financing, permitting, and planning program for ditch managers and users supports technical assistance and infrastructure improvements. Prioritize fish passage improvements to remove barriers to aquatic habitat connectivity, including ten diversion structures on St. Vrain as identified by CPW, and diversions identified by the Left Hand Watershed Center on Left Hand Creek. Establish a fund for fish passage structure maintenance.
Build capacity and implement adaptive management • Address data gaps and expand monitoring and reporting • Assist USFS, NPS, City of Longmont, Boulder County and other public land managers to supplement capacity • Assist private land managers in need of technical or financial incentives • Expand citizen science and other community learning programs	Collaboration will leverage resources of existing programs, such as the St. Vrain Forest Health Partnership, to bring together diverse partners and community members to collaboratively plan and implement cross-jurisdictional landscape-scale forest restoration that will prepare the landscape and community to receive wildland fire as a natural part of the ecosystem. Adaptive management planning underway at the Left Hand Watershed Center and other stakeholder monitoring provide a starting point to expand monitoring to reflect the goals of the SMP and to establish agreed-upon response thresholds for action along with response measures for key environmental performance standards or indicators.

6.2 OPPORTUNITY AREAS

Opportunity areas are the locations where stakeholders can place the greatest focus. Biohabitats recommended opportunity areas are based on an assessment in this SMP and general input from stakeholders throughout the process. If the most appropriate strategies are applied, these areas can achieve significant improvements or offer protection from anticipated stressors. Investing in these areas will result in measurable progress toward desired conditions for flows, habitat, water quality, and management. They represent a spectrum of current conditions, from high value resources in need of protection, to "low-hanging fruit" where multiple benefits can be achieved with modest investment, to heavily stressed areas where the benefits of restoration projects can improve local and downstream conditions and meet multiple objectives.

The strategies applied to potential opportunity areas were based on reach-specific assessment of stressors and conditions. Strategies for certain locations considered:

- Which reaches have high quality riparian and wetland areas, such as open valley wetlands in the mountains, that need to be protected from future stressors like climate change and forest fire risks.
- Which reaches have good floodplain connectivity but poor riparian vegetation that could be enhanced by invasive species treatments and additional planting.
- Which reaches have flows that pose a high ecological risk (e.g. due to altered low flows) but good potential fish habitat that would benefit from habitat and flow improvement.

Many areas offered multiple potential improvement opportunities, as shown in the following summary pages. These stacked benefit approaches to project planning are important not only for cost efficiency, but also because taking a holistic approach to solutions lowers the risk of unintended results and improves outcomes. For example, the success of enhancing stream flows will depend on channel conditions. If the channel is in poor condition, then improvements to the geometry (cross section and profile) should also be included when planning for flows. Increasing peak flows in a highly modified channel with hardened banks engineered for flood control is another example where flow modifications alone cannot provide the channel-forming processes and scour patterns necessary for cottonwood regeneration.

Figures 6.1 to 6.4 highlight opportunity areas for each zone along with applicable strategies. For these examples, reach-specific notes on how desired conditions could be met are provided in Appendix G.

St. Vrain Creek plains reach (SV02) downstream of Goosequill pump station with opportunity for invasive species management

ALPINE AND SUBALPINE OPPORTUNITY AREAS

Opportunity areas in this zone are high quality habitat that is increasingly vulnerable to climate change, recreational pressures, and some fire risk. Flows are mostly in very good to good condition (i.e., similar to natural flows and therefore with low ecological risk), and water quality is good, except in uppermost Left Hand Creek. Most of the land is publicly owned, and recreation and infrastructure management are major challenges to the US Forest Service (USFS) and National Park Service (NPS). Refer to Appendix G for additional information.

