# Cache la Poudre River Watershed-Based Plan

April 2020

(National Park Service, 2019)

COALITION FOR THE POUDRE RIVER WATERSHED

## Acknowledgements

CPRW is a 501(c)3 nonprofit based in Fort Collins, CO. Our mission is to improve & maintain the ecological health of the Poudre River watershed through community collaboration. The Cache la Poudre Watershed plan would not be possible without the support from our partners & stakeholders. Our stakeholders have expertise in restoration science, ecology, collaboration, forestry, water quality, water supply management, and river management. Our stakeholder committees include representatives from the US Forest Service, Colorado State University, Larimer County, Rocky Mountain Research Station, City of Fort Collins, City of Greeley, Colorado State Forest Service, Town of Windsor, and University of Northern Colorado among others.

Colorado Department of Public Health & Environment provided technical and administrative support during this process. LRE Water provided technical analysis and consultation services, without which this project would not have been possible.

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**Acronyms**

AGWA - Automated Geospatial Watershed Assessment
APEX - Agricultural Policy Environmental eXtender
BMP - Best Management Practice
CDPHE - Colorado Department of Public Health and Environment
CDSN – Colorado Data Sharing Network
CLP – Cache la Poudre River
CPRW - Coalition for the Poudre River Watershed
CSU – Colorado State University
CWA - The Clean Water Act
DEM - Digital Elevation Model
EPA – U.S. Environmental Protection Agency
FEMA - Federal Emergency Management Agency
GRAIP_Lite - Geomorphic Road Analysis and Inventory Package Lite
HUC – Hydrologic Unit Code
KINEROS2 - Kinematic Runoff and Erosion Tool
NHD – National Hydrography Dataset
NLCD – National Land Cover Database
NTT - Nutrient Tracking Tool
STEPL – Spreadsheet Tool for Estimating Pollutant Load
SWAT - Soil and Water Assessment Tool
TMDLs - Total Maximum Daily Loads
USFS - United States Forest Service
USGS – United States Geological Survey
USLE - Universal Soil Loss Equation
WARMF - Watershed Analysis Risk Management Framework
WEPP - Watershed Erosion Prediction Project
WQCC - Water Quality Control Commission
WQP – Water Quality Portal
WWTP – Wastewater Treatment Plant

# 1 Executive Summary

The Cache la Poudre (CLP) watershed is an important drainage in the Front Range of Colorado. It spans over 1,200,000 acres and is home to over 400,000 people. The watershed emerges from the headwaters within the Roosevelt National Forest and drains down to the urban areas of the Front Range; farming, ranching, recreation and fast-growing cities including Fort Collins and Greeley are all key stakeholders within the watershed.

Given the large extent of the watershed and the range of watershed characteristics, water quality conditions and threats, the goal of this plan is to create a planning foundation for future implementation of watershed health restoration activities that will protect and increase the resilience of the CLP watershed. To support this goal, this project focused on developing a planning and analysis framework that can be used to support prioritization and future implementation of restoration projects. The framework was then applied to two pilot sub-drainages, North Fork Lone Pine Creek (COSPCP08) in the headwaters, and Sheep Draw (COSPCP13a) in the lower basin. Figure 1-1 illustrates the framework presented in this plan.

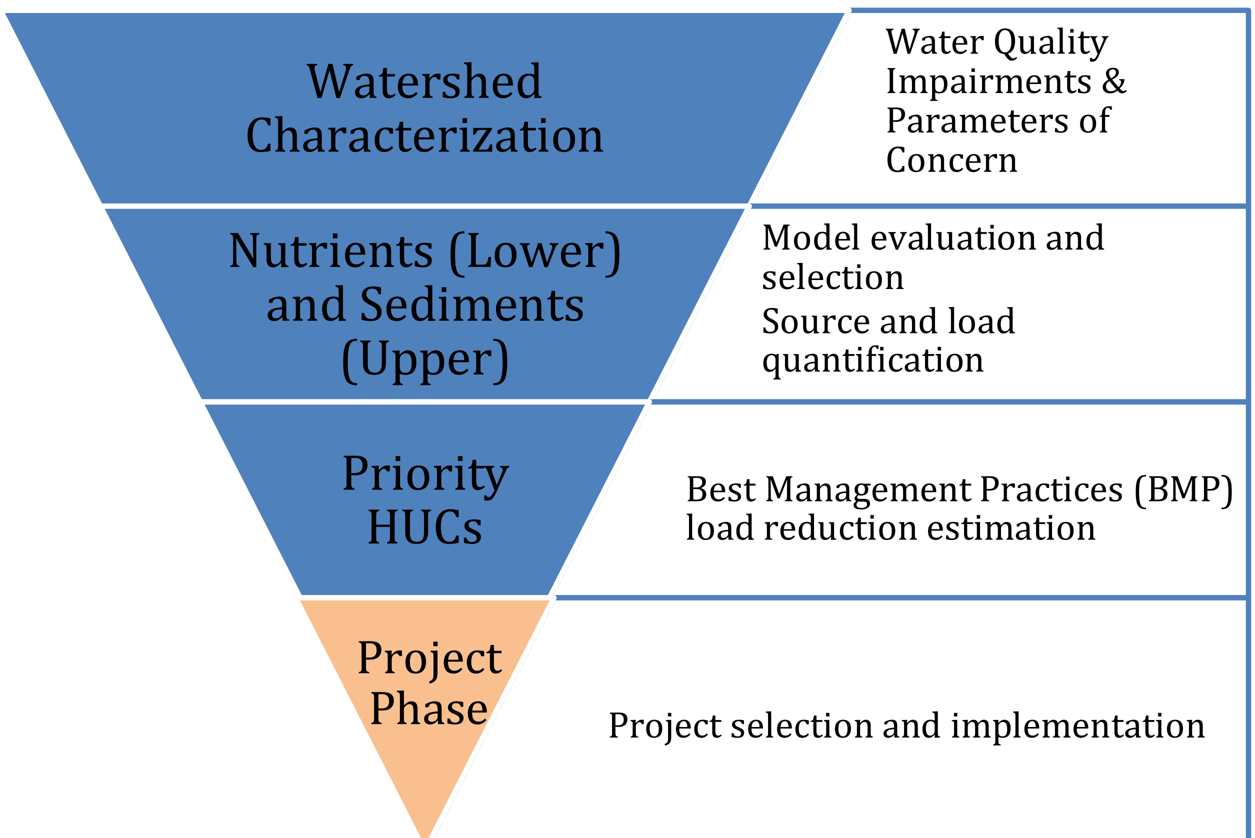



*Figure 1-1 CPRW Watershed Plan Analysis Framework*

The intent of this plan is to be flexible, scalable and expandable to other areas and parameters of concern in the watershed as future priorities arise over time. To that end, this planning effort included the development of several interactive Watershed Planning support tools that can be leveraged for future watershed planning, analysis, and implementation activities in other parts of the watershed.

**CPRW Interactive Watershed Planning Support Tools Created Under the 319 Grant**

- **Spatial Database:** An ArcGIS-based geodatabase with a range of spatial data covering the span of the watershed. This geodatabase provides a centralized platform for compiling watershed spatial data and an interactive tool that CPRW can utilize to analyze and investigate spatial data throughout the watershed.
- **Water Quality Dashboard:** A Google Data Visual Studio data exploration tool that enables CPRW to efficiently access, filter, visualize, analyze and export water quality data compiled from national, state and regional sources.
- **BMP Load Reduction Calculators:** An Excel-based tool that leverages the STEPL spreadsheet model functionality and results to estimate the load reductions of selected BMPs within a specific watershed.

Watershed-wide water quality impairments were identified using the EPA 303(d) list and a water quality assessment based on data compiled from national, state and local databases towards which the CPRW can focus restoration efforts, including but not limited to:

- Sediments
- Nutrients
- Dissolved Metals
- Temperature
- *E. Coli*

In addition, CPRW identified the following issues of concern in the watershed through stakeholder meetings and surveys:

- Nutrients (Phosphorus, nitrogen)
- Sediment
- High temperature
- Litter/trash in the river
- E. *coli*
- Forest health- wildfires
- Flooding
- State highways
- County & forest roads
- Septic systems
- Forest health- insect disease/mortality
- Recreation
- Grazing/agriculture
- Storage tanks
- Water Wells

CPRW and its stakeholders selected nutrients in the lower CLP and sediments in the upper CLP as the parameters of interest for the framework illustration and the potential focus of priority projects. In particular, sediments from roads were selected as a focus for quantification in this plan because research has shown that forest roads are a primary source of long-term sediment delivery in forested headwaters, such as those in the Upper CLP, and there are few road-erosion studies from Colorado. Even though high intensity wildfires are generally considered to be the most significant to water quality in the headwaters (City of Fort Collins, 2016), those events are episodic, have been well studied, and there are significant management efforts currently being directed at reducing the threat they pose to water quality in the Poudre.

The Spatial Database and Water Quality Dashboard interactive tools can be leveraged to implement projects focusing on other parameters for future projects.

A range of watershed models were evaluated to identify those that could be applied to quantify sediments and nutrients loads and sources; STEPL was selected to quantify sources and associated loads of nutrients and sediments from sources including cropland, pastureland, urban areas, forests and feedlots. GRAIP_Lite was selected to evaluate sediments from roads. and

The STEPL tool estimated that approximately 425 tons of nutrients are produced from nonpoint landuse-based sources in the lower CLP. Of the sources considered, cropland and pastureland contributed the majority of nutrients throughout the area considered. On a HUC12 basis, STEPL estimated that nutrient loading ranged from approximately 12 to 70 tons per year (approximately 1 – 4 pounds per acre per year.)

The GRAIP_Lite tool estimated that 1,500 tons of sediments are delivered from US Forest Service (USFS) roads per year within the upper CLP, an average of approximately 5 pounds per acre of land and 2.2 tons per kilometer of road per year throughout the evaluation area. Model results are presented on a HUC12 basis to identify potential areas with relatively higher sediment loading from roads throughout the watershed. GRAIP_Lite estimated that HUC12 watersheds in the CLP delivered from 0 to 220 tons per year (0 – 15 pounds per acre of land and 0 to 5 tons per kilometer of USFS road per year).

CPRW selected North Fork Lone Pine Creek in the upper CLP and Sheep Draw watershed in the lower CLP as HUC12 watersheds as the potential implementation targets for further evaluation during the project phase. Although these watersheds were not among the highest contributors of sediments and nutrients based on modeling results, they were selected based on stakeholder input, the ability to leverage existing work in the area, partnering opportunities and other logistical considerations.

Sheep Draw and North Lone Pine Creek-specific BMP Load Reduction Calculators were built using the STEPL model as a “backend” analysis tool. These calculators estimate the nutrient and sediment load reductions from a range of CPRW-preferred BMPs based on the number of acres on which the BMP is applied. The calculators allow CPRW to estimate the net and relative percentage reduction of nutrient and/or sediment loads, as well as to compare different alternatives.

CPRW will use these tools and evaluation as it works with stakeholders and partners to select projects, seek out additional funding, and implement BMPs in the next phase of this project.

The United States Environmental Protection Agency (EPA) requires all implementation, demonstration, and outreach-education projects funded under Section 319 of the federal Clean Water Act to be supported by a Comprehensive Watershed Plan that includes nine listed elements. The nine EPA required elements, and the location of the plan component addressing these elements are listed below.

*Table 1-1 EPA Watershed Plan Elements and location within the plan*

| Element | Location | Current Status |
|---|---|---|
| 1) An identification of the causes and sources | 5.2, 5.3 | Completed watershed-wide for defined parameters; more detailed analysis done for two subwatersheds. |
| 2) An estimate of the load reductions expected for the management measures | 6.2.2, 6.3.2 | Watershed-specific tools created for two subwatersheds; tool methodology can be applied to other subwatersheds. |
| 3) A description of the NPS management measures that will need to be implemented to achieve the load reductions and an identification of the critical areas in which those measures will be needed to implement this plan. | 6.1 | Management measures identified and prioritized; tools created to estimate load reductions; final management measure selection and load reduction calculations will be project specific and cannot be developed until the project phase. |
| 4) An estimate of the amounts of technical and financial assistance needed; associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. | 7.1.1 | Guidelines are provided. BMP cost estimate information is provided for select BMPs. Project cost estimates will be project specific and cannot be developed until the project phase. |
| 5) An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented. | 7.1.2 | Established information/education measures will be adapted to include project implementation activities. |

| | | |
|---|---|---|
| 6) A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious. | 7.1.3 | Guidelines are provided. An implementation schedule will be project specific and cannot be developed until the project phase. |
| 7) A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented. | 7.1.3 | Guidelines are provided. Milestones will be project specific and cannot be developed until the project phase. |
| 8) A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised. | 7.1.3 | Guidelines are provided. Criteria will be project specific and cannot be developed until the project phase. |
| 9) A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (8) immediately above. | 4.3.1, 7.1.4 | Guidelines are provided. Monitoring will be project specific and cannot be developed until the project phase. Current water quality monitoring efforts across the watershed are also highlighted. |

# 2 Introduction

## 2.1 CPRW Mission and Background of CPRW

The Coalition for the Poudre River Watershed's mission is to improve and maintain the ecological health of the Poudre River Watershed through community collaboration. CPRW was formed as a result of the Hewlett Gulch & High Park Fires that occurred during the summer of 2012 and burned 95,172 acres of the upper watershed. Severe erosion, higher than normal runoff volume, and debris flows all contributed to extreme degradation of water quality in the mainstem and tributaries of the Cache La Poudre Watershed. This in turn impaired not only instream ecological health but also threatened critical water supply infrastructure. The Upper Poudre River Watershed supplies drinking & industrial water to much of the northern Front Range and is the principal source of raw water for the cities of Fort Collins and Greeley. After the fire, sediment and turbidity levels prevented the cities from using the Poudre as a source of drinking water supply, particularly after summer storm events.

The High Park Fire was a call to action for many organizations in Larimer County. Shortly after the fires began, a group of natural resource agencies, nonprofits, representatives from the cities of Fort Collins, Greeley, Larimer County local businesses, and individuals gathered to discuss how they could work together to rehabilitate the lands affected by the burn. Initially formed as an informal network known as the High Park Restoration Coalition, the group was successful at identifying the top priorities for restoration efforts, finding funding to implement the plans, and training volunteers to help with implementation. Based on the success of these early efforts, in May 2013, members of the High Park Restoration Coalition organization evolved into a formal nonprofit coalition, the Coalition for the Poudre River Watershed (CPRW), with the goal of providing leadership and coordination for the collaborative stewardship of the Cache La Poudre River Watershed.

In 2015, CPRW received funding through the Community Block Development Grant for Disaster Recovery program to work with stakeholders from United States Forest Service, Colorado State Forest Service, Rocky Mountain Research Station, The Nature Conservancy, Colorado State University, Larimer County, City of Fort Collins, City of Greeley, Rocky Mountain Flycasters, and Wildlands Restoration Volunteers to develop a Watershed Resiliency Plan for the Upper Poudre Watershed. This analysis focused on the headwaters of the Poudre starting from the canyon mouth. The analyses identified 7th level HUCs that were least resilient to hazards like wildfires and floods. Stakeholders worked together to define the watershed values (forest, river health, community values, and water supply) that were included in the analysis and chose healthy upland forests, resilient river corridors and water supply. The analysis used existing spatial data to rank 7th level HUCS from high resiliency to low resiliency. The intent of the plan was to help CPRW focus our implementation efforts to areas where restoration would have the greatest benefit to protect key watershed values.

While CPRW's initial efforts were focused on the headwater areas of the Poudre watershed, in 2016 CPRW expanded its reach to include the entire watershed from headwaters to the confluence with the South Platte River. CPRW received additional funding through the CDBG-DR program to complete a Flood Recovery & Resiliency Master Plan for the lower Poudre ("Lower Poudre Plan"). With the initiation of the lower Poudre Plan, CPRW is now officially working across the whole watershed. By building on the work we have started in the lower watershed, we believe we can increase collaboration and dialogue in this important watershed.

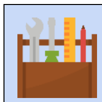
## 2.2 Project Goals and Objectives

The initial proposal for this plan was submitted in January 2014 with the goal of preventing water quality problems stemming from significant stressors like catastrophic wildfires to complement the Upper Poudre Prioritization and Resiliency Plan. In between the time that the proposal was submitted, and the project approved in early 2017 and initiated in 2019, CPRW was able to move forward with several projects, including:

- Upper Poudre Prioritization and Resiliency Plan- Completed in 2016
- Post-Fire Prioritization Plan- Completed in 2016
- Lower Poudre Flood Recovery and Resilience Master Plan and Sediment Transport Model- Completed in 2017

At the inception of this project, the plan was focused on the upper portions of the Cache la Poudre (CLP) River; however, in order to align with stakeholder input and priorities, the project was extended to also include the lower CLP. Given the large extent of the watershed and the variation of the range of watershed characteristics, water quality conditions, threats, the goal of this project is to create a ***planning foundation*** for future implementation of watershed health restoration activities that will protect and increase the resilience of the CLP watershed.

To support this goal, this project focused on developing a planning and analysis framework that can be used to support prioritization and future implementation of restoration projects. Selected HUC12s and associated parameters of concern are used to illustrate this framework: Nutrients in Sheep Draw in the lower CLP and sediments from roads in Lone Pine Creek in the Upper CLP are focused on a potential implementation targets. However, the intent of this initial effort is to be flexible, scalable and expandable to other areas and constituents of concern in the watershed as future priorities arise over time. To that end, this project included the development of several interactive tools that are called out throughout the document with the Toolbox icon.



The Toolbox icon identifies interactive Watershed Planning support tools that were developed for this initial planning effort and can be leveraged for future watershed planning, analysis, and implementation activities.

## 2.3 Stakeholder Concerns

Collaboration is core to CPRW's mission and is the primary tool used to plan and prioritize watershed needs and implement projects. CPRW has established stakeholder groups for both the Upper and the Lower watershed that meet regularly. Both the Upper and Lower Watershed Plans were developed based on input and guidance from both stakeholder groups and the local communities. During the Upper and Lower Poudre Master planning processes, CPRW held various community meetings and workshops that were open to the public. In addition, CPRW sent out a variety of surveys to gain a better perspective on stakeholder concerns and values across the watershed. Stakeholder concerns and values were incorporated into both the upper and lower Poudre focus areas and parameters of concern. Upper watershed concerns included: high severity wildfire, climate change, drought, development in the Wildland Urban Interface, flooding, and future water development projects among others. Concerns identified by the lower watershed stakeholders were sediment issues, flooding, erosion, development in the floodplain, water quality issues, and climate change.

As a part of the NPS-319 watershed planning process, CPRW also held stakeholder meetings to discuss the plan and distributed a survey specific to water quality and river health issues to stakeholders across the entire watershed to help identify their concerns and values. These surveys were general and included issues across both the upper and lower watershed.

A compiled list of concerns from the surveys are as follows:

- Nutrients (phosphorus, nitrogen)
- Sediment
- High temperature
- Litter/trash in the river
- E. *coli*

Other watershed threats and concerns have also been identified in the City of Fort Collins Source Water Protection Plan. The City worked with CDPHE and local stakeholders and compiled a potential contaminant inventory and other issues of concern that may impact drinking water sources and the watershed. The list of potential contaminants and issues of concern includes the following:

- Forest health- wildfires
- Flooding
- State highways
- County & forest roads
- Septic systems
- Forest health- insect disease/mortality
- Recreation
- Grazing/agriculture
- Storage tanks
- Water Wells

# 3 Watershed Characteristics

The Cache la Poudre (Poudre) Watershed is an important drainage in the Front Range. At 1,219,038 acres, it is one of the largest drainages in northern Colorado and is home to approximately 300,000 people. It is located in north central Colorado in both Larimer and Weld Counties. In its upper reaches, lies Colorado's only designated Wild & Scenic River. Thirty miles of the river are designated as “wild,” and 46 miles are designated as “recreational.” The upper Poudre watershed (above the canyon mouth) is approximately 565 square miles and is dominated by coniferous forests with less than four square miles of developed land. (City of Fort Collins 2016).

The river is 140 miles in length, starting from its headwaters in Rocky Mountain National Park to its confluence with the South Platte River (National Wild and Scenic Rivers System 2019). The river flows approximately 65 miles through the Poudre canyon, to 5,500 feet in elevation from its starting elevation of 10,800 feet. The watershed topography flattens below the canyon mouth as it moves into a plains river system. After the river leaves the canyon, it travels through the City of Fort Collins, Towns of Timnath and Windsor and the City of Greeley. The primary tributaries of the Poudre are the North Fork, Little South Fork Poudre and Joe Wright Creek. There are nine reservoirs and five trans-basin diversions in the upper watershed. The mainstem Poudre currently does not have any impoundments (City of Fort Collins 2016). At this time, there are two proposed reservoir expansion projects and one proposed reservoir project in the watershed. The two proposed reservoir expansion projects include Halligan Reservoir and Seaman Reservoir. Glade Reservoir is the proposed project that is a part of Northern Colorado Water Conservancy District's Northern Integrated Supply project.

In 2015, the City of Fort Collins (City) initiated an effort to gather data on the existing conditions of 24 miles of the mainstem Poudre River from Gateway Natural Areas until the river meets Interstate-25. The City developed the River Health Assessment Framework (RHAF) to clearly define the City's vision toward improving the health of the Poudre River, and guide the City's management efforts toward restoring and sustaining ecosystem functions and services. The RHAF methodology is built around indicators of the essential physical, chemical, and biological elements of the river ecosystem. Each indicator is described by several metrics that are measurable or observable aspects of the river ecosystem and translated into an A-F grading system. For the study area, the Poudre River received an overall grade of C. This grade indicates that while the river has been altered and degraded by a variety of stressors, it still supports a functioning river ecosystem (City of Fort Collins 2016).

Since 2015, CPRW has applied the RHAF to two other parts of the watershed, in partial form in the lower Poudre in 2017, and in the headwaters in 2019. The headwaters RHAF was completed in January 2020. CPRW modified the RHAF for the upper watershed, and the full assessment was completed on the mainstem, North Fork, South Fork, Joe Wright Creek. A more rapid, desktop-based assessment was completed on every perennial tributary in the upper watershed. Figure 3-1 illustrates the assessment approach and region. The overall grade of the upper watershed is a B. Stressors in the upper watershed include flow and other hydrologic alterations, roads/bridges and stream crossings, development and agriculture in the floodplain. P 1 draft complete next steps w stakeholders to integrate across basin

## State of the Upper Poudre Assessment Approach

**Assessment Types:** The Upper Poudre Watershed holds streams large and small. Streams were assessed in accordance with their relative influence on watershed health using one of three approaches. Each compatible assessment type varied in the amount of time and effort dedicated to evaluating a given reach of stream. The table below describes the assessment types, with the map showing the distribution.

| Assessment Type | Assessment Approach | Applicable Stream Type | Scope of Survey |
|---|---|---|---|
| **Type 1** | • Stream reaches holistically graded and assigned one health grade<br>• Assessments carried out using a mix of remote and field-based assessment | Minor, named tributaries | • 58 streams , totaling 510 miles in length<br>• 90% of the total length of streams evaluated.<br>• 1,045 individual reaches<br>• ~200 ground-truth points |
| **Type 2** | • Stream reach health evaluated based on nine indicators<br>• Assessments carried out using a mix of remote and field-based assessment | Tributaries of special interest to CPRW | • 43 miles of Elkhorn, Lone Pine and Beaver Creeks<br>• 46 individual reaches |
| **Type 3** | • Stream reach health evaluated based on nine indicators.<br>• Cover types within the historical extent of the riparian corridor mapped<br>• Assessments carried out using a mix of remote and field-based assessment. | Primary watershed drainages | • 172 mi. of the Cache la Poudre, La Poudre Pass Creek, Joe Wright Creek, South Fork of the Poudre, and North Fork of the Poudre<br>• 2,546 mapped riparian polygons<br>• Approximately 100 ground-truth points |

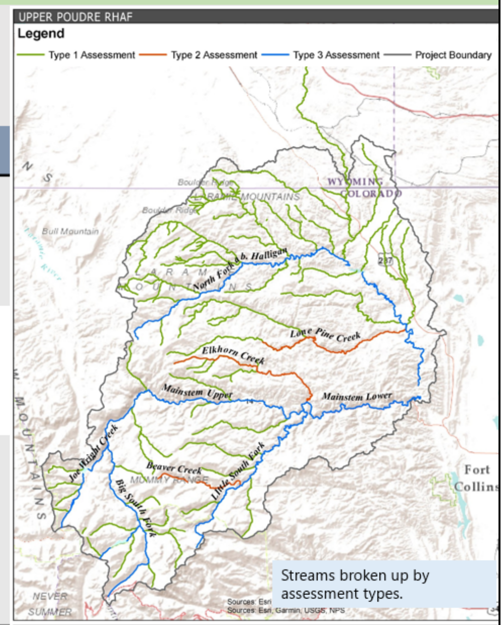



*Figure 3-1 State of the Upper Poudre RHAF Assessment Approach*

## 3.1 Project focus

For the purposes of this project, the upper watershed is defined as the headwaters in Rocky Mountain National Park to the canyon mouth. The lower watershed begins east of I-25 and extends until the Poudre reaches its confluence with the South Platte (Figure 3-2). As discussed in Section 2, this project focused on developing a planning and analysis framework that can be used to support prioritization and future implementation of restoration projects. The framework was then applied to two stakeholder-priority pilot sub-drainages that are targeted for potential future implementation projects: North Fork Lone Pine Creek (HUC12: 101900070602, stream segment COSPCP09_A) in the headwaters, and Sheep Draw (HUC12: 101900071004, stream segment COSPCP13a_A) in the lower basin (Figure 3-3). In addition, we focused the analysis on one nonpoint source constituent of concern within each watershed based on the multiple constituents of concerns identified in the water quality assessment, CPRW's resiliency plan and by watershed stakeholders.