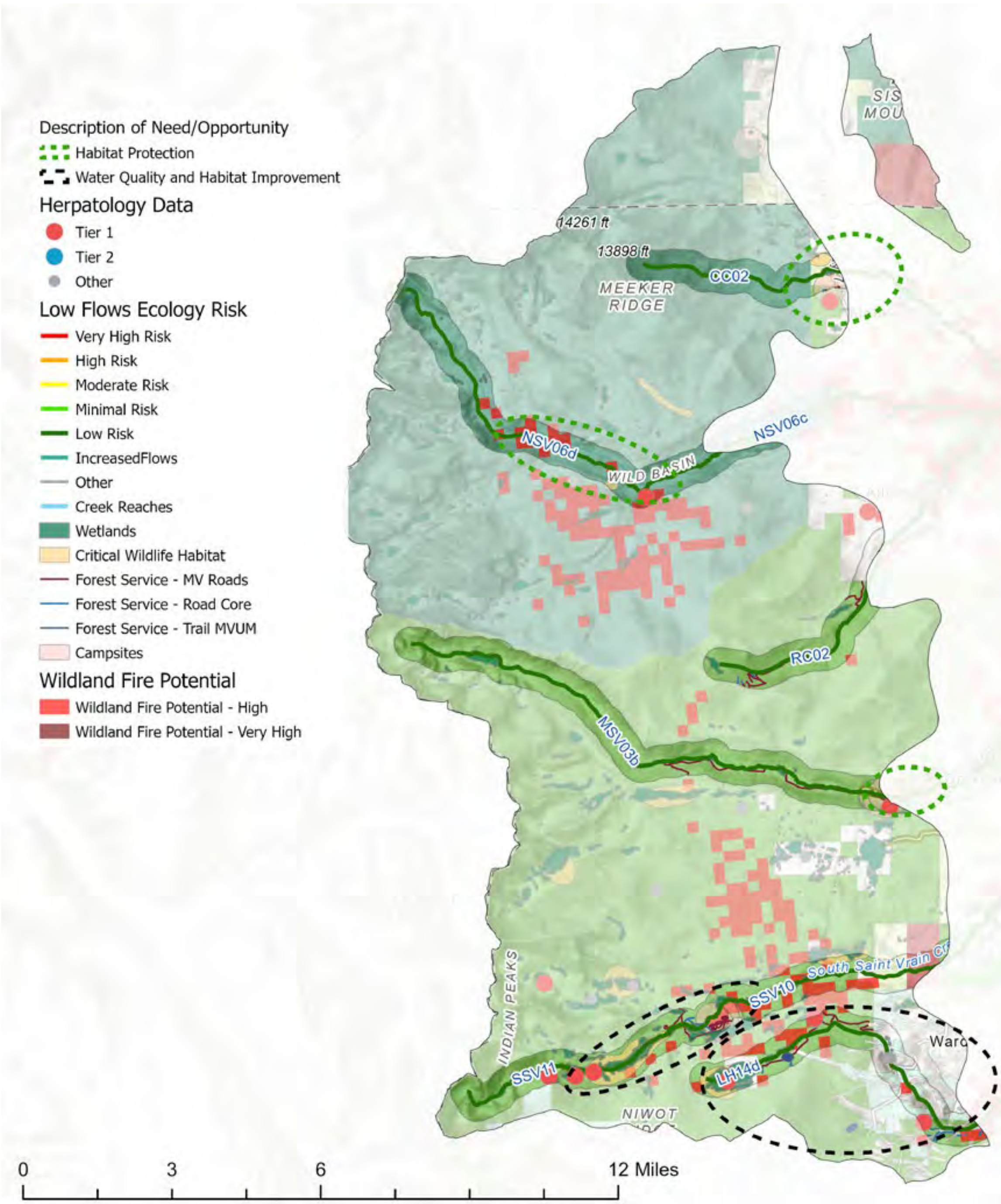


Figure 6.1 Examples of Potential Opportunity Areas in Alpine and Subalpine Zone

CANYONS AND FOOTHILLS OPPORTUNITY AREAS

In the canyons and foothills, opportunity areas include reaches with high quality habitat that would benefit from protection as well as reaches with impaired flows and impaired water quality that need improvement. Most of the land has high to very high risk of forest fire and is publicly (federally) owned, including City owned property at Button Rock Preserve, Boulder County and City owned open space. There is private property interspersed in valleys and throughout most of Left Hand canyon. Opportunity areas shown for North St. Vrain (NSV01 to NSV04) would benefit from flow enhancement and water use management for recreation. Middle St Vrain (MSV02-MSV03a) would benefit from habitat protection and enhancement and improved recreation management. South St. Vrain (SSV06 and SSV7) include habitat protection and flow/water use management, and SSV01-SSV03 opportunities are focused on habitat restoration and ditch diversion improvements.