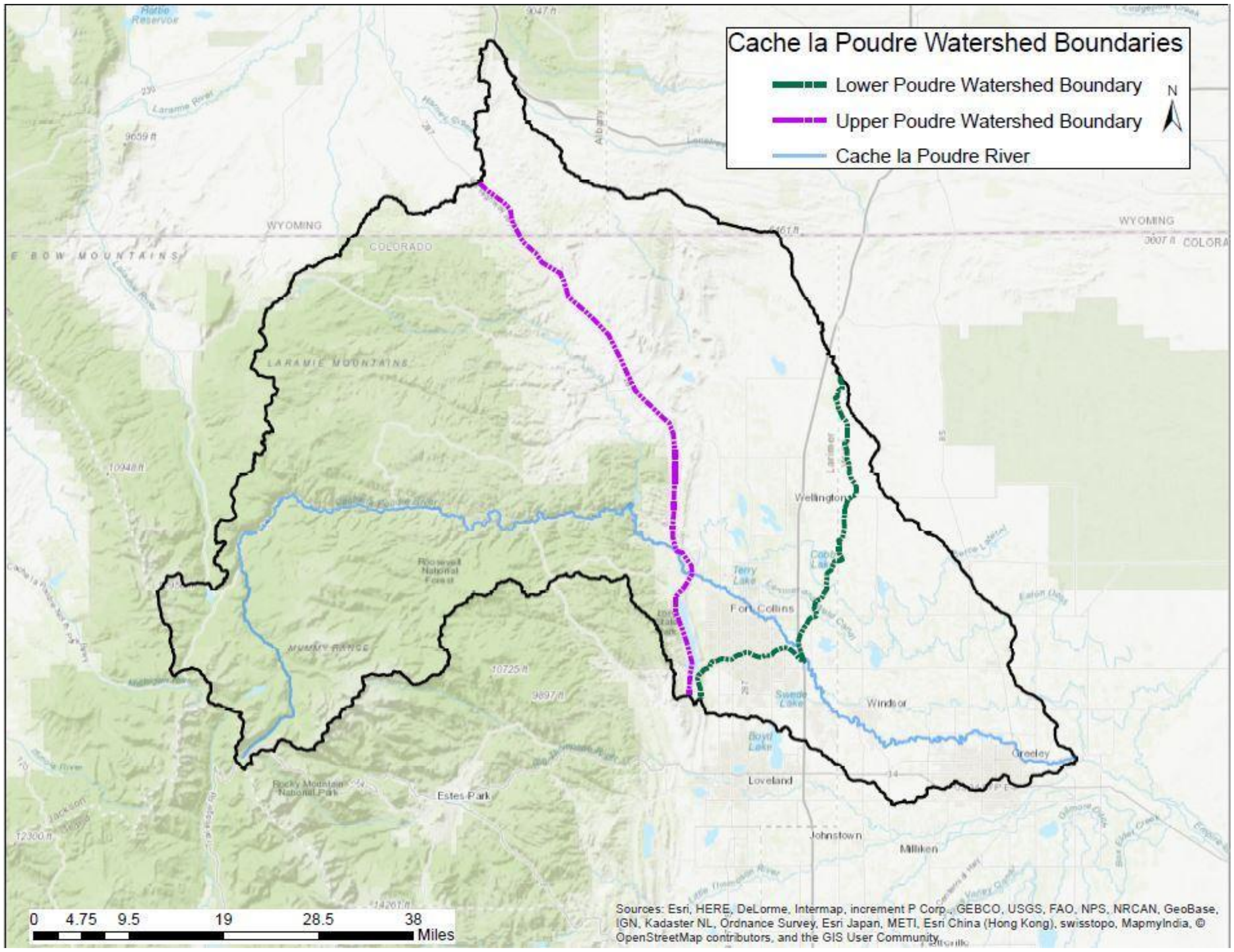



*Figure 3-2 Cache la Poudre Watershed Boundaries*

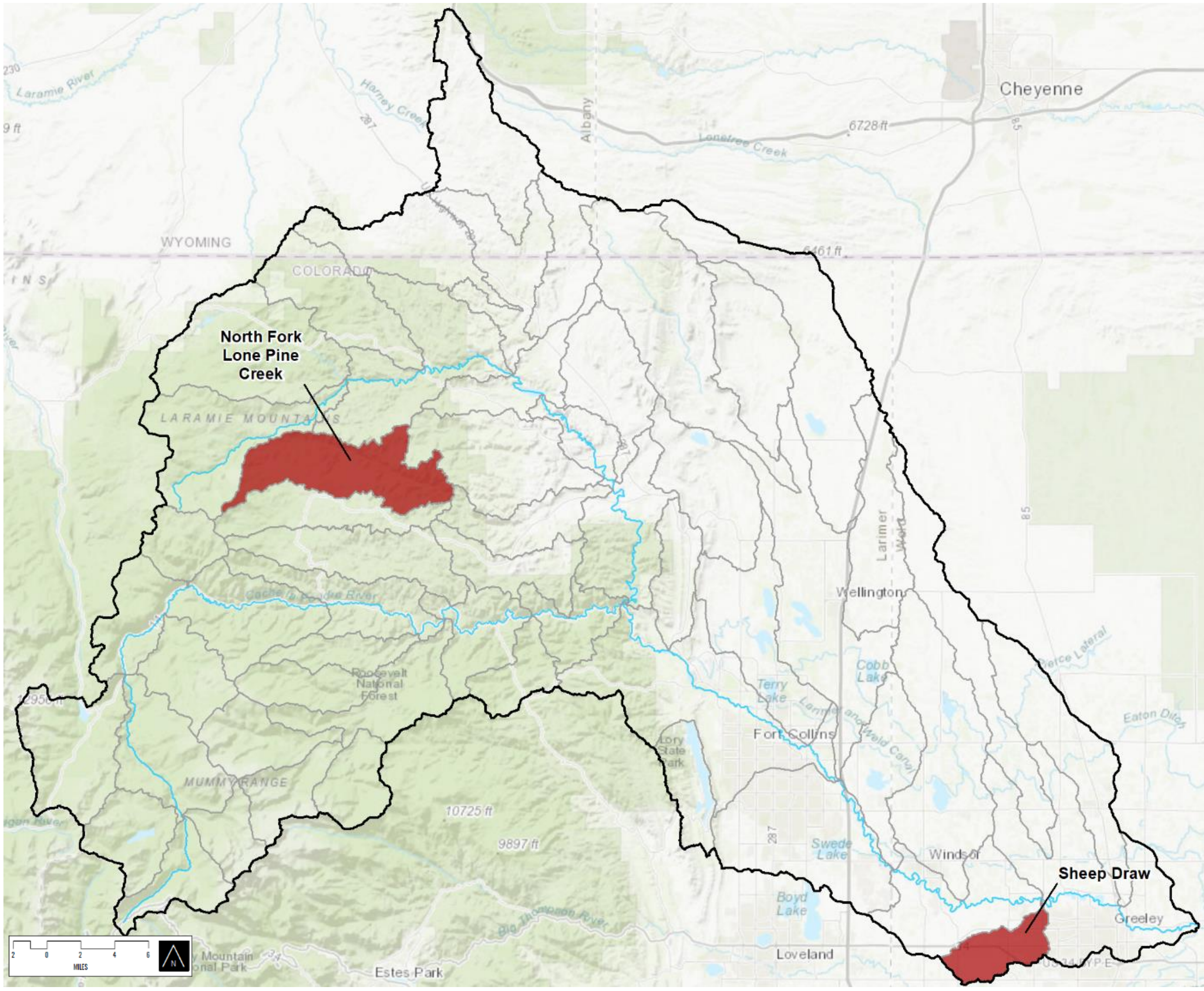



*Figure 3-3 Focus Areas North Fork Lone Pine Creek and Sheep Draw*

Table 3-1 lists all the HUC12 watersheds in the Cache La Poudre.

*Table 3-1 HUC 12 Watersheds in the CLP*

| HUC 12 | HUC 12 Name |
|---|---|
| **101800100405** | Willow Creek-Laramie River |
| **101900070210** | Sevenmile Creek-Cache La Poudre River |
| **101900070301** | Elkhorn Creek |
| **101900070302** | Youngs Gulch |
| **101900070303** | Skin Gulch-Cache La Poudre River |
| **101900070304** | Gordon Creek |
| **101900070305** | Hill Gulch-Cache La Poudre River |
| **101900070401** | North Fork Cache La Poudre River-Panhandle Creek |
| **101900070402** | Sheep Creek-North Fork Cache La Poudre Creek |
| **101900070403** | North Fork Cache La Poudre River-Bull Creek |
| **101900070404** | Trail Creek-North Fork Cache La Poudre River |

| HUC 12 | HUC 12 Name |
|---|---|
| **101900070502** | Lower Dale Creek |
| **101900070101** | Beaver Creek |
| **101900070102** | Headwaters South Fork Cache La Poudre River |
| **101900070103** | Pennock Creek |
| **101900070104** | Little Beaver Creek |
| **101900070105** | Pendergrass Creek-South Fork Cache La Poudre River |
| **101900070201** | Hague Creek |
| **101900070202** | Headwaters Cache La Poudre River |
| **101900070203** | La Poudre Pass Creek |
| **101900070204** | Joe Wright Creek |
| **101900070205** | Willow Creek-Cache La Poudre River |
| **101900070206** | Sheep Creek |
| **101900070207** | Roaring Creek |
| **101900070208** | Black Hollow-Cache La Poudre River |
| **101900070209** | Bennett Creek |
| **101900070503** | Fish Creek-Dale Creek |
| **101900070504** | Deadman Creek |
| **101900070601** | South Fork Lone Pine Creek |
| **101900070602** | North Fork Lone Pine Creek |
| **101900070603** | Lone Pine Creek |
| **101900070701** | Halligan Reservoir |
| **101900070702** | Rabbit Creek |
| **101900070703** | Stonewall Creek |
| **101900070704** | Miton Seaman Reservoir-North Fork Cache La Poudre River |
| **101900070801** | Owl Creek |
| **101900070802** | Horsetooth Reservoir |
| **101900070803** | Headwaters Dry Creek |
| **101900070804** | Douglas Reservoir-Dry Creek |
| **101900070805** | City of Fort Collins-Cache La Poudre River |
| **101900070901** | Upper Boxelder Creek |
| **101900070902** | Rawhide Creek-Boxelder Creek |
| **101900071002** | Fossil Creek-Reservoir-Cache La Poudre River |
| **101900070904** | Coal Creek-Boxelder Creek |
| **101900070905** | Indian Creek-Boxelder Creek |
| **101900071001** | Timnath Reservoir |
| **101900071003** | Windsor Reservoir |
| **101900071004** | Sheep Draw |
| **101900071005** | 101900071005 |
| **101900070501** | Upper Dale Creek |
| **101900071006** | Coalbank Creek |
| **101900071007** | Eaton Draw |
| **101900071008** | Outlet Cache La Poudre River |
| **101900070903** | Lower Boxelder Creek |

### 3.1.1 North Fork Lone Pine Creek

The HUC12 of focus in the upper watershed is North Fork Lone Pine Creek (COSPCP08). Lone Pine Creek is a tributary to the North Fork of the Poudre. It is approximately 30,000 acres and is dominated by dry ponderosa pine with some mixed conifer and a small area of spruce-fir at the highest elevations. This watershed was not burned in the 2012 High Park or Hewlett Gulch wildfires. However, North Fork Lone Pine Creek was identified as one of the least resilient and highest priority areas for in CPRW's Upper Poudre Resiliency Plan due to high fire risk, steep streams with high debris flow and high sediment transport. As such, CPRW has focused much of their forest health work in the Lone Pine Creek watersheds to reduce wildfire risk and protect water quality. Of the 30,000 acres in the watershed, the Plan identified 10,800 acres as non-resilient. The plan also recommended investigating road density and road/stream crossings in the watershed. There are several locations in North Fork Lone Pine Creek where the roads run parallel to North Fork Lone Pine Creek and other streams.

### 3.1.2 Sheep Draw

Sheep Draw (COSPCP13a) is the HUC12 of focus in the lower watershed. It is located in the City of Greeley and it is one of the City's largest drainage basins. It is also one of the more rapidly growing areas of the City. In CPRW's Lower Poudre Resiliency Plan, the river corridor was broken up into 28 reaches for analysis. The Sheep Draw reach was identified as one of the highest priority reaches for restoration in the plan due to lack of floodplain connection, low sediment transport and lack of instream habitat.

This section describes the watershed characteristics for the entire watershed. More details on North Fork Lone Pine Creek and Sheep Draw are provided in Section 5.4.

## 3.2 Land Use and Ownership

### 3.2.1 Ownership

The Cache la Poudre watershed is approximately 1.2 million acres. Over half of the acreage in the upper watershed (357,424 acres) is owned by the US Forest Service and managed as Roosevelt National Forest. There are three federally designated wilderness areas in the Poudre watershed including the Cache la Poudre Wilderness, Neota Wilderness and the Comanche Peak Wilderness. Approximately 677,000 acres (60%) of the watershed is privately owned. However, the majority of the privately owned acreage is below the canyon mouth (Figure 3-4; Table 3-2). Other landownership in the watershed includes the City of Fort Collins, City of Greeley, Larimer and Weld Counties and the State.

In 1996, 45 miles of the Poudre River were designated as a National Heritage Area. The heritage area begins in Larimer County at the eastern edge of Roosevelt National Forest and ends in Weld County at the confluence with the South Platte (National Park Service 2019).

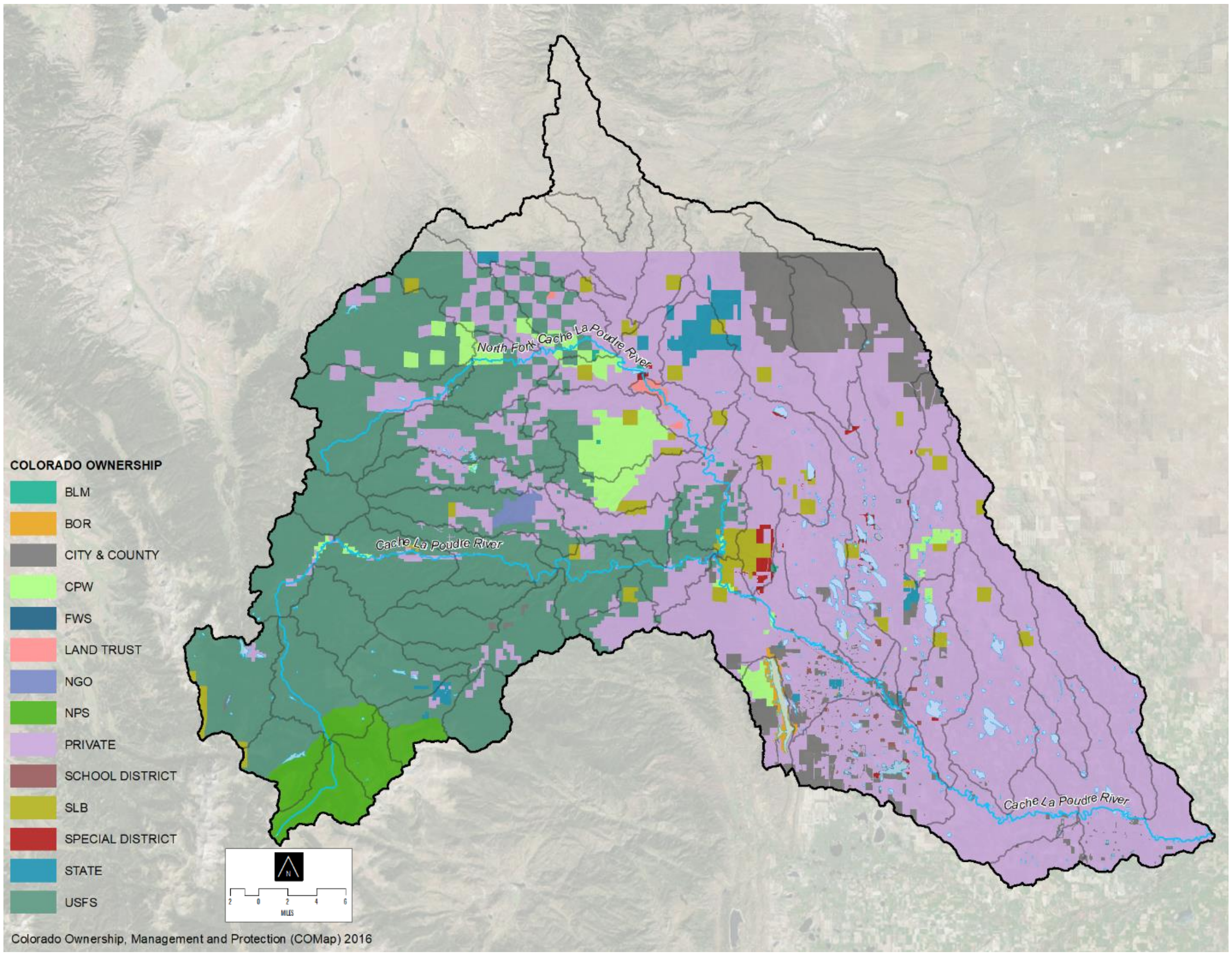



*Figure 3-4 Colorado Land Ownership in the Cache la Poudre Watershed*

*Table 3-2 CLP Colorado Land Ownership*

| Landowner | Square Miles | Acres | Percent |
|---|---|---|---|
| United States Forest Service | 558 | 357,424 | 30% |
| National Park Service | 56 | 35,762 | 3% |
| State Owned | 50 | 31,916 | 3% |
| Private | 1,058 | 677,081 | 60% |
| State, County, City, Wildlife, Parks & Rec | 40 | 25,771 | 2% |
| Bureau of Land Management | 1.4 | 876 | .007% |

## 3.2.2 Historic Land Use

The gold rush of the late 1800's brought miners and railroad building to northern Colorado and settlement began in the region. In the Poudre watershed, mining exploration was not successful. However, many trees were cut in the watershed for railroad ties by "tie hackers" and were floated down the Poudre River. Originally there were plans to install a railroad up the Poudre Canyon. It was never completed but became the foundation for Highway 14 in the canyon. The arrival of settlers also brought agriculture and irrigation to the watershed. Early irrigation structures were installed, and communities formed around the river including Laporte, Fort Collins and Timnath (National Wild and Scenic Rivers System 2019).

The Cache la Poudre River was also the foundation for western water law (NPS 2019). Farmers soon realized that the canals were not delivering enough water and that newer canals were draining much of the river so there was minimal flow left in the river when it reached Greeley. Greeley farmers fought for the concept of prior appropriation, or a system that allowed the first person or irrigation company that claimed the water to be the first person to receive the water. Those with junior water rights could not take their water until those with senior water rights received sufficient water to meet their needs. The doctrine of prior appropriation was included in the Colorado constitution in the late 1800s and it was the first state to do so (Poudre Heritage Alliance 2019).

Sugar beet farming was a central role in the agricultural industry in the Poudre watershed. Fort Collins, Greeley and Windsor built sugar beet processing factories in the early 1900s, and farmers in Larimer County grew more sugar beets than any other crop except for hay and wheat for 50 years. During the height of sugar production, Larimer and Weld Counties planted over 100,000 acres of sugar beets which placed great water demands on the Poudre River. Because of the high costs of sugar beet production, the Fort Collins factory eventually closed. However, the water delivery systems built for beet farming still remain and are used to grow other crops (US Sugar Beet Association 1936).

## 3.2.3 Current Land Use

Current land use in the watershed varies by region and is diverse (Figure 3-5). The Poudre watershed is vital for the Colorado economy and provides valuable recreation opportunities.

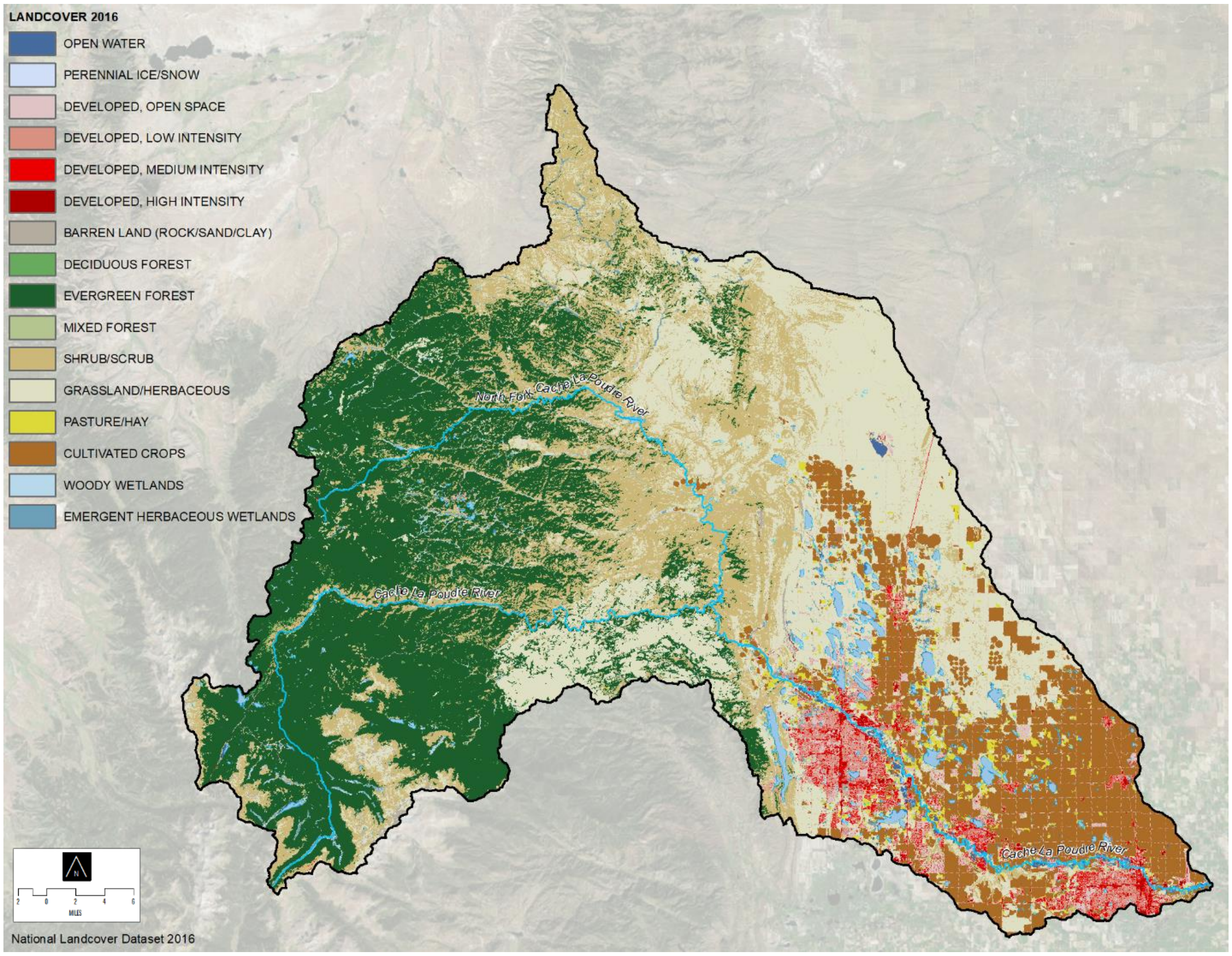



*Figure 3-5 Land Use in the Cache la Poudre Watershed*

### 3.2.3.1 Agriculture/Irrigation

The entire watershed has agricultural land uses, but most of the agriculture in the watershed is below the canyon mouth. Some agricultural land use occurs in the upper watershed, especially in the North Fork watershed. In North Fork Lone Pine Creek there is a small amount of irrigated agriculture.

The lower watershed is dominated by cultivated or agricultural land, and pasture and grazing lands. The Poudre River is vital for the agricultural industry in the region and supports a variety of agricultural businesses from farming and ranching to cattle-feeding and meatpacking, cheese making, and ethanol production (Weld County 2019). While only 7% of Weld County is within the Poudre watershed (USDA 1990), Weld County is Colorado’s leading producer of beef cattle, grain, sugar beets and it is also the state’s leading dairy producer (Weld County 2019). Specifically, in Sheep Draw, the primary land use is agriculture which comprises approximately 7,300 acres (Anderson Consulting Engineers 2006).

#### 3.2.3.2 Urban/development

Development in the upper watershed is minimal, and the majority of development is in the North Fork of the watershed, in Red Feather Lakes and along Highway 14 in the canyon. Red Feather Lakes has a population of ~340, while Glacier View Meadows development has approximately 970 lots. Paved roads in the upper watershed are generally limited to major transportation corridors. USFS, Larimer County and private road systems are largely dirt and gravel. There is minimal development in the North Fork Lone Pine Creek watershed.

The Cities of Fort Collins and Greeley have the largest populations in the watershed with ~165,000 people in Fort Collins and ~105,500 in Greeley (US Census Bureau 2019). The Town of Timnath has a population of 3,300 while the Town of Windsor has a population of 25,300. Both the Cities of Fort Collins and Greeley have public universities and a variety of industries from technology to breweries.

#### 3.2.3.3 Wildfires and Prescribed Burns

The upper Poudre watershed historically would have experience surface wildfires every 40-60 years, however, a long history of fire prevention has lengthened the fire return interval which has increased the risk of high severity wildfire. Fire suppression, climate change, insect infestations in addition to an increasing number of people who live in the Wildland-Urban Interface (WUI) increase the risk of high severity wildfires that threaten communities, roads, water supplies and other resources. There are several resources available to assess wildfire risk and identify high priority areas across the state, and specifically in the upper CLP.

The Colorado Hazard Mitigation Plan (Colorado Department of Public Safety, 2018) describes Colorado's plan to reduce hazards such as wildfires. As a part of this effort, the Colorado Wildfire Mitigation Plan was developed and addresses strategies/recommendations for addressing wildfire risk in Colorado (See Section 6.1). One wildfire risk assessment method is The Colorado Wildfire Risk Assessment Portal (CO-WRAP). CO-WRAP is a web-mapping tool that provides access to statewide wildfire risk assessment information in Colorado. CO-WRAP provides GIS data to show the likelihood of acres burning, potential fire intensity, historic fire occurrence and values at risk from wildfire. CO-WRAP can help inform land managers and landowners where forest management actions could be implemented to reduce risk. Figure 3-6 shows the wildfire risk in the upper Poudre watershed (Colorado State Forest Service 2018) and Figure 3-7 shows the Wildland Urban Interface risk in the CLP.

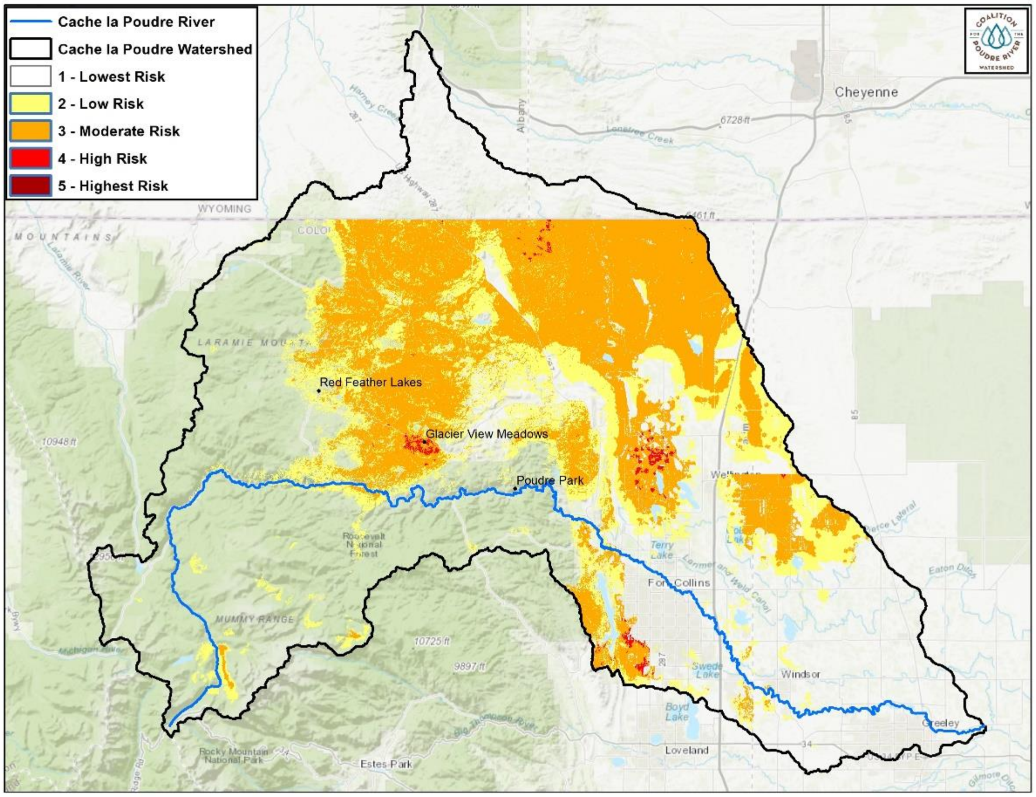



*Figure 3-6 CO-WRAP Wildfire Risk in the CLP*

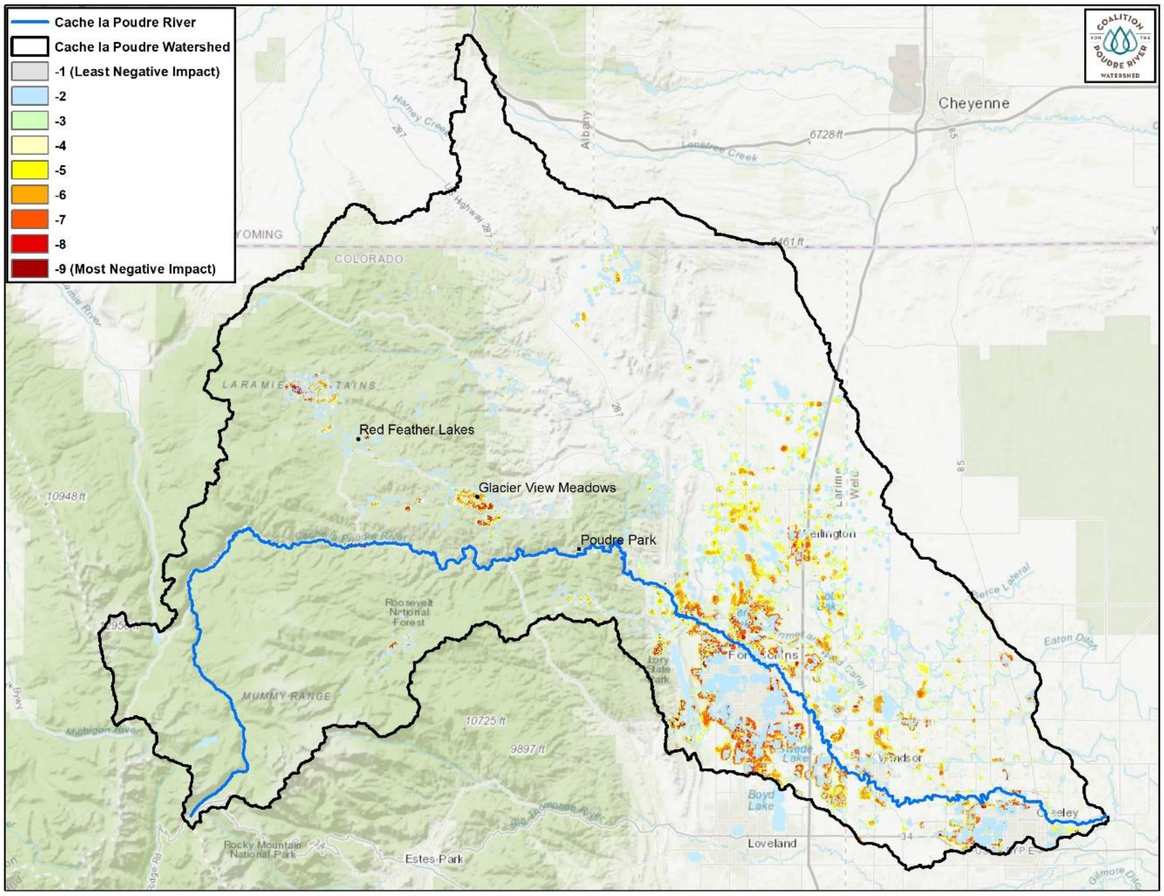



*Figure 3-7 CO-WRAP Wildland Urban Interface wildfire risk in the CLP*

In 2016, CPRW completed the Upper Poudre Resiliency Plan with the intent of improving long-term watershed resilience and to identify target areas and determine priorities and actions to increase watershed resilience to future threats. A watershed assessment analysis was completed that prioritized 7$^{th}$ level watersheds for restoration. The plan identified ~40,000 acres as not resilient to high priority threats like catastrophic wildfires, and six priority watershed target areas (JW Associates 2017). The Lone Pine Creek region was included as a priority area for CPRW to focus restoration efforts. North Lone Pine watershed was not burned in the 2012 High Park fire (Figure 3-9), but in the Upper Poudre Resiliency Plan it was ranked as a high priority area (Figure 3-8) due to high wildfire hazard, high debris flow potential, high sediment transport capacity, and it has a high road density with many roads close to streams (JW Associates 2017).

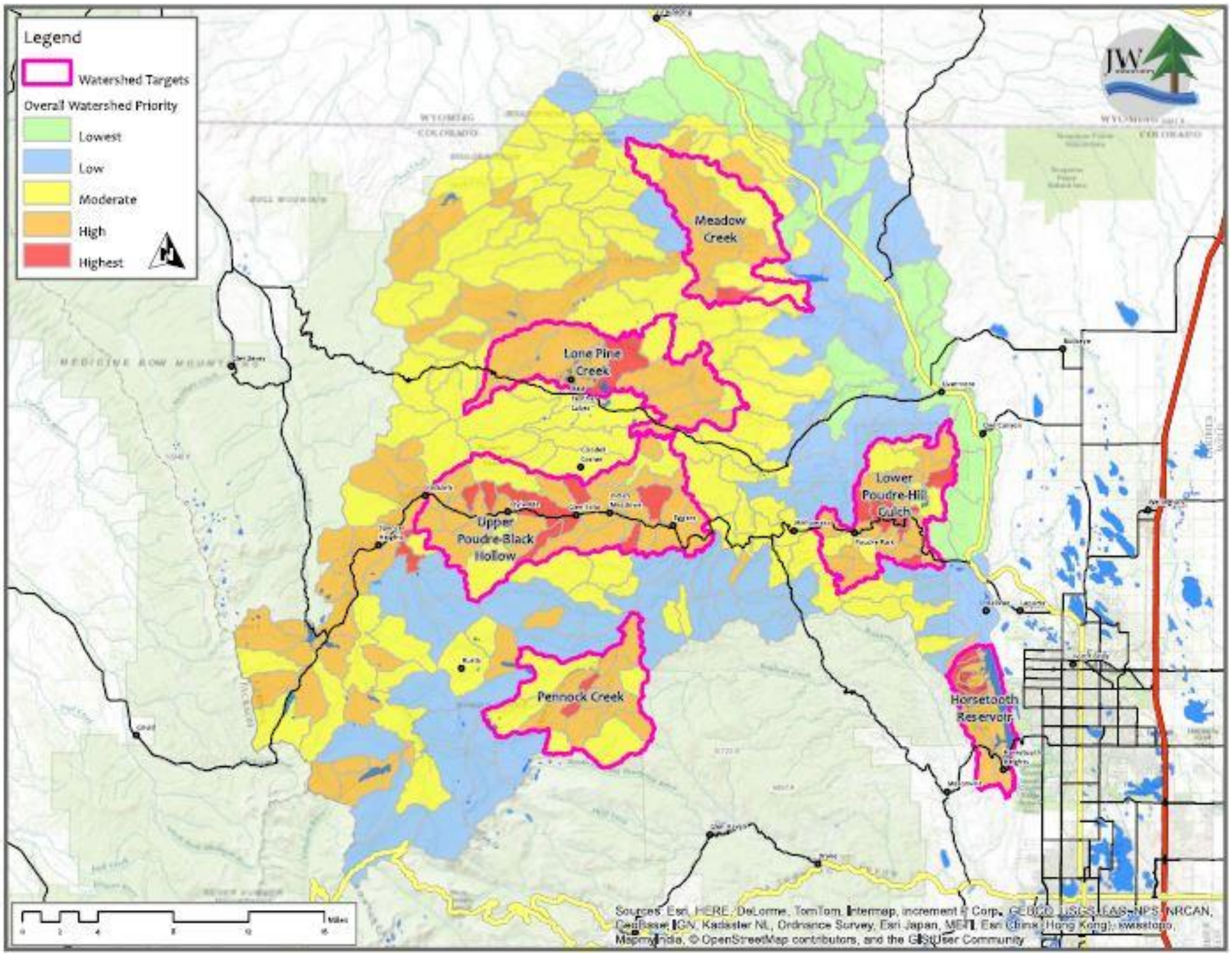



*Figure 3-8 Upper Poudre Watershed overall priority watersheds and target areas.*

The watershed has experienced several significant wildfires, as illustrated in Figure 3-9. In 2004, the Picnic Rock fire burned over 9,014 acres, and in 2012, the High Park and Hewlett Gulch wildfires burned over 95,000 acres in the watershed. These fires resulted in severe erosion, higher than normal runoff volume, and debris flows all contributed to extreme degradation of water quality in the main stem and tributaries of the Cache La Poudre Watershed. This in turn impaired not only instream ecological health but also threatened critical water supply infrastructure.

Wildfires are a part of the ecology and history of Colorado. However, recent experiences with wildfires in the Rocky Mountain West points to changing patterns in the size, severity, and negative outcomes of wildfires. Since 1994 more than 380,000 acres of communities & forests have burned in Colorado. Most researchers believe that the historical emphasis on suppressing fire resulted in forests with a higher than average density of trees. Historically, small, moderate ground wildfires are thought to have kept forests more open, with fewer older, larger trees dominating the forests, particularly in lower elevations like the Front Range foothills. Today our lower elevations forests are characterized by a high density of small trees (high fuel loads). This pattern is reinforced by more people are moving into forested areas, thus increasing pressure to suppress wildfires and create the feedback that leads to catastrophic wildfires. Catastrophic wildfires put our forest habitats, communities, rivers, and water supply at high risk.

Across Colorado, researchers and land managers are recognizing that our forests are in need of restoration treatments to return them to a healthier, more resilient condition. Prescribed/broadcast burning, and mechanical thinning are two strategies that are used to increase the resiliency of our Front Range forests to future catastrophic wildfires like High Park. CPRW works closely with partners like the US Forest Service, Colorado State Forest Service, The Nature Conservancy, Natural Resource Conservation Service among others to increase the pace and scale of prescribed fire and other forest treatments in the Poudre watershed, across landownership boundaries to achieve landscape scale forest restoration.

Figure 3-10 illustrates the completed, planned and ongoing prescribed burns on USFS land in the watershed over the past 20 years

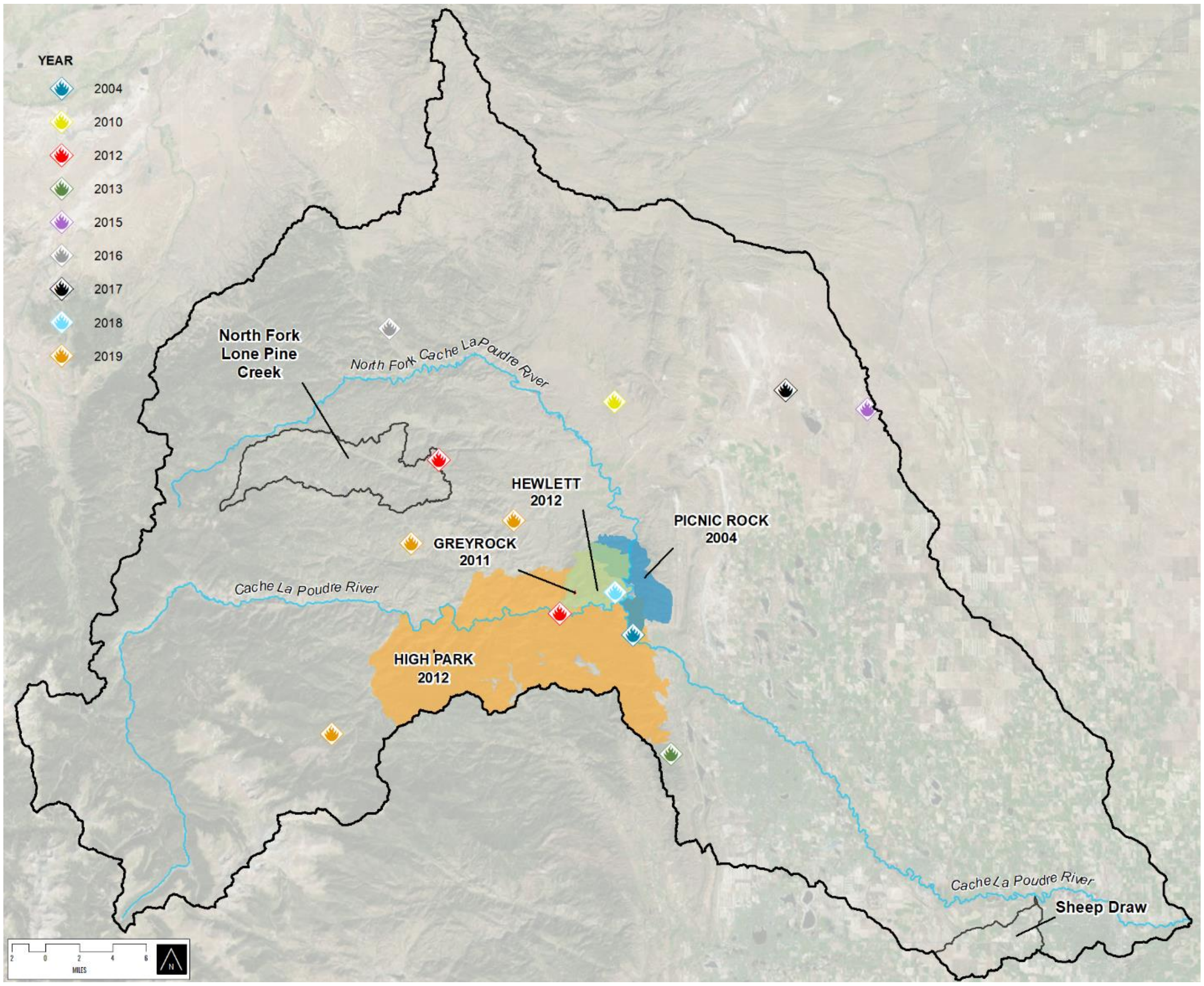



*Figure 3-9 Wildfires in the CLP*

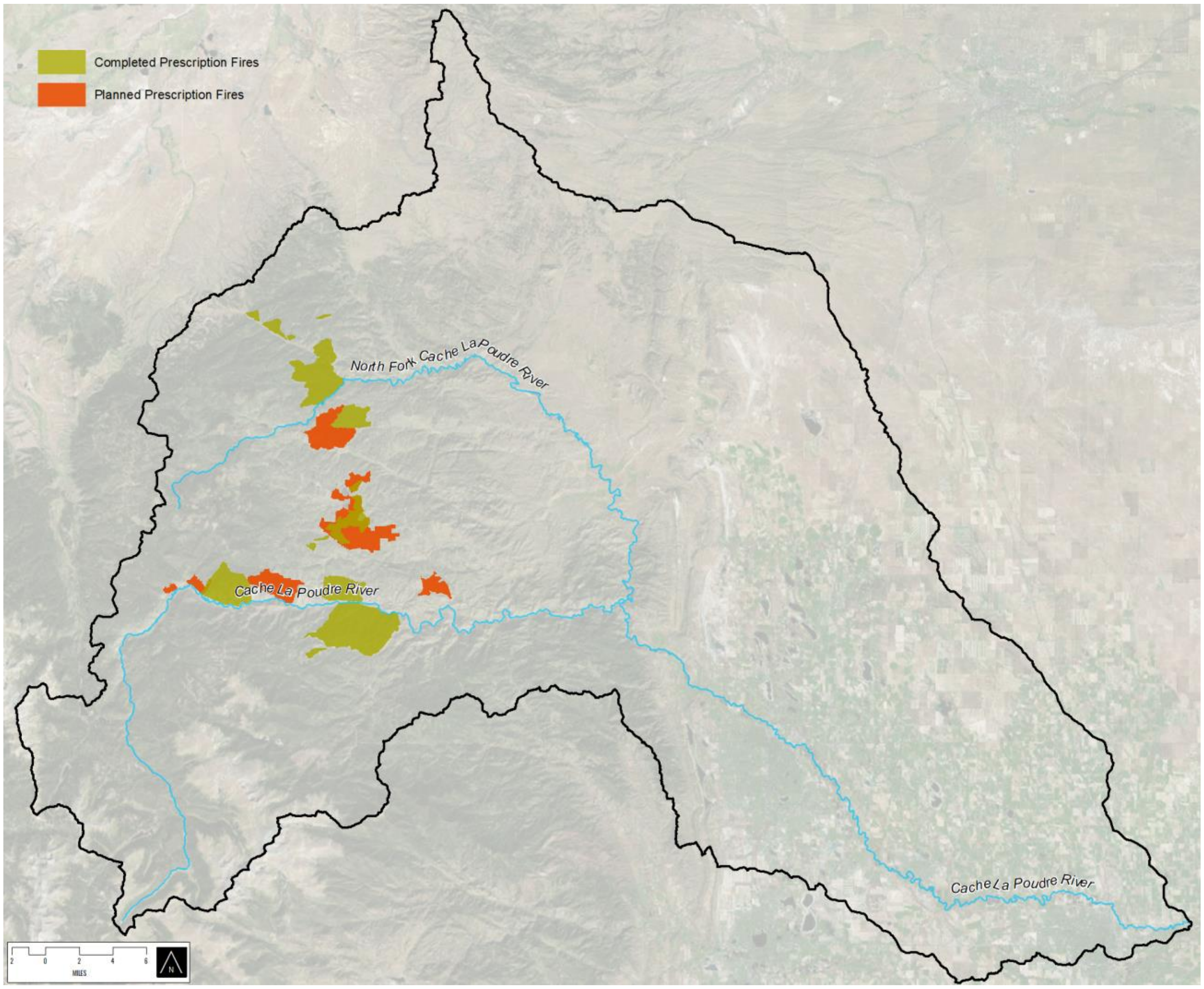



*Figure 3-10 US Forest Service Completed and Planned Prescribed Fire in the CLP*

### 3.2.3.4 Recreation/Tourism

Recreation and tourism activities provide great economic benefits to the region. Because the upper watershed is dominated by public land, much of the land use in the upper watershed supports recreation including whitewater rafting, fly fishing, hiking/camping, climbing, skiing and hunting among others. In fact, the recreational fishing industry brings in $3-4 million per year and the whitewater rafting industry on the Poudre brings in $950,000-2.7 million per year to the region. The Poudre River has been a popular river for rafting since the 1950's. The rafting season typically occurs from May- August. The Poudre River also receives over 43,000 angler days which is defined by Colorado Parks and Wildlife as 2 ½ hours of fishing time (USDA 1990). There are a variety of recreational opportunities in the North Fork Lone Pine Creek watershed with the abundance of National Forest system land.