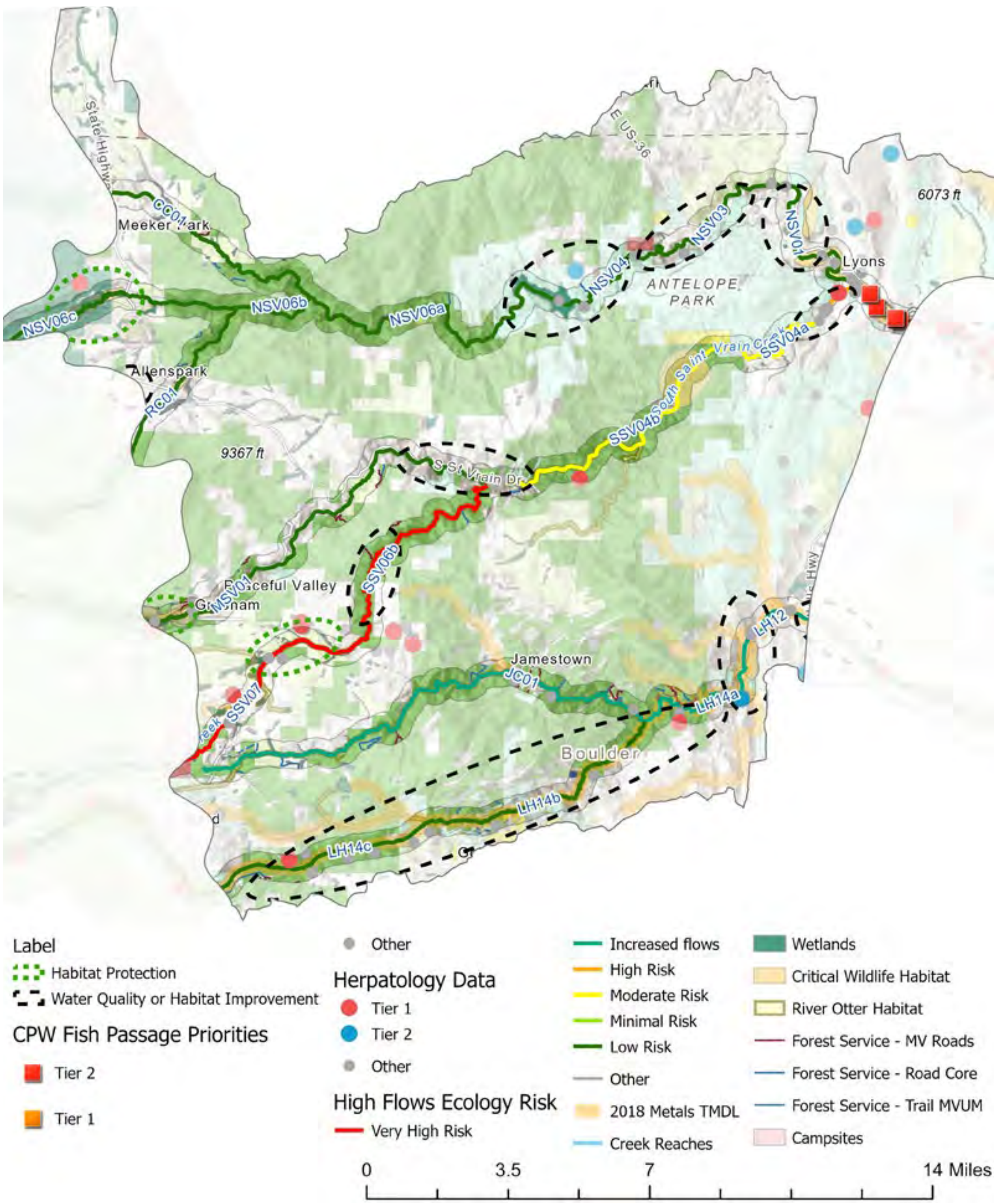


Figure 6.2 Examples of Potential Opportunity Areas in Canyons and Foothills Zone

TRANSITION ZONE OPPORTUNITY AREAS

Opportunity areas in the transition zone (Figure 6.3) are found where altered flows pose high to very high-flow ecology risks, areas that support focal wildlife species or critical habitat, reaches with good to fair floodplain connectivity but poor vegetation (to be improved), impaired water quality areas, and/or reaches where additional floodplain grading is feasible and would improve connectivity. This zone is transitional habitat between warm and cold-water aquatic life zones for small native fish species of concern. Critical wildlife habitats including riparian areas for threatened Preble's Meadow Jumping Mouse, and historical amphibian and reptile habitat have been mapped for Northern Leopard Frog (SV & LHC), Couche's spadefoot (LHC) & native snakes. Floodplain connectivity is often limited. Water quality impacts include metals and pH in Left Hand Creek and E.coli in Dry Creek and St. Vrain Creek .