In the lower watershed, the Poudre River Trail is a valued recreational asset for the community. Currently, 9.4 miles of the trail goes through Fort Collins and 21 miles stretches from Windsor to Greeley (Poudre River Trail 2019). It is often used for biking, walking/jogging, bird and wildlife viewing. According to a Fort Collins Natural Areas Program study, more than 100,000 user-days were documented on the trail in 2007 (NRAB 2011). The Poudre River Trail also travels along the river corridor in the Sheep Draw watershed. In CPRW's Lower Poudre Master Plan, stakeholders identified the Poudre Trail as one of the most valued assets in the river corridor. As such, the trail condition was included as one of the metrics in the reach priority analysis.

#### 3.2.3.5 Growth Trends

The State Demography office forecasts that Weld and Larimer Counties will double their populations by 2050. This large increase in population will present additional challenges for water supply and water quality.

## 3.3 Climate and Snowpack

### 3.3.1 Snowpack

As with other Colorado watersheds, 50-90% of stream water in the Poudre River comes from snowmelt. The Cache la Poudre Watershed can be broken up into three snow zones: the intermittent snow zone, transitional snow zone and persistent snow zone. The persistent snow zone has a consistent snow cover throughout the winter and in some high elevations there will be snow on the ground most of the year. Snowmelt from this zone supplies the majority of the water to the cities and farms downstream in the watershed. The transitional snow zone is at a lower elevation, with a higher temperature and less precipitation. The snow in this zone does not stay on the ground as long. This region is more sensitive to a warming climate. The intermittent snow zone does not maintain consistent snow cover and is centered around the foothill areas at lower elevations of the mountains. Snow accumulation and persistence is the most variable at this zone. It is also sensitive to changes in temperature, precipitation and sunlight (CSU NREL 2019).

### 3.3.2 Precipitation

Drought is common in the Poudre watershed, as well as across Colorado. The most severe drought in the last 100 years was in 2002. Approximately seventy-five percent of annual precipitation occurs from mid-April through late September. Mean average annual precipitation in the watershed ranges from 12-18 inches per year. Precipitation in winter is snow, and the average snowfall ranges between 20 inches to 49 inches (USDA 1990). In Greeley and Fort Collins, the average snowfall is 41-57 inches per year (US Climate Data 2019).

### 3.3.3 Temperature

The average temperature in the Poudre watershed ranges between 46°F and 54°F. July is the warmest month and December and January are typically the coolest months. Winters in the watershed have frequent northerly winds with periods of large gusts of wind that can drop the temperature to -35°F and lower. Summer humidity is low and evaporation is high (Clifford et al. 2009). The average date of the first frost is September 28, and the last frost in the spring is typically the first week of May. The frost-free period ranges from 129-155 days (USDA 1990).

### 3.3.4 Climate Change

In Colorado, the statewide annual average temperatures have increased by 2 °F over the past 30 years (CWCB 2014), and further temperature increases are predicted. Climate change is expected to increase the frequency of drought, insect epidemics, floods and large wildfires in the Poudre watershed and across the state (Funk and Saunders 2014).

## 3.4 Geology

The Poudre Canyon was developed in three major stages. First, a wide valley formed likely in the Miocene followed by uplift and tilting characterized by a narrow, U-shaped valley. The third stage was a narrow, V-shaped valley. The combination of this uplift and a cooler, wetter climate resulted in glaciers to develop in the Pleistocene (Bolyard 1997). The watershed contains a diversity in rocks that range in age. The geology records several major rock-forming events and deformations characteristic to the Rocky Mountain including volcanic and sedimentary rocks that were deposited in the Paleoproterozoic between about 1,790 and 1,725 million years, and intruded by calc-alkaline magmas and metamorphosed between about 1,725 and 1,695 million years ago (Premo et al 2010).

The transition from the upper to lower watershed has large changes in geology as the river flows through various Upper Cretaceous sandstones, limestones and shales. This area comprises the Dakota group, the Laramie formation, and the Niobrara formation (USACE, 2014). The floodplain geology is dominated by alluvium made up of sand, gravel, silt, and minor amounts of clay with a thickness of up to 80 feet (Hershey et al., 1964). Flood events and wind transport are the primary processes of erosion and sediment transport in the watershed.

## 3.5 Geomorphology and Hydrology

The Poudre watershed is a snowmelt driven system that characteristically experiences lower flow conditions throughout most of the year and has a surge in peak flows following the spring snowmelt. Typical peak flows from snowmelt runoff is between mid-May and late June. Flood events like the 2013 flood can occur following large rainstorms, but these events are less likely (Lynker 2017).

The hydrology of the Poudre River and its tributaries are altered due to the diversions and storage reservoirs throughout the entire watershed (City of Fort Collins 2017).
The upper watershed contains nine reservoirs and five trans-basin diversions (City of Fort Collins 2016). The reservoirs and diversions change flow volumes and timing of flows. Reservoirs in the watershed can affect base flows in the river depending on calls on water rights made by downstream users in Fort Collins, Greeley, Timnath and Windsor. Reservoirs also can trap the majority of the sediment that would otherwise be deposited into the river. Lack of sediment in the river can lead to increases in channel and bank erosion (City of Fort Collins 2017). The transbasin diversions bring in water to the Poudre river from the Wilson Supply Ditch, Laramie-Poudre Tunnel, Grand River Ditch and Michigan Ditch. Colorado-Big Thompson

water is also delivered to the Poudre through the Hansen Supply Canal from Horsetooth Reservoir. Transbasin diversions can increase peak flow magnitude and duration. Diversions occur at Gateway Park upstream of the confluence of the North Fork with the mainstem Poudre.

In the lower watershed, there are many diversion points on the river upstream of I-25 for agricultural, industrial and municipal uses. The City of Fort Collins Utilities Department diverts approximately one-half of its water supplies from the Poudre River. East of 1-25 there are seven major diversions on the river. The Greeley No. 2 ditch diverts the most water at approximately 4,000 acre-feet per year. These diversions are the active irrigation source for the adjacent agricultural lands (CWCB 2007).

The State of the Poudre report completed by the City of Fort Collins found that these diversions directly affect flow regime including peak flow, base flow and rate of change. Peak flows can be shortened during the spring and summer, and base flows are decreased by diversions during the fall and winter or during periods of drought. The river does dry up in the winter and can leave the river with little to no flow through Fort Collins and Greeley (City of Fort Collins 2017). Figure 3-11 shows a map of inputs and diversions throughout the watershed.

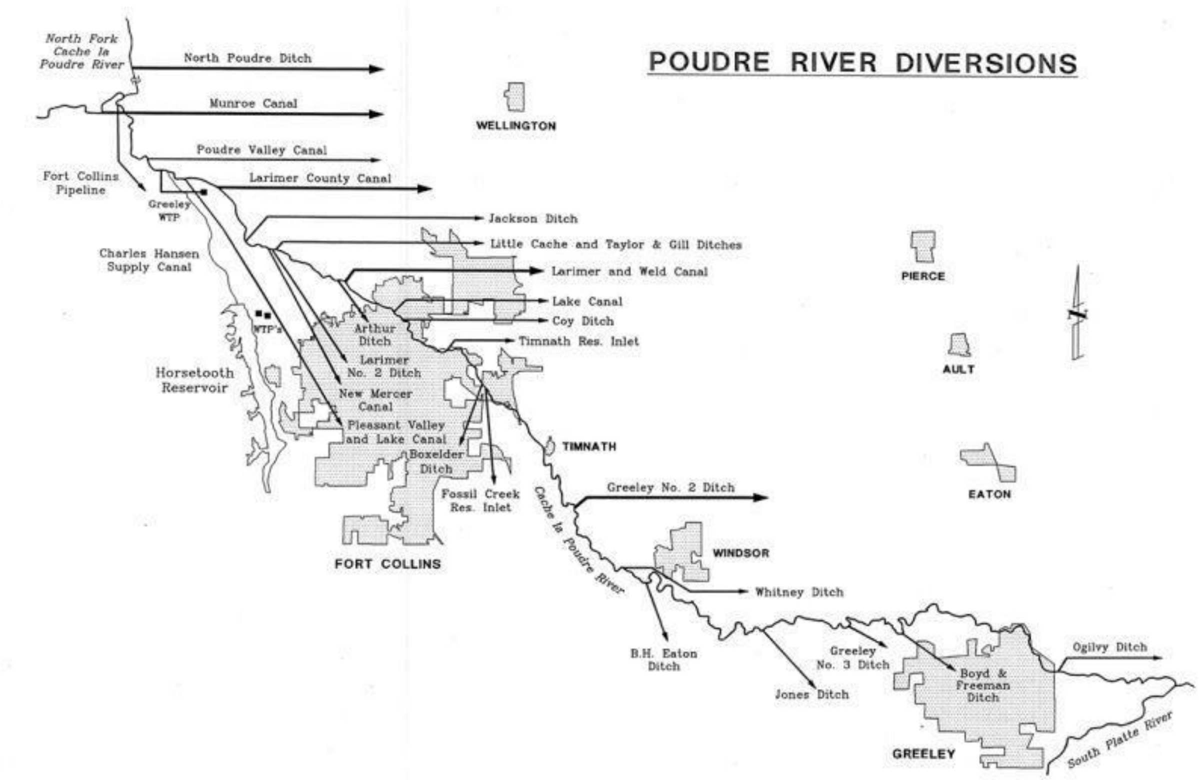



*Figure 3-11 Poudre Watershed Diagram of Major Inputs and Diversions*

## 3.6 Wildlife

Wildlife in the Poudre watershed is diverse and changes from the upper watershed to the lower watershed. Mule deer occur throughout the watershed and pronghorn can be found in the northeast portion of the upper watershed. Other species in the upper watershed include bighorn sheep, black bear, elk, moose and mountain lion. Many of the riparian areas, natural lakes and reservoirs provide aquatic habitat for a variety of fish, amphibians and invertebrate species. In the lower watershed, wild turkey occur near the confluence with the South Platte River and also can be found in the upper watershed. Pheasant, white-tailed deer and geese are common in the lower watershed and at lower elevations (USDA 1990).

There are several federally-listed threatened or endangered plants and animals that occur within the Poudre watershed. These species included the Colorado Butterfly Plant which is federally listed as threatened, the Ute Ladies'-Tresses, an orchid that is listed as threatened. Both of these plant species occur in moist soils in wet meadows and floodplains, Preble's Meadow Jumping Mouse is a threatened species that lives in heavily vegetated, riparian habitats. Mexican spotted owls are listed as threatened and can be found in canyon bottoms and mixed coniferous forests. Bald Eagles are also present in the watershed. While they were delisted in 2007, they are still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Bald Eagles build their nests near riparian areas, often in cottonwood trees (USACE 2014).

## 3.7 Water Use

The Cache la Poudre River is a tributary to the South Platte River and lies within the South Platte Basin. It drains approximately 1,056 square miles above the canyon mouth. The river typically produces 274,000 acre-feet of water. The majority of the production occurs during peak snowmelt months between April and July (Northern Water 2019). The Poudre river is often referred to as a "working river" because of its contributions to the development of water law in the United States and water delivery systems (NPS 2019).

In 2005, nine basin roundtables were established to manage and develop the state's water resources. The roundtables were formed in response to the water issues facing the state and to help manage changing water demands. The nine roundtables represent the major river basins within the state, except for the South Platte River Basin which includes two roundtables, the Metro and the South Platte Basin. The South Platte Basin Roundtable completed a consumptive and non-consumptive needs assessment for the basin. Consumptive water uses remove water from streams and rivers to support agriculture, industry and municipal needs. Non-consumptive uses do not take water from the river and can include recreation, aquatic life and environmental uses. The South Platte Basin Implementation Plan was completed in 2015. The plan provides solutions for how the basin's future water needs will be addressed at the local level.

### 3.7.1 Consumptive uses

The Upper Poudre watershed is an important source of high-quality drinking water for the City of Fort Collins, The City of Greeley (Bellvue Water Treatment Plant), Tri-districts (Soldier Canyon Filter Plant) that includes the Fort Collins-Loveland Water District, East Larimer County Water District, and North Weld County Water District. Municipal and industrial users of the river own 15 percent of the water rights on the river (Simpson 2014).

The South Platte Basin has over 830,000 irrigated acres- the highest number of irrigated acres in the state. Agricultural users of the river own 85 percent of the water rights (Simpson 2014). The major agricultural users of the river include North Poudre Irrigation Company, Water Supply and Storage Company, Larimer and Weld Irrigation Company, New Cache Irrigating Company (Greeley No. 2).

### 3.7.2 Non-consumptive uses

Environmental flows are dependent on the quality, quantity, and timing of the flows required to support freshwater ecosystems and provide benefits to humans. The South Platte Basin Roundtable completed Non-consumptive Needs Assessments (NCNAs). This effort has included an extensive inventory, analysis, and mapping effort. Identified in the NCNA is a map of the major stream and lake segments with flow-dependent environmental and recreational values. The CWCB has appropriated instream flows on the Poudre, mainly in the upper watershed, and the City of Fort Collins has two Recreational In-Channel Diversions.
Other non-consumptive uses identified in the South Platte Basin include:

- State endangered, threatened, species of special concern (includes several Federally listed species)
- Greenback Cutthroat Trout
- Important Riparian Habitat
- Migratory Bird Viewing/Hunting
- Fishing
- Recreation (including whitewater and flatwater boating)

## 3.8 Water Treatment & Infrastructure

### 3.8.1 Infrastructure

The upper watershed contains nine water supply reservoirs and five trans-basin diversions. The trans-basin diversions in the watershed deliver water from the Colorado River, Michigan River and Laramie River basins (City of Fort Collins 2016).

The City of Greeley uses and manages several of the high mountain reservoirs including Barnes Meadow, Hourglass, Comanche, Twin and Peterson Reservoirs (City of Greeley 2019). Seaman Reservoir is located just above the confluence of the North Fork and the mainstem Poudre. It currently has a storage capacity of 5,008 acre-feet. Greeley owns the water within Seaman Reservoir and has proposed to expand it to 88,000 acre-feet to meet their project municipal and industrial demand. The US Army Corps is currently identifying reasonable alternatives to Greeley's project that will be evaluated in a draft EIS (USACE 2019).

Halligan Reservoir is located on the North Fork of the Poudre and currently has a storage capacity of 6,400 acre-feet. North Poudre Irrigation Company owns the current water in the reservoir and the City of Fort Collins owns the dam and surrounding property. The proposed expansion is to increase the storage capacity to 14,500 acre-feet to meet the demand of future Fort Collins Utilities customers, and to protect against future drought, fires, floods etc. The draft Environmental Impact Statement for the Halligan Water Supply Project was released in November 2019 (USACE 2019). The City of Fort Collins also relies on Horsetooth Reservoir for drinking water. Horsetooth is located in the foothills of the watershed and has a storage capacity of 156,735-acre-feet. Horsetooth is a terminal reservoir for the Colorado-Big Thompson project that is operated by the Bureau of Reclamation and the Northern Colorado Water Conservancy District (City of Fort Collins Source 2016).

Glade Reservoir is a proposed 170,000 acre-foot reservoir that is a part of the Northern Colorado Water's Northern Integrated Supply project (NISP). If completed, Glade Reservoir would be located below the canyon mouth, northwest of the City of Fort Collins. The Final Environmental Impact Statement for NISP was released in July 2018 (USACE 2018).

## 3.8.2 Water Treatment

The City of Fort Collins operates a community water supply system that supplies drinking water to 130,000 residents within Larimer County. Half of the water each year is treated from two primary sources including Horsetooth Reservoir and the Poudre River. Two pipelines divert water from the river and a third pipeline diverts water from North Poudre Irrigation Company at the Canyon Mouth. Water from the three Poudre pipelines and from Horsetooth Reservoir deliver water to the Water Treatment Facility (City of Fort Collins 2016).

The City of Greeley uses the Bellvue Water Treatment Plant that is located at the mouth of the Poudre Canyon to treat their water. The treatment plant was completed in 1906 and can treat up to 35 million gallons of water per day. It operates 365 days a year to provide high quality drinking water to the City of Greeley (City of Greeley 2019).

## Tool Highlight: CPRW Spatial Database

As part of this watershed plan, CPRW developed an ArcGIS-based geodatabase with a range of spatial data covering the span of the watershed. This geodatabase provides a centralized platform for compiling watershed spatial data and an interactive tool that CPRW can utilize to analyze and investigate spatial data throughout the watershed. Table 3-3 illustrates the range of layers that are available within the geodatabase; CPRW can update and augment the geodatabase over time.

*Table 3-3 Types of Spatial Data in the CPRW Spatial Database*

| Group | Spatial Layers |
|---|---|
| Hydrology | Rivers<br>Lakes<br>Diversions & Canals |
| Topography | Digital Elevation Model (DEM)<br>HUC watershed boundaries<br>FEMA flood hazard zones |
| Land Use | National Land Use Land Cover<br>Irrigated agriculture<br>Land ownership |
| Impairments | CDPHE stream segmentation<br>CDPHE 303(d) and M&E listings<br>Gold water streams and lakes |
| Monitoring Points | Colorado Data Sharing Network (CDSN)<br>National Water Quality Monitoring Council Water Quality Portal (WQP)<br>Upper CLP Watershed Collaborative Monitoring Program<br>Northern Water CLP Monitoring Program |
| Point Sources | WWTP Effluent Discharges<br>Well Permits (a proxy for Onsite Waste Treatment Systems)<br>EPA Regulated Facilities |
| Model Results | STEPL (nonpoint source nutrient loading)<br>GRAIP_Lite (sediment delivery from USFS roads) |

# 4 Water Quality Conditions

## 4.1 State Standards & Uses

The Clean Water Act (CWA) regulates the discharge of pollutants in surface waters. Under the CWA, the EPA has implemented pollution control programs and developed national water quality criteria recommendations. The Water Quality Control Division (the Division) in the Colorado Department of Public Health and Environment is tasked with administering water quality programs to protect waters of the state through delegated authority by both the Colorado Water Quality Control Act and the federal Clean Water Act (on behalf of EPA). In Colorado, the Water Quality Control Commission (WQCC) is the administrative agency responsible for developing specific water quality policy in Colorado, in a manner that implements the broader policies set forth by the Legislature in the Colorado Water Quality Control Act. The WQCC adopts water quality classifications and standards to protect beneficial uses of waters of the state, as well as various regulations aimed at achieving compliance with those classifications and standards.

*Regulation 31: The Basic Standards and Methodologies for Surface Wate*r establishes a system for classifying state surface waters and for assigning standards. It describes a set of “beneficial uses,” including aquatic life, recreation, agriculture, and water supply. All waterbodies are broken out into segments, which have associated beneficial uses. *Regulation 38: Classifications and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin* classifies and provides numeric water quality standards for each segment covered by this regulation. Each beneficial use has specific standards adopted for multiple water quality parameters, as well as statewide standards that apply to all segments (such as narrative standards and radionuclides standards). The beneficial use classification with the most conservative criteria (i.e., lowest value) for each parameter. Table 4-1 lists the CPW segments and associated beneficial uses. Figure 4-1 illustrates the stream segments throughout the watershed.

*Table 4-1 Stream Segments and Beneficial Use Classifications in the CLP Watershed*

| Stream Segment or Sub-segment | Description | Agriculture | Aq Life Cold 1 | Aq Life Cold 2 | Aq Life Warm 1 | Aq Life Warm 2 | Recreation E | Recreation P | Recreation N | Water Supply |
|---|---|---|---|---|---|---|---|---|---|---|
| COSPCP01 | Mainstem of the Cache La Poudre River, and all tributaries and wetlands, within Rocky Mountain National Park and the Rawah, Neota, Comanche Peak, and Cache La Poudre Wilderness Areas. | X | X | | | | X | | | X |
| COSPCP02a | Mainstem of the Cache La Poudre River, including all tributaries and wetlands, from the boundaries of Rocky Mountain National Park and the Rawah, Neota, Comanche Peak, and Cache La Poudre Wilderness Areas to a point immediately below the confluence with the South Fork Cache La Poudre River. | X | X | | | | X | | | X |
| COSPCP02b | Mainstem of the Cache La Poudre River, including all tributaries and wetlands, from a point immediately below the confluence with the South Fork Cache La Poudre River to the Monroe Gravity Canal/North Poudre Supply canal diversion. | X | X | | | | X | | | X |
| COSPCP06 | Mainstem of the North Fork of the Cache La Poudre River, including all tributaries and wetlands, from the source to the inlet of Halligan Reservoir. | X | X | | | | X | | | X |
| COSPCP07_B | North Fork of Cache la Poudre River from five miles below Halligan Reservoir to the confluence with the mainstem of the Cache la Poudre River | X | X | | | | X | | X | |
| COSPCP07_C | North Fork Cache la Poudre River five miles below Halligan Reservoir | X | X | | | | X | | X | |
| COSPCP08* | All tributaries to the North Fork of the Cache La Poudre River, including all wetlands from, the inlet of Halligan Reservoir to the confluence with the Cache La Poudre River, except for specific listings in Segment 9. | X | | X | | | X | | | X |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| COSPCP09 | Mainstem of Rabbit Creek and Lone Pine Creek from the source to the confluence with the North Fork of the Cache La Poudre River. | X | X | | | | X | | | X |
| COSPCP10a | Mainstem of the Cache La Poudre River from the Munroe Gravity Canal Headgate/North Poudre Supply Canal diversion to a point immediately above the Larimer County Ditch diversion (40.657, -105.185) | X | X | | | | X | | | X |
| COSPCP10b | Mainstem of the Cache La Poudre River from a point immediately above the Larimer County Ditch diversion (40.657, -105.185) to Shields Street in Ft. Collins, Colorado. | X | | X | | | X | | | X |
| COSPCP11 | Mainstem of the Cache La Poudre River from Shields Street in Ft. Collins to a point immediately above the confluence with Boxelder Creek. | X | | | X | | X | | | |
| COSPCP12 | Mainstem of the Cache La Poudre River from a point immediately above the confluence with Boxelder Creek to the confluence with the South Platte River. | X | | | X | | X | | | |
| COSPCP13a_B | Dry Creek and all tributaries. | X | | | | X | X | | | |
| COSPCP13a_C | Spring Creek and Fossil Creek. | X | | | | X | X | | | |
| COSPCP13b | Mainstem of Boxelder Creek from its source to the confluence with the Cache La Poudre River. | X | | | | X | | X | X | |
| COSPCP13c | Mainstems of South Branch of Boxelder Creek, North Branch of Boxelder Creek and Sand Creek from their sources to their confluences with the mainstem of Boxelder Creek. | X | | X | | | X | | | X |
| COSPLA02a | Mainstem of the Laramie River from the source to the National Forest boundary, and all tributaries and wetlands, from the source to the Colorado/Wyoming border, except for specific listings in Segment 1. | X | X | | | | X | | | X |

*Includes pilot priority North Fork Lone Pine Creek

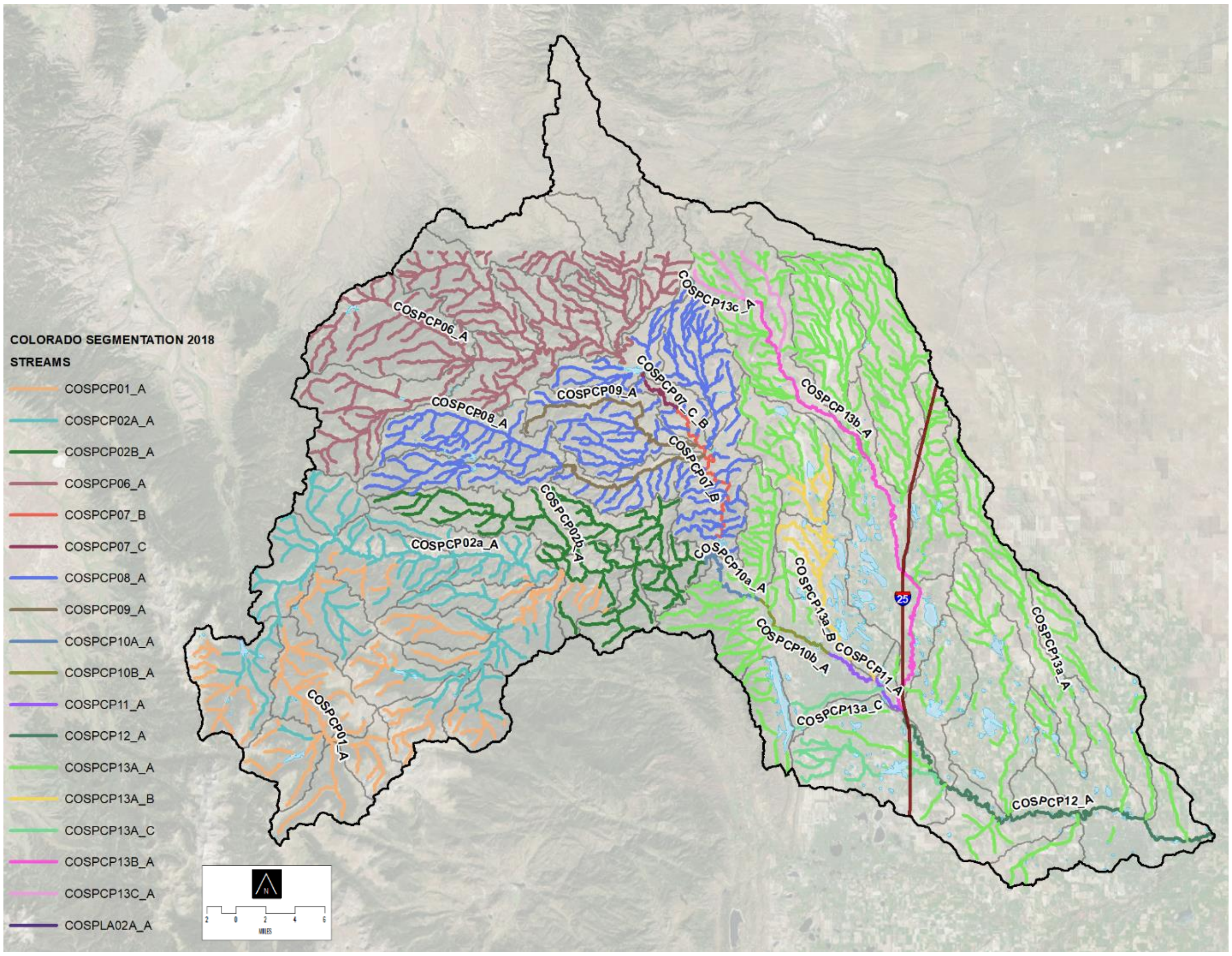



*Figure 4-1 Stream Segments in the Cache La Poudre Watershed*

## 4.2 Impaired Waters

Regulation 93 Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List establishes Colorado's Lists of Impaired Waters. Impaired waters are classified into the following categories including the three relevant to this analysis:

- Water-Quality-Limited Segments Requiring Total Maximum Daily Loads (TMDLs). A TMDL establishes the maximum amount of a pollutant allowed in a waterbody and serves as the starting point or planning tool for restoring water quality. This list is required by Section 303(d) of the CWA.
- Colorado's Monitoring and Evaluation List identifies water bodies where there is a reason to suspect water quality problems, but there is also uncertainty regarding one or more factors, such as the representative nature of the data. Waterbodies that are impaired, but it is unclear whether the cause of impairment is attributable to pollutants as opposed to pollution, are also placed on the Monitoring and Evaluation List.
- The list of Water-Quality-Limited Segments Not Requiring a TMDL identifies segments where data is available that indicates that at least one classified use is not being

supported, but a TMDL is not needed for various reasons that might include a TMDL that was already completed.

In order to assemble the list, the Colorado Water Quality Control Division (WQCD) reviews readily available water quality data, typically collected within five years of the assessment period, by segment relative to state water quality standards and proposes changes to the list to the WQCC. When adequate water quality data show the water quality standard is not being met, the waterbody is added to the 303(d) List, which is adopted by the WQCC. The WQCD then prioritizes the impaired segments on the 303(d) List for Total Maximum Daily Load (TMDL) development. The TMDL is the maximum amount of a pollutant that can be in the stream without exceeding the applicable water quality standards for that pollutant. Pollutant loads are calculated from water quality data and stream flows. The TMDL report includes an assessment of the existing sources and loads in the study area for both point and nonpoint sources, and then assigns reductions and resulting allowable loads (including a margin of safety) from each source that will meet the TMDL and thus meet water quality standards. The next step is developing a plan to address the sources identified in a TMDL and implement best management practices to reduce pollutants in order to meet the allowable load, and therefore the water quality standard.

Table 4-2 and Figure 4-2 illustrate the impaired waters in the CLP watershed according to the 2018 list[1]. Figure 4-3 and Figure 4-4 show the streams impaired for specific parameters. In summary:

- North Fork Cache la Poudre River five miles below Halligan Reservoir (COSPCP07) was listed as impaired due to sediment in the 1998 listing cycle. A TMDL was approved (EPA, 2002) for that impairment in 2002 and a TMDL goal of managing sediment flushing and release flows from Halligan Reservoir so as to attain the narrative sediment standard and fully support designated aquatic life uses.
- Of the eighteen stream segments in the CLP, fourteen are listed as impaired or on the monitoring and evaluation list (M&E List 2018). The majority of impairments are due to dissolved metals, primarily in the upper CLP.
- Stream segment COSPCP07, which covers the Mainstem of the North Fork of the Cache La Poudre River from the inlet of Halligan Reservoir to the confluence with the Cache La Poudre River has the most listings for dissolved metals, including silver, iron, cadmium, lead, and manganese.
- Eight segments are listed for total arsenic due to elevation above the water and fish standard of 0.02 ug/L. In many cases throughout the state, the technologically achievable arsenic level is higher than the water and fish standard, due to natural geography; thus the segments have a temporary modification for chronic arsenic standards[2].
- In the lower CLP, *E. coli* is listed on the Mainstem of the CLP and in Spring Creek and Fossil Creek.

[1] 5 CCR 1002-93

[2] 5 CCR 1002-38.6(2)(c)

*Table 4-2 List of Impairments by Segment in the CLP*

| Stream Segment or Sub-segment | Description | 303(d) Classification, 2018 List |
|---|---|---|
| COSPCP02a | Mainstem of the Cache La Poudre River, including all tributaries and wetlands, from the boundaries of Rocky Mountain National Park and the Rawah, Neota, Comanche Peak, and Cache La Poudre Wilderness Areas to a point immediately below the confluence with the South Fork Cache La Poudre River. | *Impaired without a TMDL:* Macroinvertebrates; Arsenic-T |
| COSPCP06 | Mainstem of the North Fork of the Cache La Poudre River, including all tributaries and wetlands, from the source to the inlet of Halligan Reservoir. | *Impaired without a TMDL:* Arsenic-T, Removed for Copper |
| COSPCP07_B | North Fork of Cache la Poudre River from five miles below Halligan Reservoir to the confluence with the mainstem of the Cache la Poudre River | *Impaired without a TMDL:* Cadmium-D; Lead-D; Manganese-D<br><br>*M&E List:* Silver-D; Arsenic-T; Iron-D |
| COSPCP07_C | North Fork Cache la Poudre River five miles below Halligan Reservoir | *Impaired with an approved TMDL:* Sediment<br><br>*M&E List:* Silver-D; Arsenic-T; Iron-D<br><br>*Impaired without a TMDL:* Cadmium-D; Lead-D; Manganese-D |
| COSPCP08* | All tributaries to the North Fork of the Cache La Poudre River, including all wetlands from, the inlet of Halligan Reservoir to the confluence with the Cache La Poudre River, except for specific listings in Segment 9. (Includes pilot priority North Lone Pine Creek HUC) | *M&E List: E. coli*<br>*Impaired Arsenic (2020)* |
| COSPCP09 | Mainstem of Rabbit Creek and Lone Pine Creek from the source to the confluence with the North Fork of the Cache La Poudre River. | *M&E List:* pH<br><br>*Impaired without a TMDL:* Arsenic-T |

| | | |
|---|---|---|
| COSPCP10a | Mainstem of the Cache La Poudre River from the Munroe Gravity Canal Headgate/North Poudre Supply Canal diversion to a point immediately above the Larimer County Ditch diversion (40.657, -105.185) | <u>*Impaired without a TMDL*</u>: Arsenic-T; Temperature |
| COSPCP10b | Mainstem of the Cache La Poudre River from a point immediately above the Larimer County Ditch diversion (40.657, -105.185) to Shields Street in Ft. Collins, Colorado. | <u>*Impaired without a TMDL*</u>: Arsenic-T |
| COSPCP11 | Mainstem of the Cache La Poudre River from Shields Street in Ft. Collins to a point immediately above the confluence with Boxelder Creek. | <u>*Impaired without a TMDL:*</u> *E. coli* |
| COSPCP12 | Mainstem of the Cache La Poudre River from a point immediately above the confluence with Boxelder Creek to the confluence with the South Platte River. | <u>*M&E List:*</u> pH<br><br><u>*Impaired without a TMDL*</u>: *E. coli* (may-dec) |
| COSPCP13a_B | Dry Creek and all tributaries. | <u>*Impaired without a TMDL*</u>*:* Manganese-D; Sulfate |
| COSPCP13a_C | Spring Creek and Fossil Creek. | <u>*Impaired without a TMDL*</u>*: E. coli* |
| COSPCP13b | Mainstem of Boxelder Creek from its source to the confluence with the Cache La Poudre River. | <u>*Impaired without a TMDL*</u>: Selenium-D; *E. coli* |
| COSPLA02a | Mainstem of the Laramie River from the source to the National Forest boundary, and all tributaries and wetlands, from the source to the Colorado/Wyoming border, except for specific listings in Segment 1. | <u>*M&E List*</u>*:* Arsenic-T; Manganese-D; pH |

*Includes pilot priority North Fork Lone Pine Creek

COSPCP13a_A includes pilot priority Sheep Draw, which has no associated impairments

T = Total

D = Dissolved

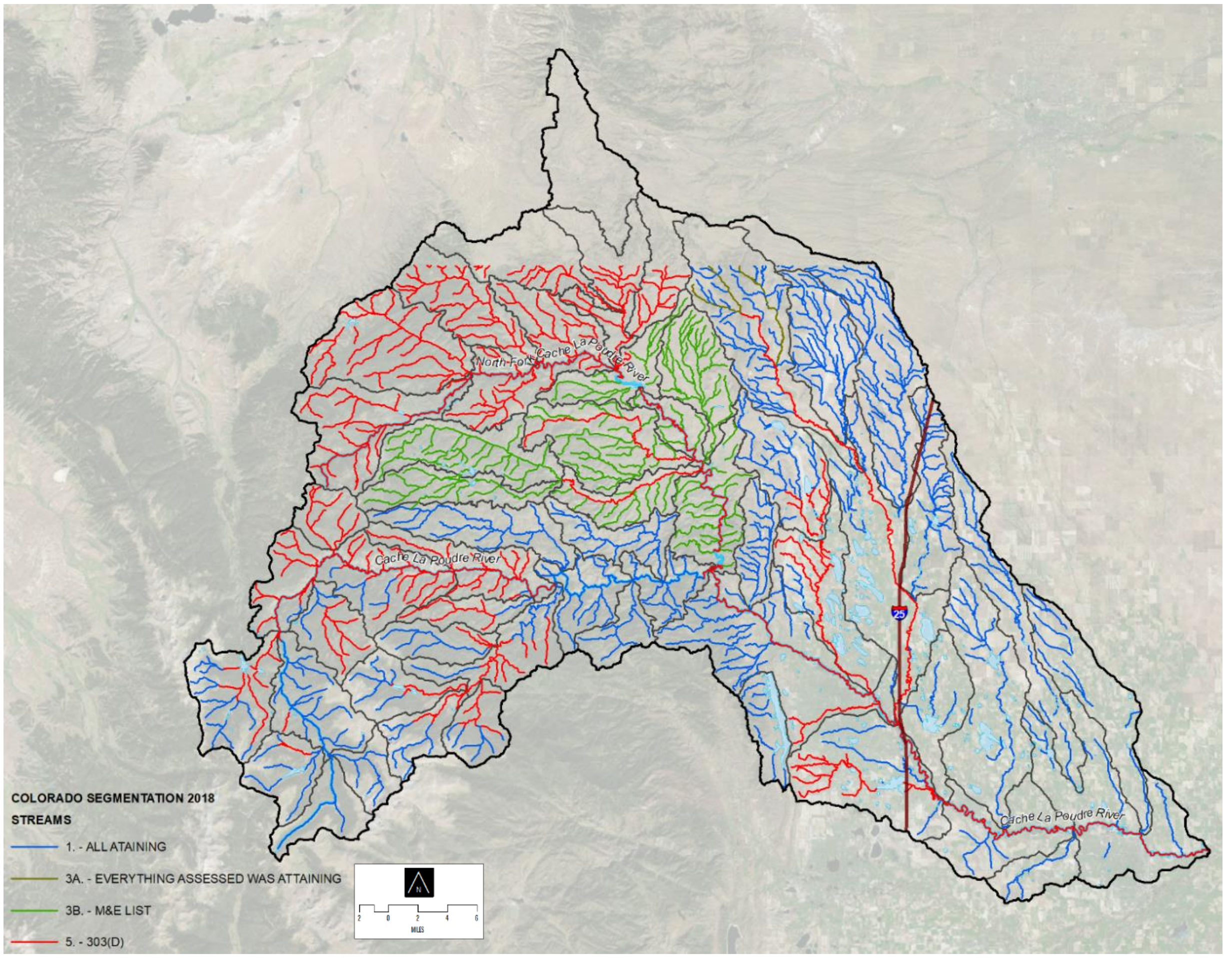



*Figure 4-2 Impaired Waters in the Cache La Poudre Watershed*

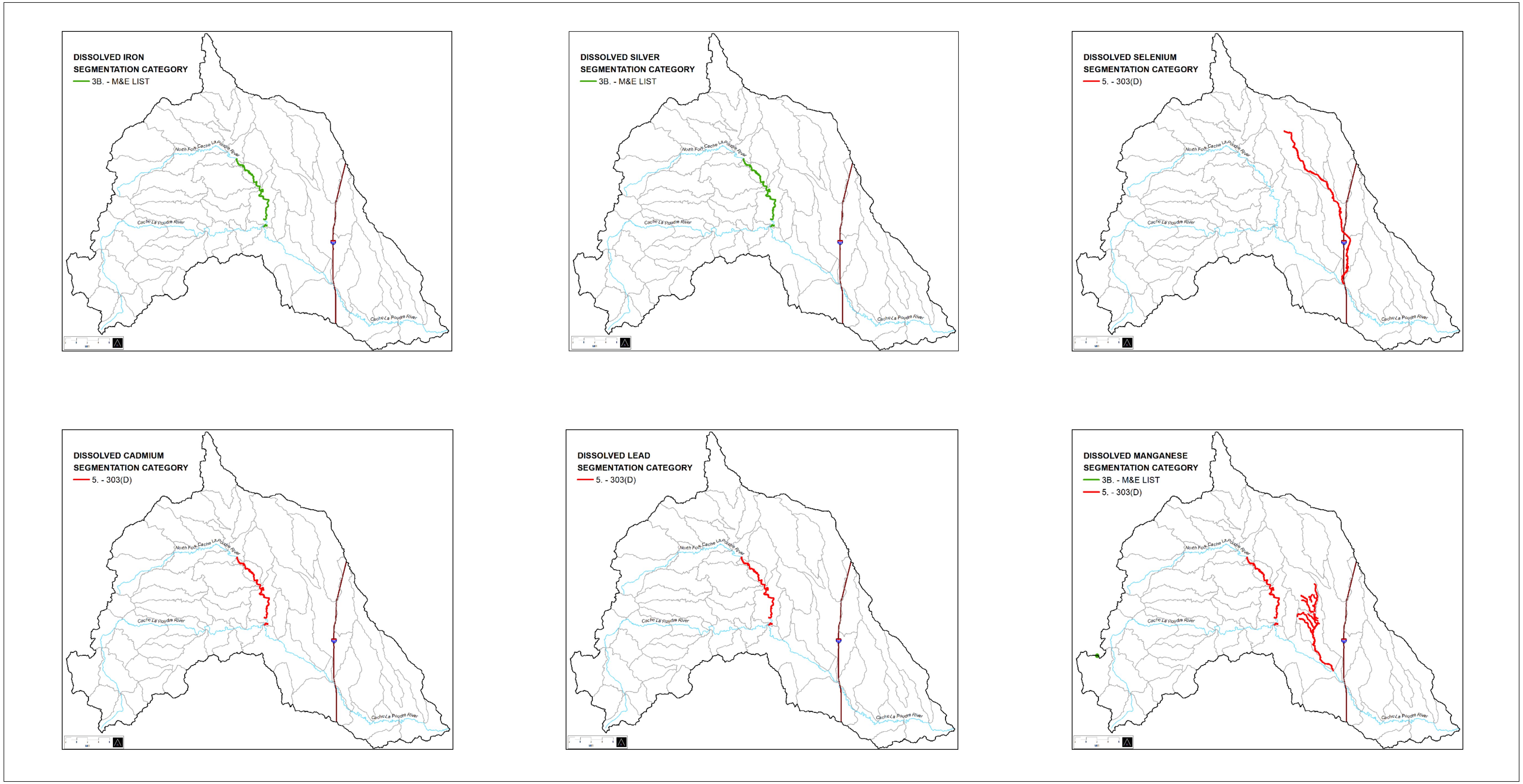



*Figure 4-3 Impaired Waters: Dissolved Metals*

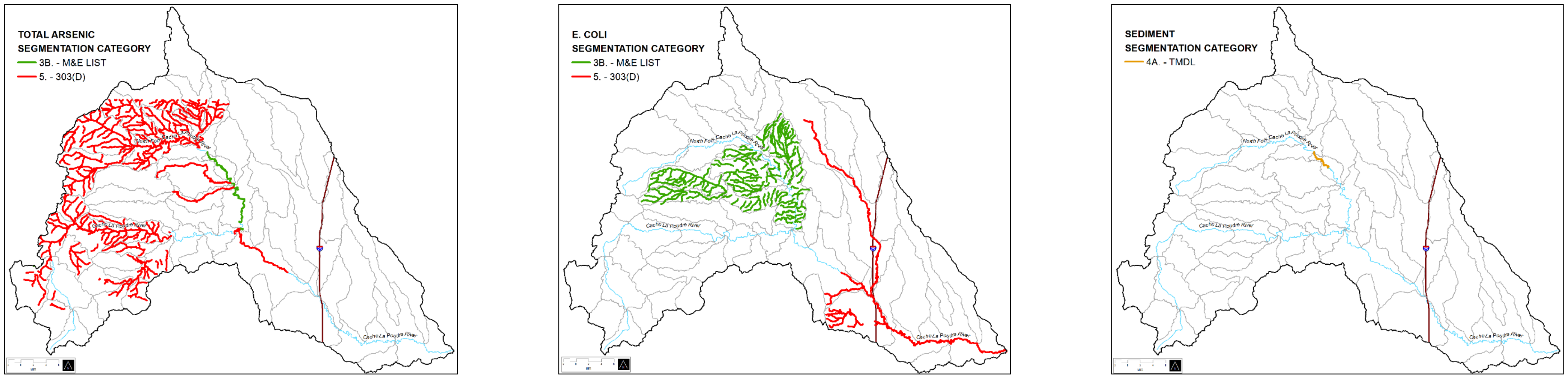



*Figure 4-4 Impaired Waters: Other Parameters*

# 4.3 Surface Water Quality

## 4.3.1 Data Compilation

Data compilation as part of this watershed planning included local, national and state water quality databases. The following data sources were compiled into the CPRW Water Quality database:

- **National Water Quality Monitoring Council Water Quality Portal (WQP):** The WQP is a cooperative service sponsored by the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), and the National Water Quality Monitoring Council (NWQMC), that integrates publicly available water quality data from the USGS National Water Information System (NWIS), the Water Quality Data Exchange (WQX), (Formerly STOrage and RETrieval (STORET)) Data Warehouse), and the United States Department of Agriculture (USDA) ARS Sustaining The Earth's Watersheds - Agricultural Research Database System (STEWARDS); and
- **Colorado Data Sharing Network (CDSN):** The CDSN is a source for uploaded Water Quality data recovered in the state of Colorado by a variety of entities including Colorado Department of Health and Environment (CDPHE), CO River Water, the Summit Water Quality Committee, and others. Because there is an optional feature to upload data to the EPA WQX database when data are uploaded to CDSN, the CDSN data has a significant overlap with the WQP; however, there are also unique records within CDSN.
- **Upper Cache la Poudre (UCLP) Watershed Collaborative Monitoring Program:** The UCLP program was established in 2008 and is designed to assist the City of Fort Collins, the City of Greeley and the Soldier Canyon Water Treatment Authority in meeting current and future drinking water treatment goals by reporting current water quality conditions and trends within the Upper Cache la Poudre River watershed and summarizing issues that potentially impact watershed health and source water quality. Sampling efforts are divided between the Upper Mainstem (including the Little South Fork Cache la Poudre River) and North Fork Cache la Poudre River watersheds.
- **Northern Water Quality Data (Northern) Water Quality Monitoring**: Northern Water's water quality monitoring activities include several programs, including multiple sites along the CLP mainstem, major tributaries and agricultural ditches for nutrients, metals, general chemistry and physical parameters (Northern Water, 2019). Northern Water water quality data was downloaded from the Northern Water Quality Data Retrieval portal[3].

Data acquisition and processing involved multiple steps, including standardization of constituent names and units, exclusion of CDSN records that are redundant with monitoring that is also included within the WQP and classifications of monitoring points with associated HUCs and stream segments.

[3] Northern Water Quality Data Retrieval Portal: http://www.northernwater.org/DynData/WQDataMain.aspx

The dataset includes multiple types of monitoring point locations, as illustrated in Figure 4-5. Figure 4-6 shows the stream monitoring locations by data source.