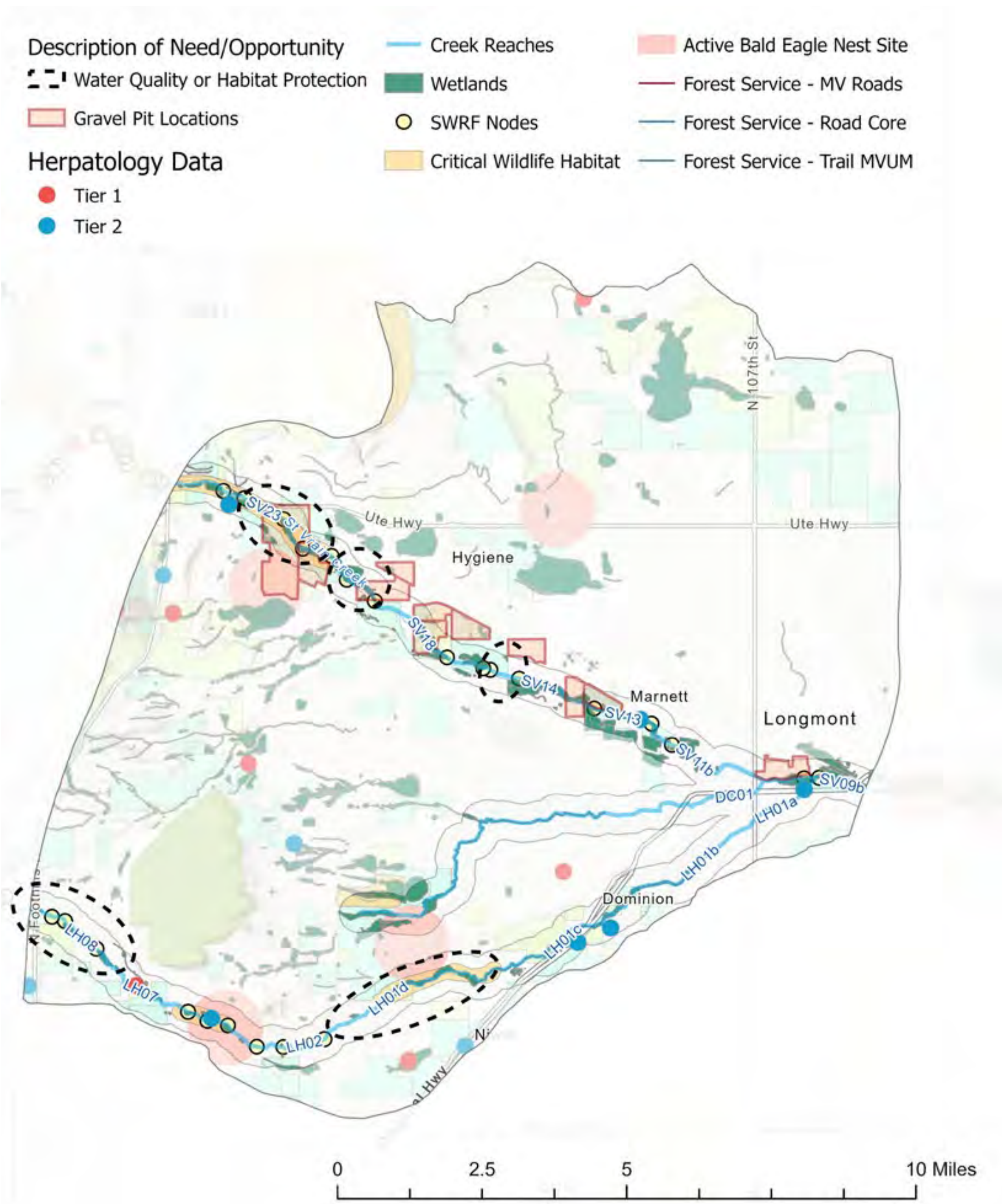


Figure 6.3 Examples of Potential Opportunity Areas in Transition Zone

PLAINS ZONE OPPORTUNITY AREAS

Opportunity areas include reaches with good to fair floodplain connectivity; naturally broad, meandering channels; reaches with good vegetation that need to be protected; areas where poor vegetation can be improved and reaches where floodplain grading for connectivity improvement is feasible. Altered flows impact riparian and other river functions because of excess erosion, inadequate high flows, deposition, and invasive species encroachment. Habitat for a wide range of species is present including warm water habitat for diverse native fish species, approximately six bald eagle nests, wild turkey and riparian birds, and roughly 20 reptile species. The diversions at Goosequill pump station and Last Chance Ditch are priority fish passage locations per CPW. Invasive riparian trees include tamarisk, Russian olive, and crack willow, which Weld County has treated in past. Oil and gas development is widespread. The entire reach has E. coli impairments and nutrient concerns (high nitrogen), with sources unknown but likely from Boulder Creek inflows, wastewater treatment, stormwater, and agricultural runoff.