The CPRW Water Quality database contains:

- Hundreds of parameters, including metal, nutrients, general chemistry, and physical parameters
- Over 500 total monitoring locations with more than 350 stream monitoring locations
- Over 200,000 results

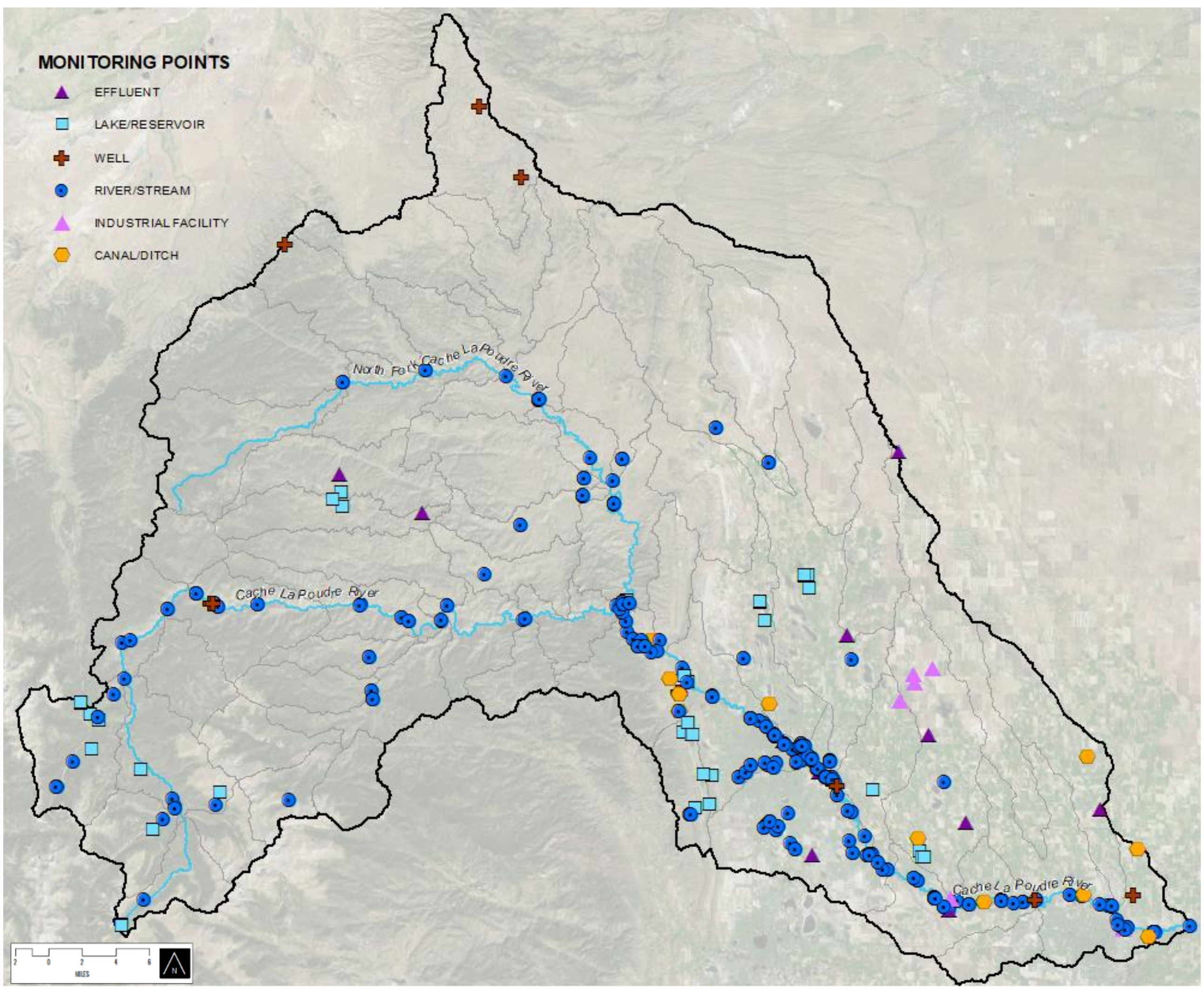



*Figure 4-5 CPRW Water Quality Database Compiled Water Quality Monitoring Points by Type*

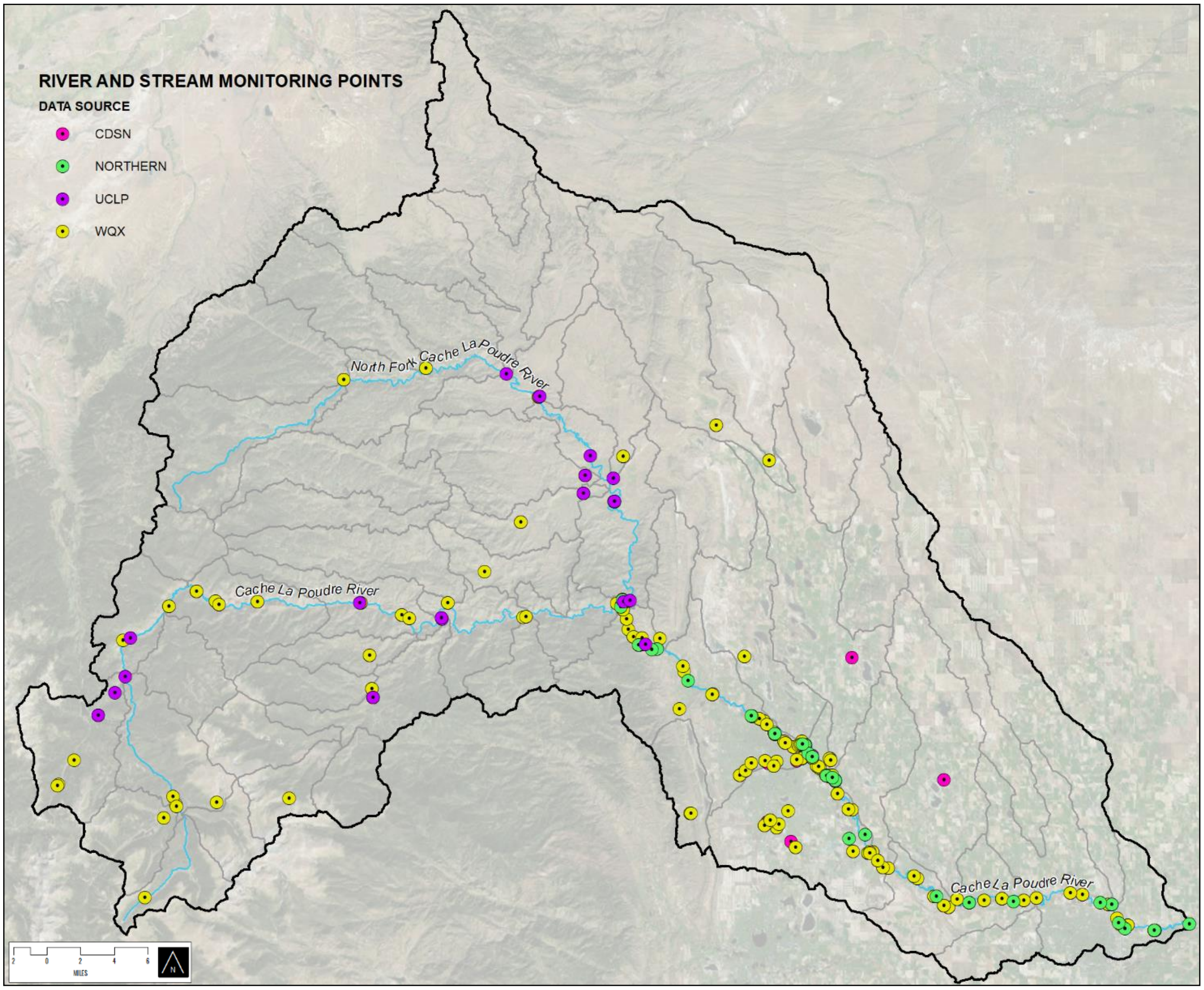


*Figure 4-6 CPRW Water Quality Database Stream Sites by Data Source*

## Tool Highlight: CPRW Water Quality Dashboard

As part of this watershed planning effort, CPRW developed an interactive Water Quality Dashboard[4] utilizing Google Data Visual Studio to leverage the large number of water quality monitoring locations and data available for each parameter to meet diverse requirements. This Dashboard enables CPRW to efficiently access, filter, visualize, analyze and export select data for both this initial planning effort as well as to facilitate assessments and evaluations for future projects. The examples below illustrate CPRW Water Quality Dashboard pages that provide results in tabular and graphical format.

#### 4.3.1.1 Monitoring Summary Statistics: Tables

DataSource | Year | Month | Parameter Group | Parameter | HUC12

StreamName | MP Type | LocID | Description

CPRW Monitoring Summary Statistics

| Data... | HUC12 | Stream | StreamName | Description | MP Type | Parame... | Paramet... | 85th... | Medi... | Min | Max | Count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | Carestream Health, Inc Effluent Di... | Facility Ind... | Nutrients | TP | 0.47 | 0.29 | 0.08 | 9.43 | 58 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589107 Saddler Ridge Metro ... | Facility Mu... | Nutrients | TP | 8.5 | 8.5 | 8.5 | 8.5 | 1 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589009 Severance | Facility Mu... | Nutrients | TP | 7.67 | 7 | 0.81 | 8.95 | 29 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | CARESTREAMEFF, Carestream He... | Facility Ind... | Nutrients | TP | 0.48 | 0.29 | 0.08 | 9.43 | 46 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589107 Saddler Ridge Metro ... | Facility Mu... | Nutrients | TKN | 1.2 | 1.2 | 1.2 | 1.2 | 1 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589009 Severance | Facility Mu... | Nutrients | TKN | 14.18 | 8.76 | 4.4 | 26.7 | 29 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | Carestream Health, Inc Effluent Di... | Facility Ind... | Nutrients | TKN | 8.53 | 4.57 | 1.24 | 13.07 | 58 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | CARESTREAMEFF, Carestream He... | Facility Ind... | Nutrients | TKN | 7.46 | 4.07 | 1.24 | 13.07 | 46 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589107 Saddler Ridge Metro ... | Facility Mu... | Nutrients | NO3+NO2 | 44.96 | 44.96 | 44.96 | 44.96 | 1 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589009 Severance | Facility Mu... | Nutrients | NO3+NO2 | 23.94 | 18.63 | 0 | 27.37 | 26 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589107 Saddler Ridge Metro ... | Facility Mu... | Nutrients | NO3 | 44.79 | 44.79 | 44.79 | 44.79 | 1 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | COG589009 Severance | Facility Mu... | Nutrients | NO3 | 21.2 | 15.84 | 3.41 | 26.64 | 18 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to... | Carestream Health, Inc Effluent Di... | Facility Ind... | Nutrients | NO3 | 11.15 | 7.55 | 1.11 | 16.75 | 58 |
| Public | Windsor Reservoir | COSPCP13a | All tributaries to | CARESTREAMEFF Carestream He | Facility Ind | Nutrients | NO3 | 11.12 | 7.52 | 1.11 | 16.75 | 46 |

*Figure 4-7 Monitoring Summary Statistics Page of the CPRW Water Quality Dashboard*

The monitoring summary statistics page allows users to view and export the 85th percentile, median, minimum, maximum and count of results for each monitoring point and parameter combination (Figure 4-7). Results can be filtered by multiple attributes, including Data Source (e.g. upper CLP), Parameter Group, Monitoring Point Type and HUC12. Filtering allows users to quickly target locations and parameters of interest. Likewise, data can be aggregated by selected years and/or months. For example, users can quickly ascertain the 85th percentile values for the last five years of data or look at the median values of specific months and seasons.

[4] CPRW Water Quality Dashboard: https://datastudio.google.com/open/1MTN3K6k1L8QzLc2aEj-s-sHtkQ7oYCFe

#### 4.3.1.2 Parameter Breakout: Graphs

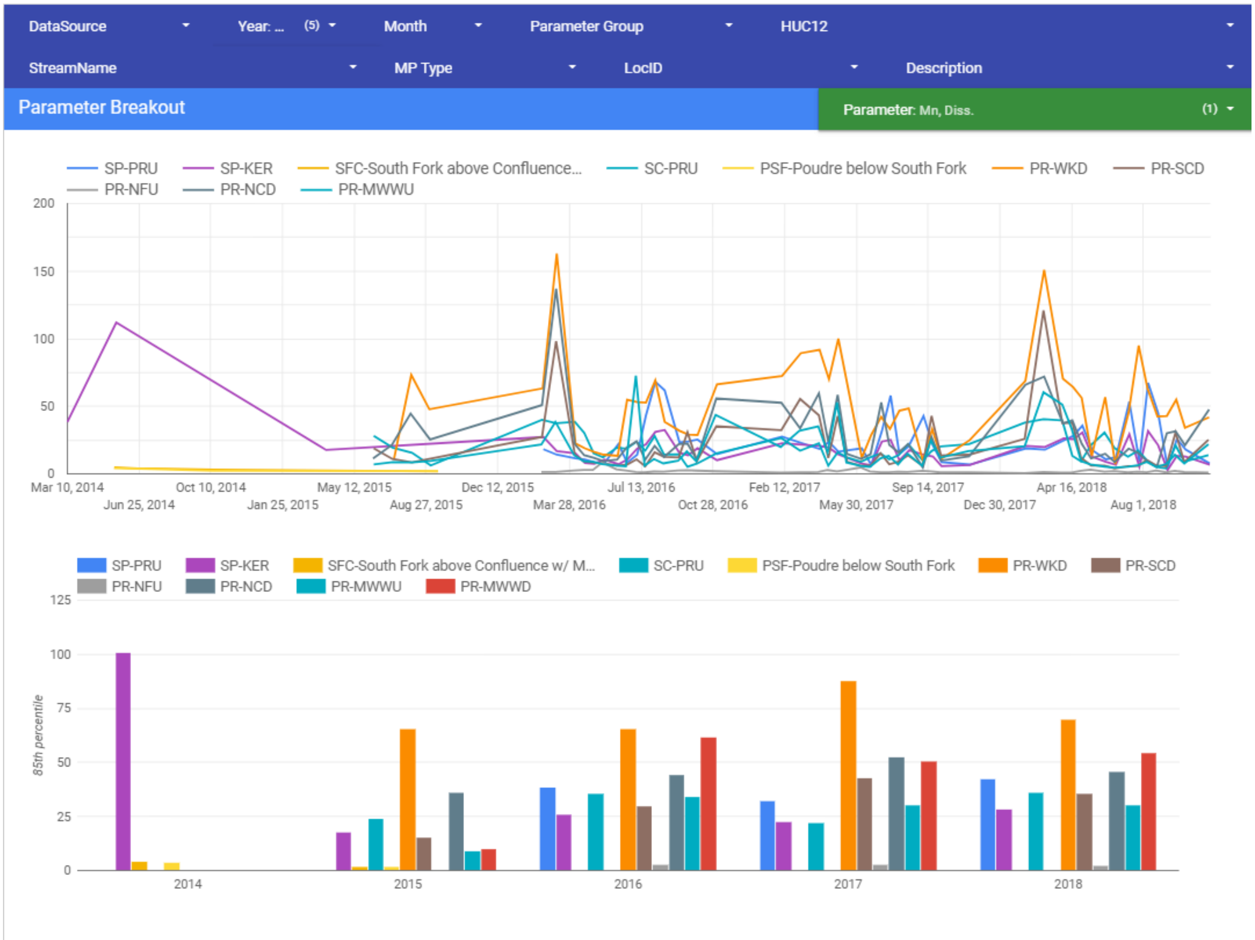



*Figure 4-8 Parameter Summary Page of the CPRW Water Quality Dashboard*

The parameter summary page allows users to view time series and yearly summary graphs for selected monitoring points and timeframes for a selected parameter (Figure 4-8). Results can be filtered by multiple attributes, including HUC12 area and Monitoring Point Type. Similar to the Monitoring Summary Statistics page, filtering allows the user to target specific scenarios, such as viewing the time series and yearly summary results for a selected parameter and HUC12 region.

### 4.3.2 Water Quality Summary Illustration: Nutrients

The CPRW Water Quality Dashboard results can be integrated with the geodatabase to illustrate monitoring point statistical summaries for selected time periods throughout the watershed. This section illustrates these results for a subset of nutrient parameters, as nutrients were identified as a key parameter group of concern by the stakeholders (See section 4.4.1 for more information.) CPRW can use the CPRW Water Quality Dashboard and Spatial Database to illustrate additional water quality summary maps.

Figure 4-9 illustrates summary information for total phosphorus and Figure 4-10 illustrates summary information for nitrate plus nitrite ($NO_2$+$NO_3$); Although $NO_2$+$NO_3$ has its own standard, $NO_2+NO_3$ was used as a proxy for total nitrogen, as significantly more data is available for $NO_2+NO_3$ than total nitrogen. $NO_2+NO_3$ is potentially an underestimate of total nitrogen, as total nitrogen is made up of $NO_2+NO_3$ plus total kjeldahl nitrogen.

The nutrient water quality summary information illustrates that both phosphorus and nitrogen values tend to increase in the lower portion of the watershed east of I-25. Downstream summary values are consistently above the interim total phosphorus (170 ug/L) and total nitrogen (2,010 ug/L) standards. Although the application of these numerical standards to stream segments is not planned until after May 31, 2022, the higher nutrient levels in the lower CLP indicate a potential impairment on which CPRW and its stakeholders are targeting for reduction activities.

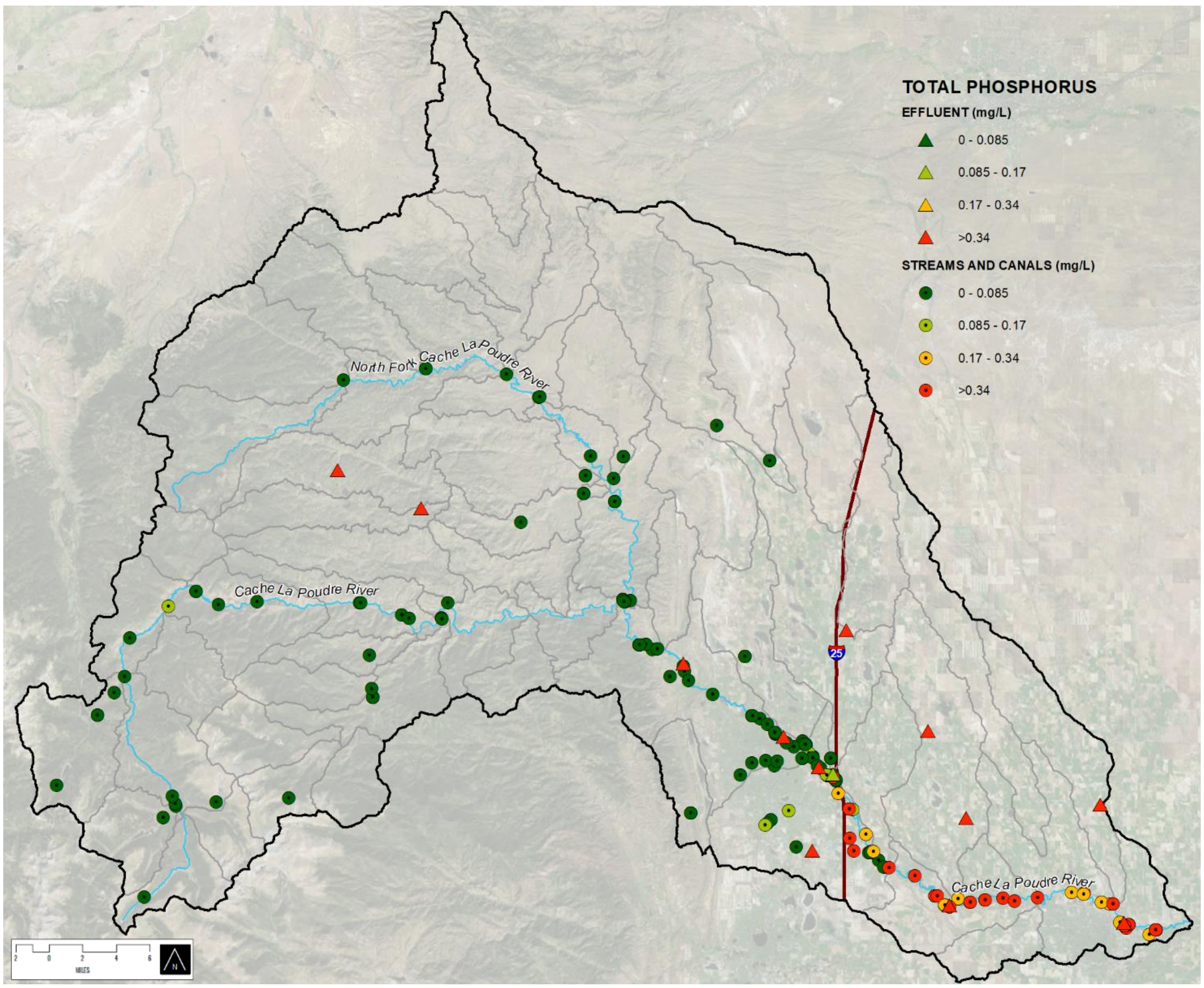



*Figure 4-9 Total Phosphorus median Values for Stream, Canal and Wastewater Treatment Plant Data Available from 2008-2018*

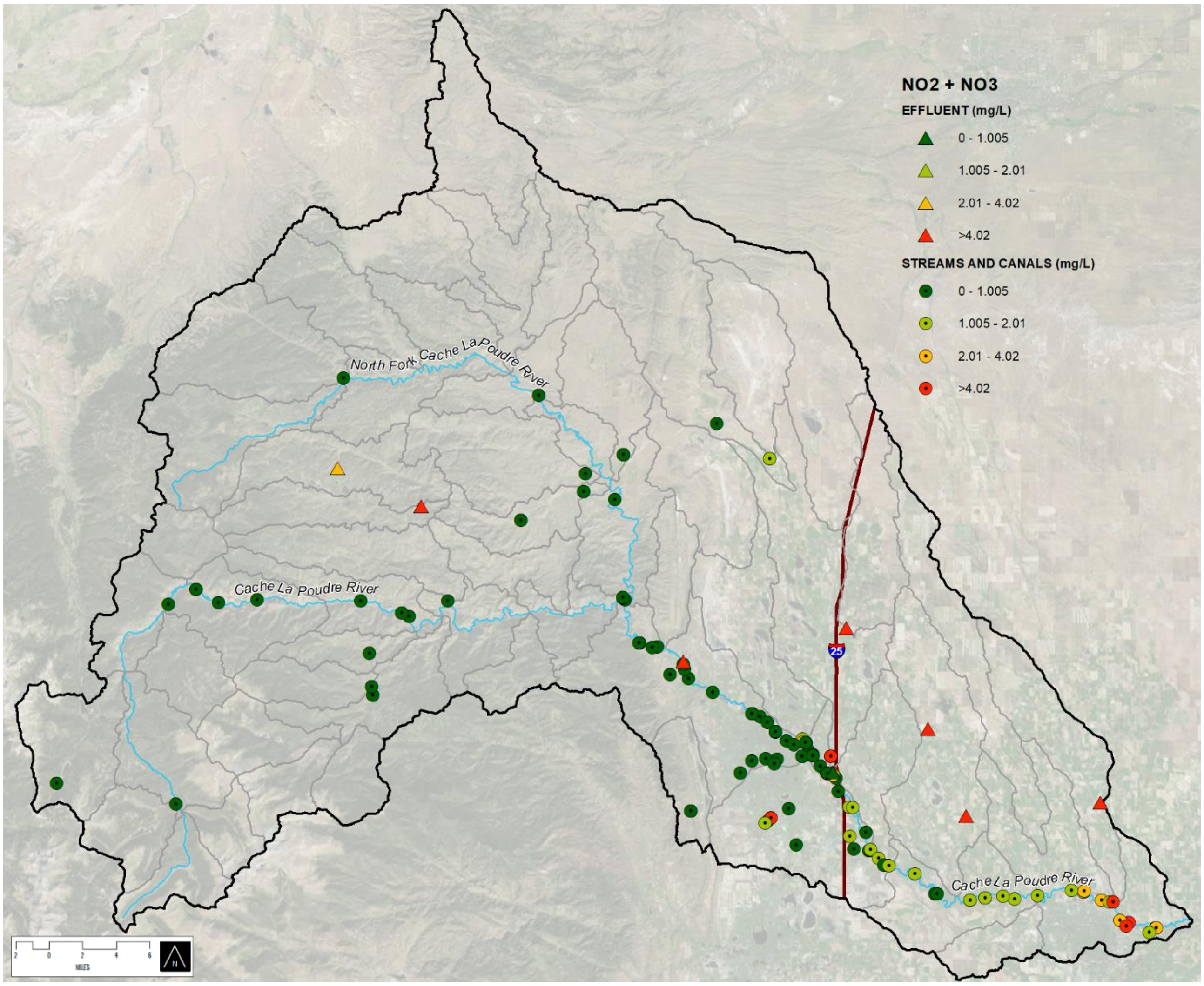


*Figure 4-10 NO2 + NO3 Median Values for Stream, Canal and Wastewater Treatment Plant Data Available from 2008-2018*

Similar statistical summary results generated from the CPRW Water Quality Dashboard are available within the CPRW Spatial Database and can be utilized for future planning efforts focused on other parameters.

## 4.4 Summary of Potential Parameters of Concern

As illustrated in Sections 4.2 and 4.3 above by the 303(d) listings and the nutrient water quality analysis, several parameters are of potential concern in the CLP watershed towards which the CPRW can focus restoration efforts, including but not limited to:

- Sediments
- Nutrients
- Dissolved Metals
- Temperature
- *E. Coli*

*Both the CPRW Water Quality Dashboard and the Spatial Database tools can be leveraged in future efforts to help investigate and analyze the water quality associated with these parameters throughout the watershed.*

CPRW and its stakeholders reviewed the list of the parameters to identify which pollutants on which to focus the initial framework application analysis. For this initial planning effort, CPRW elected to focus on two constituents: Sediments in the upper CLP and nutrients in the lower CLP for the reasons described in Section 4.4.1.

Stakeholders were also interested in the potential for analyzing *E. coli* and temperature given the extent of the listed reaches. However, both parameters have ongoing planning efforts that are examining ways to measure and estimate loadings and develop potential solutions to these specific associated water quality problems. An effort to develop Total Maximum Daily Loads for *E. coli* on five listed reaches in the Poudre is set to launch in 2020. That process will examine sources, loadings, and develop BMPs to reduce loadings. Even though this effort is not analyzing all reaches that are listed for *E. coli*, it seemed duplicative to initiate a separate effort on *E. coli* in the headwaters. Similarly, a working group of local jurisdictions is currently meeting to analyze temperature issues on the Poudre, specifically in the listed reach, to analyze what actions may be taken to address the listing.

Arsenic was not identified as a high priority by the watershed stakeholders. Arsenic standards are currently being evaluated within the Water Quality Forum Basic Standards Workgroup process. During the 2005 Basic Standards Rulemaking Hearing, a chronic "Water + Fish" standard was developed based on the potential for human consumption of fish and use of the water as a water supply. It should be noted that elevated background concentrations of arsenic occur in many waterbodies across Colorado, and arsenic sources are now being explored statewide to determine natural variability and to identify potential controls. The WQCC has adopted an arsenic temporary modification for streams in Colorado with dischargers, that expires on December 31, 2024[5].

## 4.4.1 Focus Constituents: Sediments and Nutrients

### 4.4.1.1 Sediments in the Upper CLP

As illustrated above, a portion of the North Fork of the CLP was listed as impaired due to sediment. In addition, several other impairments, specifically dissolved metals, are also listed in the upper Cache La Poudre. Pathogens, metals and nutrients can enter waterways with sediment. These pollutants exist in various phases but once attached to particles (sediment and/or organic matter) they can persist in the sediment bed. Pollutants sorbed to sediment can be transported in the water column. Pollutants that have settled out of the water column as the

[5] The arsenic temporary modification expiration date was recently changed to 2024 from 2021 at the December 9, 2019 Temporary Modifications Rulemaking Hearing.

sediment settles out can be re-suspended during high flows (Cervantes 2012, Chon et al., 2012) or can be released during anoxic conditions at the bottoms of lakes and reservoirs.

Therefore, BMPs that reduce sediment pollution can also reduce the loading of other pollutants that bind to or are transported by sediment entering waterways (Lee et al., 2000). Many BMPs aimed at reducing sediment pollution do so by reducing the amount of runoff or slowing the velocity runoff which reduces erosion and transport of other pollutants on the surface. Thus, by targeting sediments and associated sediment BMPs, CPRW will also address multiple impairments in the upper CLP as an additional non-quantified benefit.

The 2012 wildfires in the Poudre (Hewlett Gulch and High Park Fire) clearly demonstrated the dramatic negative impacts that high intensity wildfires can have on water quality. High intensity wildfires can negatively alter post fire hydrology and sedimentation, causing very large increases in surface runoff and subsequent sedimentation, debris flows, and erosion. Post fire rain events thus cause significant degradation of water quality. The Poudre supplies drinking water for ~300,000 people and therefore, intense stressors like High Park Fire can limit or impair the ability of the Poudre to reliably deliver drinking water. During the Upper Poudre Resiliency Planning process, sediment issues from wildfires were identified as primary stakeholder concerns.

#### 4.4.1.2 Why Sediments from Roads?

Although wildfires can have dramatic negative impacts to water quality, research has shown that unless best management practices are adhered to, roads can collectively contribute high amounts of sediment to water supplies (Niah et al 2017). Research has shown that forest roads are a primary source of long-term sediment delivery in forested headwaters, such as those in the Upper CLP. The Lower CLP has limited forest roads, but may have increased sediments from construction activities. Some have estimated roads contributing 1 to 10 tons of sediment per acre annually (Elliott, 2000; MacDonald and Stednick, 2003, cited in Niah et al 2017). Estimates of sediment delivery from roads in Colorado are slightly higher, ranging from from about 2 to 31 tons per acre in a given year (MacDonald and Stednick, 2003; L. MacDonald, pers. comm., Sept. 26, 2016, cited in Niah et al 2017). The potential for erosion from unpaved roads to delivery sediment to streams is generally proportional to the amount of watershed affected. Given that there are concerns about expansion of residential development across Colorado's forested headwaters, there is the potential for unpaved roads to increasingly put water quality at risk (Niah et al 2017).

Although the scientific literature indicates significant potential risk to water quality and other watershed values from road-related sediment delivery, there are few road-erosion studies from Colorado. Additionally, researchers have identified a strong need for the development of tools to predict the delivery of sediment from unpaved roads into and through the stream channel network (MacDonald and Stednick 2003). There are very few studies that have examined sediment delivery from roads to streams (MacDonald & Stednick, 2003). Even though high intensity wildfires are generally considered to be the most significant to water quality in the headwaters (City of Fort Collins, 2016), those events are episodic, have been well studied[6], and there are

[6] For example, a recent analysis conducted by consultants for CPRW estimated sediment yields in North Fork Lone Pine Creek that may result from high intensity wildfires. The analysis showed that pre-burn, sediment yields in North Fork Lone Pine Creek would be ~4 ton/ha/yr, while post high intensity wildfires, could expect sediment yields of ~1100 ton/acre/yr, a 300% increase. (SolSpec 2019)

significant management efforts being directed at reducing the threat they pose to water quality in the Poudre. Sediment delivery from the road system in the headwaters may be a smaller total quantity, but this source is chronic and persistent in nature. Stakeholders were interested in what chronic inputs of sediment may be contributing to the watershed to better understand what additional BMPs or restoration actions may be planned and implemented to address all negative consequences of sediment in high priority areas of the watershed. The paucity of data and analysis of this important aspect of sediment impacts on water quality in the Poudre prompted CPRW and its stakeholders to focus on this issue for further analysis.

#### 4.4.1.3 Nutrients in the Lower CLP

Nutrients (nitrogen and phosphorus) are natural and necessary parts of aquatic ecosystems. Nutrients support the growth of aquatic plants and algae, which in turn provide food and habitat for aquatic organisms. However, they can cause significant water quality degradation when their concentrations are too high in creeks, streams, rivers, and other waterbodies. Nutrient pollution is a common water quality concern across North America, including in Colorado.

In the Poudre, concentrations tend to increase as the river flows downstream, which coincides with increasing potential point and nonpoint sources from urban and agricultural sources. In 2012, state water quality regulators initiated Regulation 85, which would more strictly regulate point sources of nutrient discharges. While nonpoint source reductions of nutrients are not mandatory in the regulations, nonpoint dischargers are encouraged to reduce nutrient discharges through the voluntary adoption of best management practices that can reduce nutrient pollution in surface waters. Regulation 85 has a deadline of 2022 for voluntary reductions in nutrient discharges. These new regulatory standards have created interest among stakeholders in planning for a range of activities that can assist with managing nutrient concentrations and are one of the drivers behind stakeholder interest in focusing on nutrients for this project.

As illustrated in Section 4.3.2 water quality monitoring results for nutrients in the lower CLP indicate that stream segment COSPCP12 may be impaired for nutrients based on the interim values in WQCC Regulation 5 CCR 1002-31.17. Stakeholders in the lower CLP identified nutrients as a key parameter of concern. Nutrients enter water bodies through point and nonpoint sources; CPRW will focus on nonpoint sources.

# 5 Source and Loading Assessment

Identifying pollution sources and estimating pollutant loading is essential to targeting future management actions. Knowing where pollutants are coming from allows stakeholders to more effectively control and combat sources to restore and protect the watershed. A loading analysis provides a numeric estimate of pollutant loads coming from the various sources in the watershed. The estimates of source loads allow managers to evaluate the relative magnitude of pollution from different sources and identify potential “hot spots”. Together, the source identification and loading assessment help stakeholders plan restoration strategies, target load reduction efforts and estimate the projected future loads under different conditions (i.e. after restoration).

As described in Section 4.4.1, for this initial planning effort CPRW identified sediments from roads as a key source of sediment to be investigated in the upper CLP and nutrients as the focus constituents for the lower CLP. The source and loading assessment presented in the following sections focuses on these areas. In addition, the watershed characterization, including the Geodatabase and Water Quality Dashboard tools, can be used to support potential source and loading assessments of other parameters of concern.

In order to conduct the source and loading assessment:

- A suite of models was evaluated to determine which models would be most appropriate to identify sources and loads for the identified parameters of interest;
- The selected models were applied to the upper CLP and lower CLP to quantify sources and loading from road sediments and nutrients, respectively;
- CPRW selected Priority HUC12 areas on which to focus further evaluation based on model results, stakeholder input and logistical factors, as detailed in Section 5.4

## 5.1 Watershed Model Evaluation

### 5.1.1 Model Criteria

Models for watershed planning vary in their range of parameters and BMPs that can be modeled and their capability to assess the effectiveness of selected BMPs. The primary water quality parameters of interest to CPRW in the priority HUC regions are sediments from roads (in the Lone Pine Creek area); nutrients are the primary water quality parameters in the lower CLP. *E. Coli* has also been identified as a secondary water quality parameter of interest. Therefore, it is appropriate to select two models that are more tailored to different land use types and parameters and the associated BMPs for each region. The selected watershed models will be utilized within the CPRW watershed planning effort to assist in:

- Identifying sources of nonpoint source pollution at the watershed scale
- Quantifying nonpoint source pollution at the watershed scale
- Exploring how various Best Management Practices (BMPs) could reduce nonpoint source loading in priority HUCs

Based on the modeling objectives, the model evaluation criteria included:

1. Inclusion of primary water quality parameters of interest
2. Data availability: Is required data available in the priority HUCS?
3. Ease of use: data input, processing, and output, transferability to other HUCs
4. Provides loading estimates from different sources
5. Suitable for use in small watersheds (HUC12 size)
6. Inclusion of BMPs of interest to CPRW
7. Prefer a model where BMP implementation scenarios can be run in the model

### 5.1.2 Model Summaries

Eight water quality models were examined for application in the Cache La Poudre Watershed. Table 5-1 and Table 5-2 present a comparison table that summarizes model parameters, BMPs, data needs and pros and cons for models considered for the upper CLP and lower CLP, respectively.

**GRAIP_Lite. Geomorphic Road Analysis and Inventory Package Lite.** GRAIP_Lite is used to model road-related sediment impacts to streams. It uses existing data sets (DEMs, GIS layer of roads) to calculate sediment production from individual road segments. GRAIP_Lite is often used in watershed assessments to prioritize subwatersheds for restoration or remediation efforts. Model outputs are described using specific sediment (mg/yr/km$^2$) which can easily be used to determine where the largest problems are. GRAIP_Lite has an alternatives module that allows the user to specify various treatment options for individual roads and model the road-related sediment impacts before, during and after the treatment. Examples of road treatments include creating new roads, decommissioning old roads, paving existing roads, changing the location or size of culverts, and changing the level of traffic on a given road.
*Note: A previous study in Montana found that GRAIP_Lite over-predicted the sediment contribution from roads in areas where observed erosion rates were low.*

**Automated Geospatial Watershed Assessment (AGWA)** is an ArcGIS interface that automates the transformation of spatial data into the required model inputs of two existing hydrologic models, the Soil and Water Assessment Tool (SWAT) and the Kinematic Runoff and Erosion Tool (KINEROS2). The user selects which hydrologic model to use; there are pros and cons to using one or the other. The advantage of selecting the SWAT model is having the additional capability to model nitrogen and phosphorus loading in addition to sediment loading. The advantage of selecting KINEROS2 is the ability to explicitly place best management practices (BMPs) in their geographically correct position (e.g., riparian buffer strips) and then model the effects of the BMPs. In either model, simulating BMPs requires the user to create a new overland flow-modeling element with the cover characteristics of the BMP and re-run the model. While AGWA does require a large set of GIS data, all the inputs are nationally available and can be supplemented with local data. For example, AGWA does not specifically account for sediment production from road erosion, except for when roads are large enough to appear as an NLCD land use class. For this project, roads are the greatest source of anthropogenic sediment in the forested upper portion of CLP River so roads need to be modeled in greater detail. An additional roads GIS layer can be overlaid on the NLCD data to achieve this.

**Watershed Erosion Prediction Project (WEPP)** is a series of tools developed by the U.S. Forest Service used to estimate soil erosion and sediment delivery on hillslopes and small watersheds. The two tools most relevant to this project are the WEPP::Road and the Disturbed WEPP. WEPP::Road is used to model erosion on existing or proposed forest roads and outputs an average annual sediment delivery. Disturbed WEPP is used to evaluate the impacts of forest management (thinning and fire) on erosion and sedimentation. Both tools are user-friendly, but do not have a spatial component so input parameters for each sub-watershed would need to be calculated separately in GIS.

**Spreadsheet Tool for Estimating Pollutant Load (STEPL)** calculates annual nutrient and sediment loads. Nutrient loading is calculated from different land uses and management practices. Sediment loading is calculated using the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The load reductions that result from implementing BMPs are computed for each sub-watershed in the model. STEPL is a spread-sheet based model making it very user-friendly and simple to use. There are a wide range of BMPs to choose from in the model and there is an option for the user to create a custom BMP. BMPs are not applied spatially and realistic values for BMP coverage would need to be calculated separately in GIS.

**Soil Water Retention Tool (SWAT)** is a river basin or watershed scale model that can be used to predict the impact of land management practices on nutrient and sediment loads. A recent extension of the SWAT model, ArcSWAT, encompasses many land use and water quality tools and can create spatial SWAT outputs. ArcSWAT also has the ability to analyze pathogens in addition to nutrients and sediment. SWAT is capable of analyzing complex watersheds and requires a significant amount of input data, most of which is publicly available. The model offers many agricultural BMPs, but has a limited urban BMPs (detention basins, infiltration practices, vegetative filter strips, street sweeping, and wetlands). One of the major benefits of using SWAT is the large amount of available literature, documentation and workshops available for using the model. However, the learning curve for this model can be high and may require significant customization.

**WERF SELECT Model** is a simple planning tool based in Excel that focuses on stormwater pollution. The SELECT tool models annual loads of TSS, N, P, and Zinc reaching receiving waters. This tool allows the user to examine the effectiveness and lifetime cost of a limited number of stormwater BMPs. The main model inputs are land use and a long-term record of hourly rainfall. The main benefit of this tool is the lifetime cost estimates of BMPs. The cons are that it only focuses on stormwater and has a limited set of BMPs that can be applied: Extended detention, Bio-retention, Wetland basin, Swale, Permeable pavement, Filter, Generic (user-defined).

**Watershed Analysis Risk Management Framework** is a model and decision support system that simulates hydrologic, physical, chemical, and biological processes. WARMF can account for various land use types as well as point and nonpoint sources of pollution. The model can output data for 40+ water quality parameters including sediment, nutrients, algae and bacteria. WARMF has a comprehensive simulation engine that allows the user to explore changes in land use and pollutant loading at the watershed scale. This is a relatively user-friendly and intuitive model. Its main use has been generating modeling pollutant allocations and necessary load reductions for the purpose of meeting TMDLs. BMPs are not applied spatially and realistic values for BMP coverage would need to be calculated separately in GIS. More detailed BMP analyses can be completed using WARMF in conjunction with other water quality models.

**eRAMS CLEAN Nutrient Dashboard** integrates the SWAT and SPARROW models in a framework developed to explore optimal nutrient abatement based on nutrient sources in a watershed. The tool accounts for nutrient loading from wastewater treatment plants (with varying technologies and upgrade options), urban stormwater, agricultural, and channel conditions. Each source of nutrients is modeled to determine baseline conditions and relative contributions of each source to the overall load. The effect of a range of BMPs and the cost to implement and maintain these practices can then be explored. One of the main benefits of the CLEAN Nutrient Dashboard is that it can summarize existing water quality information and explore a range of BMPs for all sources of nutrients. In addition, there is a depth of Colorado specific data included in the tool and local support from the model developers at CSU.

**Nutrient Tracking Tool (NTT)** is a web-based tool built to evaluate the economic and environmental impacts of management practices at the farm or small watershed level. Nutrient losses, sediment losses, and crop yield differences are estimated between BMP scenarios using data from the Agricultural Policy Environmental eXtender (APEX). Results from the model represent average nutrient and sediment losses from the field based on 35 years of simulated weather. BMPs in this model are specifically focused on agricultural practices and are typically applied at the field level. NTT has been tested for use in several U.S. States, but it has not been tested for use in Colorado. This will require input data (including default model parameters) and results to be carefully reviewed and screened before use to prevent misleading outcomes.

*Table 5-1 Models considered for estimating sediment yield and effects of BMPs in the upper CLP*

| Model | Tool Type | Considers roads? | Pollutants | Outputs | BMPs | Min Data Needs | Level of Effort | Pros | Cons |
|---|---|---|---|---|---|---|---|---|---|
| ***GRAIP_Lite**** | ***GIS tool*** | ***Yes*** | ***Sediment*** | ***specific sediment (Mg/yr/km$^2$)*** | ***Only road related*** | ***DEM, Roads GIS layer (can include more detail, e.g., culvert sizes and location)*** | ***Low*** | ***Focused on sediment from roads. Identifies which road segments have the highest contribution. Can target BMPs to specific road segments.*** | ***Can't expand to other sources or parameters.*** |
| STEPL | On-line or download Excel tool | Not specifically | Sediment, N, P, BOD, *E. coli* | Annual load from each source | Urban, Agriculture, Forest | Land cover. All other inputs provided (e.g., septic density, domestic animal populations) | Low for sediment in general Medium for roads-specific | Could easily estimate general sources and load reductions from different types of BMPs based on changes in land cover. Can optimize BMPs to achieve a specified load reduction. | Not road specific |
| AGWA | Downloaded Software | Not specifically, but can be modified | Sediment, N, P | Sediment yield, N/P load contributed by subwatershed | Change land cover characteristics. Could use for urban, agriculture and forest BMPs. | DEM, land cover data, soils data, precipitation | High, but with lots of supporting documentation. Modelling BMPs could be very time intensive. | High level of detail for BMPs and modeling scenarios. | High level of complexity and level of effort. |
| WEPP_road | Online | Yes | Sediment | Avg annual sediment delivery | Can only change the road conditions | Individual road segments data (e.g., length, pavement type, soil texture) | High. Model is very simple, but running scenarios/processing results must be done externally (excel) | Simple to run for specific road segments if have detailed road information. | Not spatially based.<br>Would need to run on an individual road segment basis. Doesn't save data. Manual process.<br>Specific road data not easily available. |
| Disturbed WEPP | Online | No | Sediment | Avg annual sediment delivery | Forest (burn and logging related) | Forest inputs (e.g., vegetation cover, road cover, soil texture, gradient, percent cover) | High. Model is very simple, but running scenarios/processing results must be done externally (excel) | Not road related.<br>Simple to run for specific scenario. | Road segment data would need to be extracted from GIS. |
| NTT | Online | No | Sediment, N, P | Nutrient and sediment losses from fields or small watershed | Agriculture | Agricultural Policy Environmental eXtender (APEX) (publicly available) | Low | Can estimate the effects of management changes at the field scale. User friendly and easy to use. | Has not been tested in Colorado. Only focuses on changes to agricultural practices. Hard to scale up. |

*Selected model

*Table 5-2 Models considered for estimating sediment and nutrient yield and effects of BMPs in the lower CLP*

| Model | Tool Type | Land Use (Urban/Ag) | Pollutants | Outputs | BMPs | Data Needs | Level of Effort | Pros | Cons |
|---|---|---|---|---|---|---|---|---|---|
| ***STEPL**** | ***On-line or download Excel tool*** | ***Both*** | ***Sediment, N, P, BOD, E. coli*** | ***Annual load from each source*** | ***Urban, Agriculture, Forest (Over 60 BMPs)*** | ***Land cover. Other inputs provided (by HUC12). We would aggregate data from GIS*** | ***Low*** | ***Could easily estimate general sources and load reductions from different types of BMPs based on changes in land cover. Can optimize BMPs to achieve a specified load reduction.*** | ***Can't specify location of BMPs (calculated on HUC12 land use percentage basis)*** |
| eRAMS CLEAN | Online, requires login on a free account | Both | N,P | Avg annual N/P load by source | Wastewater, stormwater, agriculture | All included in dashboard. Can upload additional water quality data. | Low | Easy to use, differentiates load by source, includes point sources | Limited number of BMPs. Agriculture and WWTP focused. |
| SWAT | Downloaded Software | Both | Sediment, N, P, *E.coli* (indirectly) | Daily, monthly or annual load | Mostly agricultural, limited urban options. | DEM, soil, precipitation, vegetation, and land management | High | Very detailed, versatile after set up | Significant upfront setup time, complicated to build BMP scenarios |
| WERF SELECT | Downloaded Excel-based tool | Urban | TSS, N, P, Zn, Cu, Fecal Coliform | Annual pollutant load, estimate of the whole life cost of the BMPs | Limited options. All urban stormwater. | Hourly rainfall, land use | Low | Stormwater specific | Focused only on stormwater |
| WARMF | Downloaded Software | Both | T, P, Fecal Coliform, algae | Annual loads and reductions required to meet TMDLs | Not directly, can adjust input parameters to simulate BMP effects | DEM, land use, fertilizer, point sources. Gauged flow, water quality data and nonpoint source data are required for calibration. | Medium | Can specify location of BMPs, ability to analyze 40+ parameters | High level data input requirements and learning curve |
| NTT | Online | No | Sediment, N, P | Nutrient and sediment losses from fields or small watershed | Agriculture | Agricultural Policy Environmental eXtender (APEX) (publicly available) | Low | Can estimate the effects of management changes at the field scale. User friendly and easy to use. | Has not been tested in Colorado. Only focuses on changes to agricultural practices. Hard to scale up. |

*Selected model

### 5.1.3 Model Selection

CPRW selected GRAIP_Lite to model sediment from roads in the upper CLP because it specifically addresses road sediment and could be applied with available spatial input information.

STEPL was selected to model nonpoint source nutrients in the lower CLP because it is user friendly, all the model inputs are readily available through the spatial data inventory, and BMPs are built into the model. In addition, STEPL can be used to estimate *E. coli* concentrations and reductions in *E. coli* from BMPs, in addition to nutrients and sediments.

## 5.2 Sediments from Roads in the upper CLP (GRAIP_Lite)

CPRW applied the GRAIP_Lite tool developed by the USFS to determine broad-scale road surface sediment risks over a HUC12 watershed scale. GRAIP_Lite modeling was conducted in the upper CLP area watersheds illustrated in **Error! Reference source not found.**.