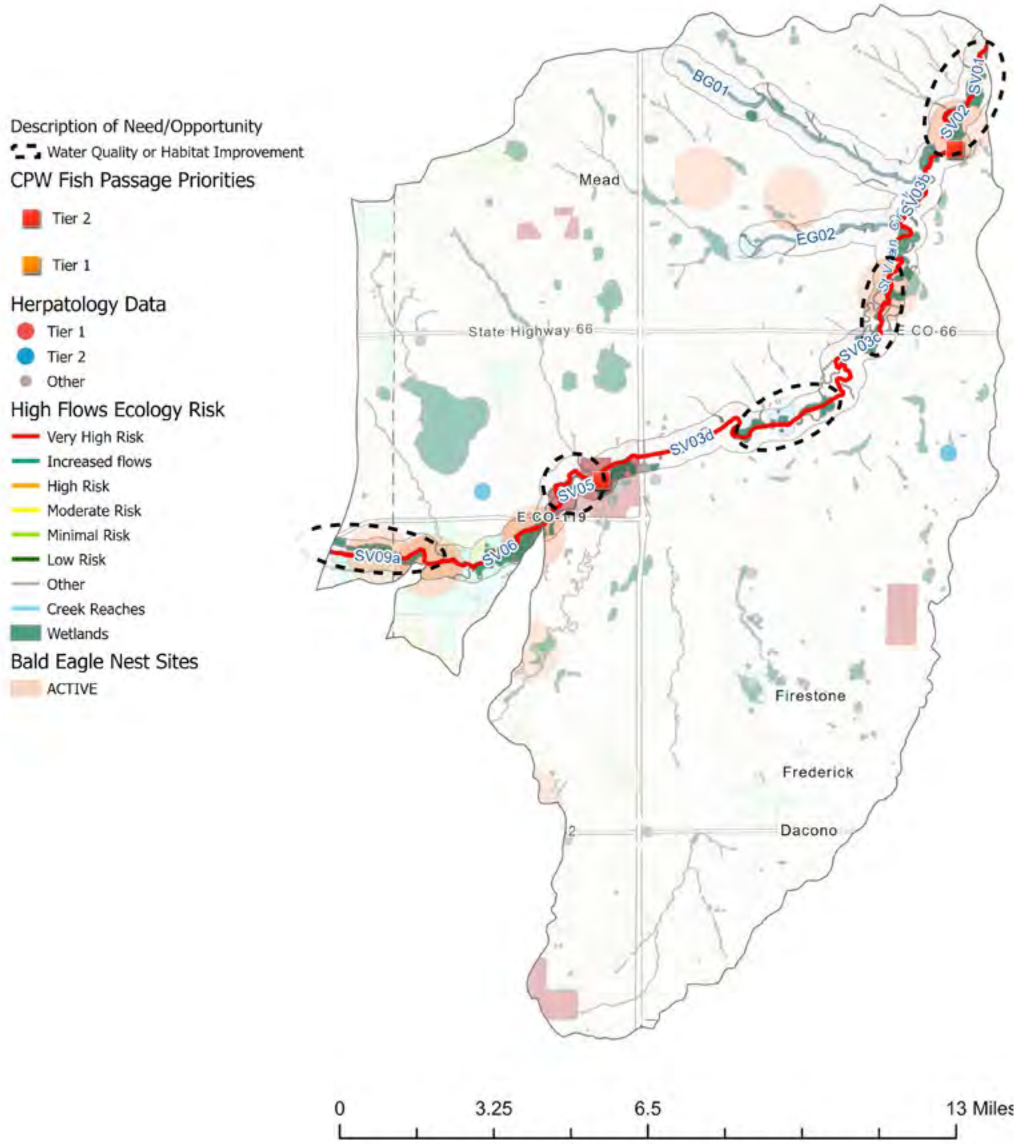


Figure 6.4 Examples of Potential Opportunity Areas in Plains Zone

Section 7 – Next Steps

Next steps include: 1) project coordination; 2) initiatives to be overseen by stakeholders, and; 3) SMP Phase 2 tasks. These steps are intended to support flexible planning, creative problem solving, and ongoing communication that will be essential for protecting the quality of life of the region in the face of changing population, climate impacts and water and land uses.

7.1 PROJECT COORDINATION

To maintain momentum, stakeholder leadership groups should be convened to focus on the desired conditions for each of the topical areas: Flow, Habitat, Water Quality, and Water Management. Each group should include at least one overlapping representative and agricultural producer/representative. Each group should seek to establish a feasibility project through continued collaboration, convening of subject experts, identification of data needs, and consensus building to determine priority projects for implementation. Once priorities are established, group tasks should focus on setting up a communication plan to share information in a timely manner, review and approve feasibility project scopes, and development of a funding plan for pilot project implementation.

7.2 INITIATIVES

The tables below present potential initiatives for implementation with a "road map" for both near-term planning actions and projects (1-5 years), and mid-term to longer term approaches (5-15 years or more). These actions and projects will take time and should not be rushed. Ultimately, the initiatives could demonstrate how thorough stream management planning can assist with better financial planning and fundraising, partner coordination, more effective on-the-ground solutions, and better communication of information to guide decisions and track progress.

INITIATIVE 1: FLOW MANAGEMENT

Strategies

- Fill data gaps and develop the framework for enhancing stream flows
- Establish reservoir operation agreements

Leadership

- Form *Streamflow Advisory Group* core technical team with representatives from multiple entities. Potential participants include: SVLHWCD, City of Longmont, Boulder County, Trout Unlimited, CPW, Left Hand Watershed Center, Highland and Oligarchy Ditches, Left Hand Ditch Co. and gravel companies *Proposed Initiative Champion: SVLHWCD*

Implementation

Near-Term

Secure funding for Phase 2 in-depth planning for the following potential projects:

- Flow studies should include refining preliminary flow targets and evaluating the potential of water rights and strategies to meet preliminary targets for low flows. The feasibility assessment may include a "string of pearls" concept for St. Vrain Creek. Conduct pilot project to test scenarios if funding allows for it.
- Evaluation of reservoir operation scenarios to address high flows (i.e., every 2-5 years) in at-risk reaches. Scenario development should focus on "highest practical" alternatives under range of year types and representing reasonable future condition to improve flow regime. Preliminary flow targets can be used for initial evaluation. Parallel effort should refine flow targets for recreation and habitat based on reach-scale determination of desired conditions for channel and floodplain connectivity.

Long term

Using the outcome of the Phase 2 feasibility assessment and reservoir operation evaluation:

- Establish *Voluntary Low-Flow Agreement Program.*
- Establish *Pilot, Voluntarily Cooperative Reservoir Operation Agreement* to test hydrologic scenarios and logistics. Follow-up feasibility analysis should revise agreement based on pilot study outcome, refined targets, and consideration of potential exchanges needed to reduce water losses in downstream irrigation ponds and reservoirs from increasing evaporation due to warming temperatures.[1]
- Establish coordinated management program (could include St. Vrain Creek management coordinator) to oversee and review monitoring data and adjust management and agreements as needed.

Opportunity Areas (See also Appendix G)

- Transition Zone reaches where baseflows pose a significant flow-ecology risk such as St. Vrain Creek, SV 17-SV 20 between Oligarchy & Niwot diversions
- Canyon/Foothills and Transition zone reservoirs. Example: Button Rock Dam for St. Vrain Creek Lyons Whitewater Park

1. Releases from Button Rock are diverted to the North pipeline by City of Longmont to maintain quality of raw water supply and increase treatment efficiency of Nelson Flanders Water Treatment Plant, i.e. the alternative of keeping water in the river increases sediment loading.

INITIATIVE 2: HABITAT RESTORATION AND PROTECTION

Strategies

- Restore habitat and floodplain connectivity
- Protect wetland and riparian buffers

Leadership

Form *Habitat and Floodplain Management Group* core technical team with representatives from multiple entities. Potential participants include: USFS, SVLHWCD, City of Longmont, Weld County, Boulder County, Trout Unlimited, CPW and Left Hand Watershed Center, agricultural liaison. Consider other participants such as the NPS and private landowners.

Implementation

Near-Term

As part of Phase 2 SMP:

- Build on the community science program started by the Left Hand Watershed Center with a focus on BMPs to promote the ethics of community stewardship.
- Further evaluate additional wildlife and biological Indicators and develop specific thresholds for action by zone based on additional monitoring or research by supporting the Left Hand Watershed Center's Adaptive Management at-scale project.
- Prioritize focal wetland and riparian protection areas in unconfined stream reaches that aid in flood retention and sediment deposition. Where possible, create pathways for reintroducing beaver populations or the installation of Temporary Wood Grade Structures (TWiGS) to encourage complex channel morphologies.
- Conduct more detailed assessments of habitat and infrastructure in identified opportunity areas where stresses can be addressed to improve conservation targets, e.g. through fish passage modifications
- Create and promote adoption of basin-wide "creek good neighbor program". Include outreach and education for recreation impacted areas.
- Conduct pilot habitat restoration project in area impacted by recreation with USFS.

Long term

- Develop and test prototype land management agreements for floodplain and buffer protection, which use financial incentives for corridor easements and restoration projects to improve flood resiliency for public safety, habitat and water quality.
- Create funding plan to increase financing to compensate landowners for improved floodplain management. Track improvements and economic benefit-costs of program.

Opportunity Areas (See also Appendix G)

- In alpine/subalpine and canyon/foothills zones, large wetland complexes and open valleys, such as upper South St. Vrain Creek, particularly with critical or historic habitat for amphibians of concern.
- In transition and plains zones, approximately 10 locations for fish passage and riparian enhancements.

INITIATIVE 3: WATER QUALITY IMPROVEMENTS

Strategies

- Increase project implementation
- Enhance water quality monitoring

Leadership

- The Keep it Clean Partnership and the Left Hand Watershed Center, through their new Adaptive Management at-scale project are leading efforts in the basin. Support those leaders and actively engage other potential entities such as Trout Unlimited, SVLHWCD, Left Hand Water District and its SWPP contributors such as CO Rural Water Association, USFS, CDPHE and CO Division of Reclamation, Mining, and Safety to increase participation.

Implementation

Near-Term

- Work with the Keep it Clean Partnership and the Left Hand Watershed Center's adaptive management efforts to stay up to date on reclamation progress (especially status of Captain Jack mine), monitoring plans, data management and education and outreach efforts related to metals and E. coli issues for the planning area.
- Initiate/support a pilot demonstration program for Best Management Practices to improve the water quality of urban and agricultural runoff.
- Support the Left Hand Watershed Center in their role assisting the EPA and CDPHE's efforts to remediate the Captain Jack Mine and other priority sites and provide input to agencies to support implementation.

Long term

- Increase education to reduce nutrient loading from urban and agricultural lands.
- Participate in planning for wastewater treatment facility improvements.
- Increase aquatic nuisance species outreach with the recreation community.

Opportunity Areas (See also Appendix G)

- Alpine and canyon reaches of Left Hand and James Creeks.
- Transition and plains reaches of St. Vrain Creek downstream of Hygiene and Dry Creek.

INITIATIVE 4: WATER USE & MANAGEMENT (INFRASTRUCTURE)

Strategies

- Manage diversion structure, ditch improvements, and irrigation practices
- On-channel measuring devices
- Fish passage
- Impediment removals and coordinated management

Leadership

- Form *Infrastructure & Water Use Advisory Group* with representatives from City of Longmont, Boulder County, ditch companies, the Left Hand Watershed Center, Trout Unlimited, CPW, DWR, and representatives from the recreation (fishing) community and agricultural producers/water users.

Implementation

Near-Term

- Coordinate funding and timing of infrastructure improvement projects.
- Build capacity for ditch companies and resource managers who are responsible for financing both streambank maintenance and infrastructure improvements to find co-funders that support other multiple benefits. These include diversion measurement devices, headgate improvements to manage sediments and sand, fish passages, and ditch and on-farm efficiencies.

Long term

- Develop long term mechanisms for smart financing and coordinated stream and infrastructure improvement plans to reduce financial burdens of ditch assessments and to streamline permitting and infrastructure improvements.

Opportunity Areas (See also Appendix G)

- Transition Zone, St. Vrain SV 17-SV 20

7.3 SMP PHASE 2 TASKS

Phase 2 will refine the potential topics and targets described in this Phase 1 Plan, select appropriate strategies, initiate planning actions and pilot projects, and support a data-driven stream management program. Uncertainties and challenges to be addressed in Phase 2 include feasibility analyses of alternatives, data gaps, logistics of implementation, and adaptive management planning. Recommended tasks and deliverables to complete the SMP and support long-term policies, financial planning, technology, and management improvements are listed below.

Task 1. Establish Steering Committees & Ongoing Stakeholder Engagement

Deliverables:

- Communication Plan for Phase 2 SMP and beyond

Task 2. Address Data Gaps and Refine Measurable Objectives & Targets

Deliverables:

- Additional assessment of reach-specific channel conditions
- Refined measurable objectives and flow targets

Task 3. Feasibility Projects Through Continued Collaboration of Subject Experts

Deliverables:

- List of priority projects
- Funding plans and timelines for pilot project implementation
- Enhanced Streamflow Feasibility Study and Water Rights Review. Could include point flow model revisions to refine/test reservoir release scenarios
- Cooperative Reservoir Management Feasibility Study

Task 4. Conduct Pilot Projects

Deliverables:

- Pilot test results for release scenarios to monitor river conditions compared to model and baseline conditions
- Infrastructure rehabilitations and upgrades
- Habitat restorations

Task 5. Identify Potential Alternative Actions & Priorities

Deliverables:

- Structure assessment, high-level concepts for improvements and alternatives analysis

Task 6. Implementation Plan for Priority Actions/Monitoring and Adaptive Management.

Deliverables:

- Project needs and preliminary cost estimates
- Monitoring and adaptive management plan

7.4 CONCLUSION

Maintaining and improving water management and the health of St. Vrain and Left Hand Creeks in the face of mounting pressures will require focused leadership, data collection, selection of agreed upon and appropriate strategies, pilot projects, policies, and agreements as identified in this Plan. Specifically, the following key efforts should be further developed, along with other recommendations herein, as part of Phase 2:

- Flows: Conduct feasibility assessments of stream enhancements and reservoir operating agreements to address reaches with high to very high ecological risks for environmental flow as well as recreation considerations.
- Habitat: Protect high-quality riparian and wetland habitat with a focus on protecting and enhancing upper watershed unconfined meadows from recreation impacts, fire and climate change, and add conservation and restoration measures in opportunity areas, particularly on private lands. Restore aquatic and riparian habitat in high ecological risk locations slated for flow enhancements and priority fish passage improvements.
- Water quality: Increase implementation of the 2015 Watershed Plan and address data gaps associated with metals, E. coli and other pollutants.
- Water use management: Improve diversion structures, ditch and on-farm efficiency; including metering and measuring, and feasibility assessments for improved delivery.

If implemented, the strategies in this SMP will advance water stewardship for multiple benefits supported by stakeholders within the watershed.

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