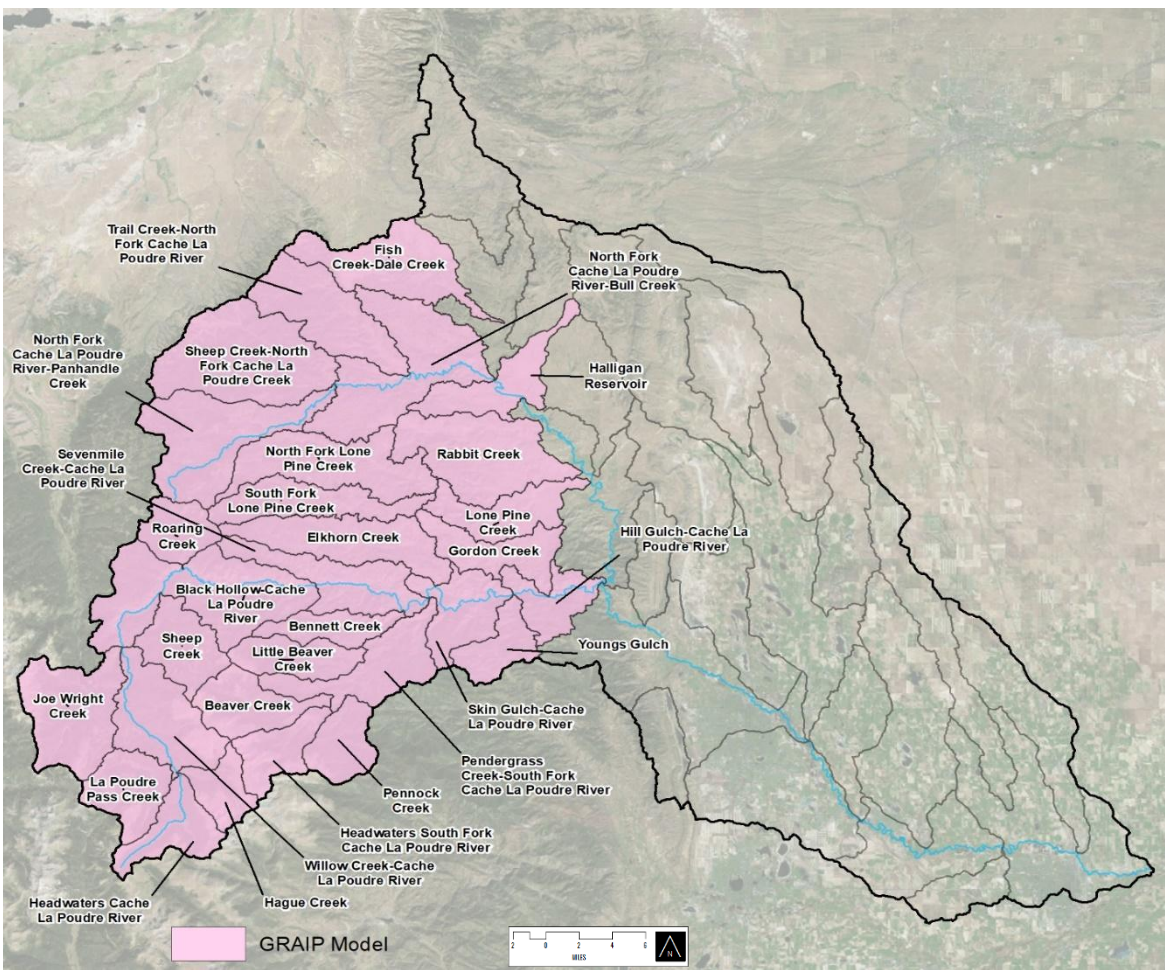


*Figure 5-1 GRAIP_Lite Modeled HUC12 Level Watersheds*

## 5.2.1 Model Overview

GRAIP_Lite is an efficient GIS tool that predicts sediment delivery from roads to streams using minimal field data. GRAIP_Lite uses a digital elevation model (DEM), a road layer, and a small field calibration dataset to first calculate sediment produced by road segments, and then determine the sediment delivery to streams based on factors including road surface type, maintenance and traffic level, relative road to stream location and slope. More details on the model calculations, assumptions and application are available in the *GRAIP_Lite: A System for Road Impact Assessment* Manual (USFS 2019).

### 5.2.1.1 Model Inputs

#### 5.2.1.1.1 DEM

GRAIP_Lite uses the DEM elevation information to model streams and slopes based on topography. For this analysis, the DEM for the study area was downloaded from the National Elevation Dataset (NED) with a nominal 30m resolution, and projected into NAD83 UTM 13 N coordinate system. Note that because the GRAIP_Lite-modeled streams are derived by the DEM, the modeled stream network may have small differences from the actual stream network.

#### 5.2.1.1.2 Roads

USFS road data in the study area was obtained from the "National Forest System Roads" layer in the INFRA database[7]. GRAIP_Lite was designed to input this specific data source; the USFS road layer contains attributes that classify road surfacing and maintenance levels that is used by the model to estimate parameters related to sediment production. The GRAIP_Lite model was run for the entire CLP watershed, but there are only model results for watersheds that contained USFS roads (Figure 5-2). There are no USFS roads in the lower CLP.

CDOT provides information about local roads in the study area. These roads were not included in the analysis due to the significant overlap between the USFS roads and the local roads that could not be resolved without significant effort that was beyond the scope of this initial project.

[7] https://data.fs.usda.gov/geodata/edw/datasets.php?dsetCategory=transportation

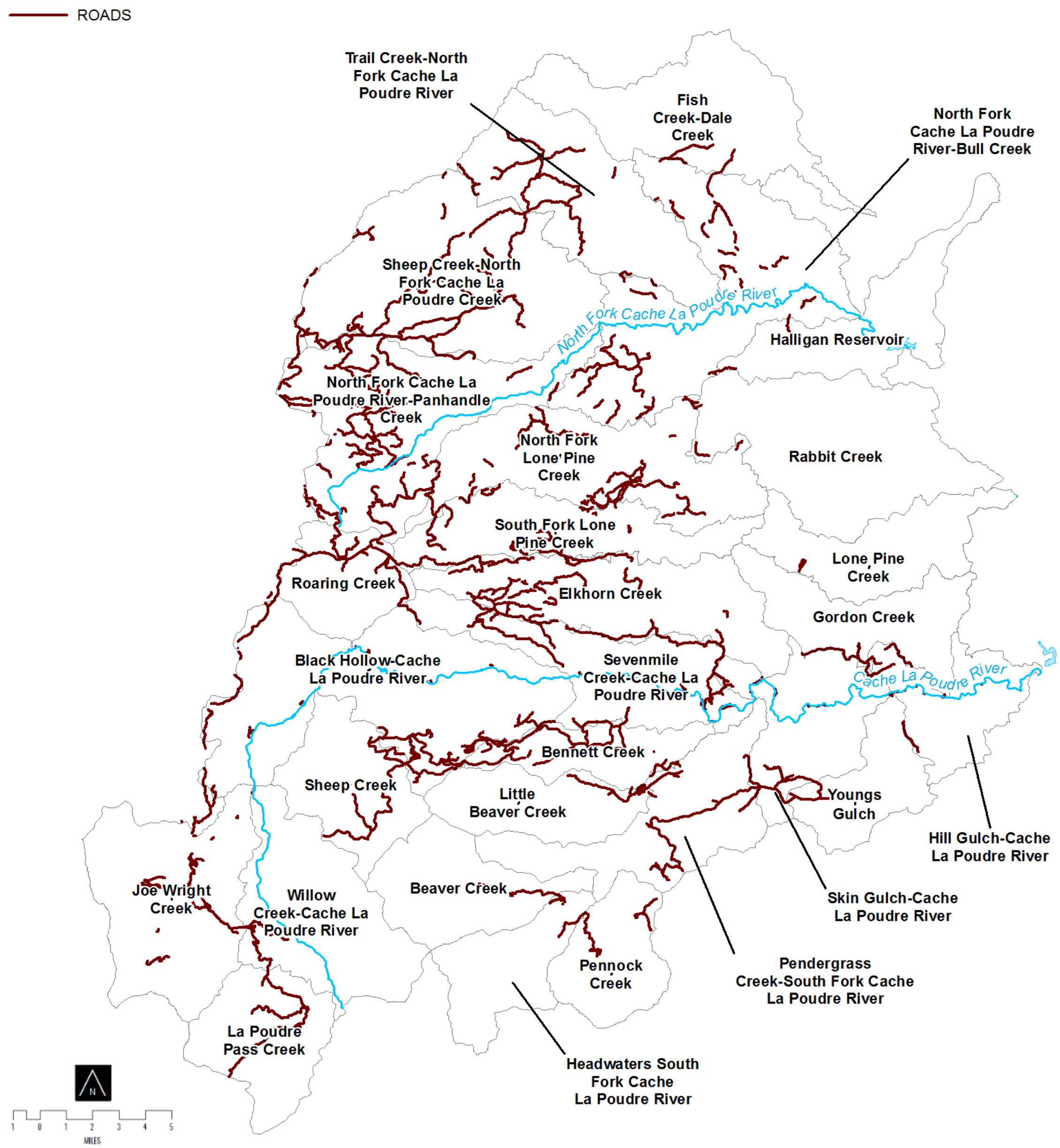



*Figure 5-2 Modeled USFS Roads in the Study Area*

### 5.2.1.2 Calibration Data Set

GRAIP_Lite uses the calibration data set to improve the accuracy of the model by including site-specific model parameters. Developing a custom calibration zone requires surveys and potential field work. This analysis used the default calibration data. The default data is conservative in that it assumes the highest base rate erosion and an average value of road connectivity. The default data does not make assumptions about mean annual precipitation or mean elevation since those parameters are included in the base rate calculation. Together, the conditions used in the default calibration data set represent the highest risk so that uncertainty in the model is set to represent a worst-case scenario and the model is less likely to underestimate the impacts of roads.

## 5.2.2 GRAIP_Lite Results

This section presents the GRAIP_Lite results for sediment delivered to streams in the upper CLP from USFS roads.

### 5.2.2.1 Sediment Delivery to Streams by Road Segment

Figure 5-3 illustrates the GRAIP_Lite model estimates of sediment delivery by road segment in kg/year. Darker colored road segments indicate a higher rate of sediment delivery. There are very few road segments that are contributing large amounts of sediment. In general, individual roads contribute fairly low amounts of sediment, but have a cumulative impact on streams; these cumulative effects on a HUC12 basis are illustrated in the following sections.

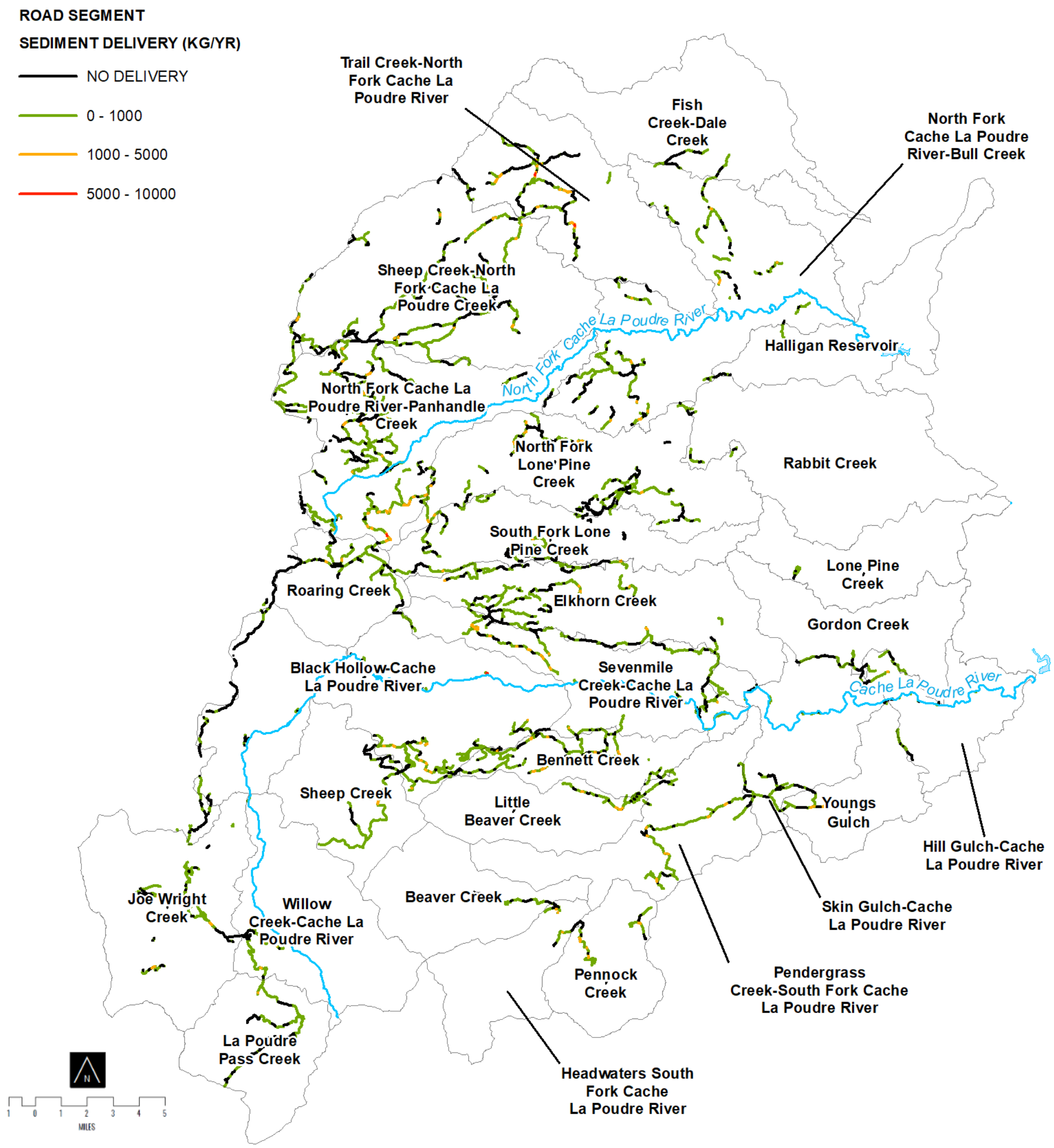



*Figure 5-3 Sediment Delivery by USFS Road Segment (kg/yr)*

### 5.2.2.2 Sediment Delivery from Roads by HUC12

The GRAIP_Lite model aggregates the sediment delivery by road segment into subwatersheds. These results can be used to identify “hot spots” and evaluate priority areas to target for potential road management sediment reduction activities.

Three metrics are used to quantify road sediment delivery for each subwatershed area in the study area:

1. **Net Sediment Loading**: the total amount of sediment delivered to streams within the subwatershed,
2. **Sediment Delivery by Area**: the amount of sediment delivered per $km^2$ of the subwatershed watershed, and
3. **Sediment Delivery by Road Length**: the amount of sediment delivered per km of road within the subwatershed.

For this analysis, the HUC12 level was used to divide the study areas into subwatersheds. Table 5-3 presents these GRAIP_Lite results summarized by HUC12. Each results column in the summary table is conditionally formatted to indicate values low (white) to high (red). Figures that illustrate these results are presented in the sections below.

*Table 5-3 GRAIP_Lite Results Summarized by HUC12*

| HUC12 Name | HUC12 Acreage | Sediment loading (tons per year) | Sediment loading by area (tons per year/$km^2$) | Sediment loading by road length (tons per year/km of roads) | Length of roads (km) |
|---|---|---|---|---|---|
| Beaver Creek-101900070102 | 14,136 | 10 | 0.2 | 1.6 | 6.0 |
| Bennett Creek-101900070210 | 9,210 | 88 | 2.4 | 2.7 | 32.9 |
| Black Hollow-Cache La Poudre River-101900070210 | 37,738 | 120 | 0.8 | 2.5 | 48.9 |
| City of Fort Collins-Cache La Poudre River-101900070805 | 51,120 | 0 | 0.0 | 0.0 | 0.2 |
| Elkhorn Creek-101900070303 | 22,259 | 70 | 0.8 | 1.4 | 51.9 |
| Fish Creek-Dale Creek-101900070502 | 23,098 | 6 | 0.1 | 1.0 | 5.9 |
| Gordon Creek-101900070305 | 13,908 | 3 | 0.0 | 0.3 | 7.5 |
| Halligan Reservoir-101900070704 | 15,217 | 2 | 0.0 | 1.1 | 1.8 |
| Headwaters South Fork Cache La Poudre River-101900070105 | 11,094 | 16 | 0.4 | 3.4 | 4.8 |
| Hill Gulch-Cache La Poudre River-101900070805 | 11,161 | 9 | 0.2 | 1.2 | 7.1 |
| Joe Wright Creek-101900070205 | 24,469 | 59 | 0.6 | 2.5 | 23.6 |
| La Poudre Pass Creek-101900070205 | 14,066 | 19 | 0.3 | 1.0 | 18.3 |
| Little Beaver Creek-101900070105 | 11,563 | 40 | 0.9 | 4.1 | 9.8 |
| Lone Pine Creek-101900070704 | 14,153 | 0 | 0.0 | 0.1 | 1.6 |

| HUC12 Name | HUC12 Acreage | Sediment loading (tons per year) | Sediment loading by area (tons per year/$km^2$) | Sediment loading by road length (tons per year/km of roads) | Length of roads (km) |
|---|---|---|---|---|---|
| North Fork Cache La Poudre River-Bull Creek-101900070502 | 34,295 | 87 | 0.6 | 2.0 | 44.1 |
| North Fork Cache La Poudre River-Panhandle Creek-101900070403 | 29,787 | 219 | 1.8 | 2.3 | 95.2 |
| North Fork Lone Pine Creek-101900070603 | 25,269 | 89 | 0.9 | 1.9 | 46.1 |
| Pendergrass Creek-South Fork Cache La Poudre River-101900070210 | 18,640 | 74 | 1.0 | 3.1 | 23.6 |
| Pennock Creek-101900070105 | 11,068 | 45 | 1.0 | 5.3 | 8.5 |
| Rabbit Creek-101900070704 | 28,861 | 2 | 0.0 | 1.0 | 2.3 |
| Roaring Creek-101900070208 | 9,938 | 39 | 1.0 | 1.7 | 22.2 |
| Sevenmile Creek-Cache La Poudre River-101900070303 | 18,640 | 115 | 1.5 | 3.1 | 37.4 |
| Sheep Creek-101900070208 | 13,966 | 24 | 0.4 | 1.2 | 19.7 |
| Sheep Creek-North Fork Cache La Poudre Creek-101900070403 | 35,587 | 122 | 0.8 | 1.9 | 64.4 |
| Skin Gulch-Cache La Poudre River-101900070305 | 14,920 | 19 | 0.3 | 1.1 | 17.3 |
| South Fork Lone Pine Creek-101900070602 | 16,306 | 33 | 0.5 | 1.3 | 26.1 |
| Trail Creek-North Fork Cache La Poudre River-101900070403 | 23,034 | 110 | 1.2 | 3.4 | 32.4 |
| Upper Dale Creek-101900070501 | 28,654 | 0 | 0.0 | 0.0 | 2.1 |
| Willow Creek-Cache La Poudre River-101900070208 | 21,936 | 28 | 0.3 | 2.8 | 10.0 |
| Youngs Gulch-101900070303 | 9,823 | 25 | 0.6 | 4.8 | 5.2 |
| **TOTAL** | **613,829** | **1,472** | **0.6** | **2.2** | **677** |

#### 5.2.2.2.1 Net Sediment Loading

Net sediment loading is the total amount of sediment delivered to streams from roads per year. Figure 5-4 presents the total sediment delivery from USFS roads.

Darker colored HUCs contribute more sediment to streams. Since individual road segments generally contribute small amounts of sediment, HUCs with more roads tend to deliver more sediment to streams. The most amount of sediment contributed by any one HUC12 is ~200 tons/year in the North Fork Cache La Poudre River- Panhandle Creek watershed; this HUC also has the highest total length of roads within the watershed.

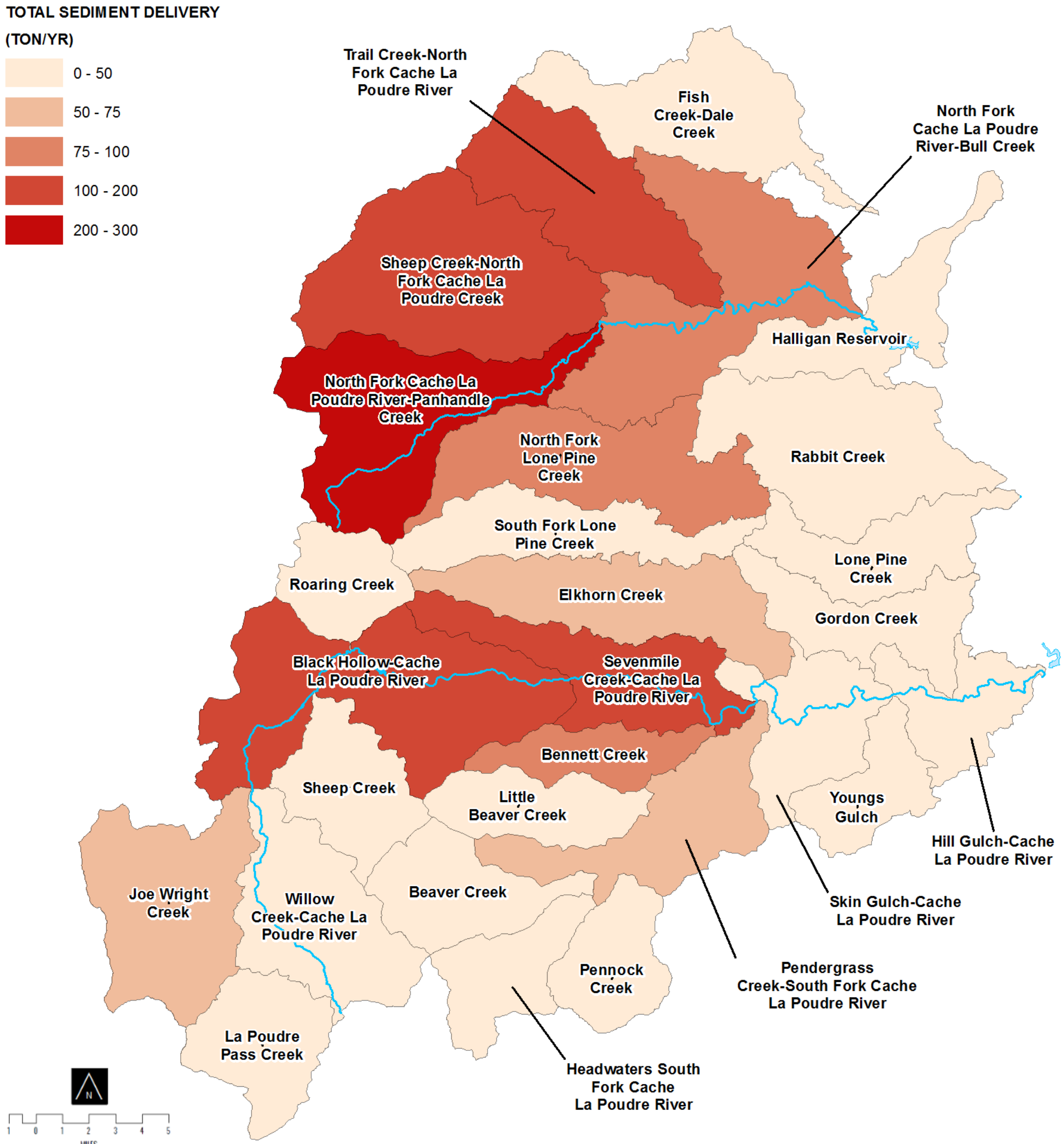



*Figure 5-4 Total Sediment Load Delivered from USFS Roads (tons/year) by HUC12*

### 5.2.2.2.2 Sediment Delivery by Area

The sediment delivery by area can be used to identify subwatersheds that are generating relatively large amounts of sediment per unit area. Sediment delivery by area was calculated by dividing the total sediment delivery by the area of the HUC12 (Figure 5-5).

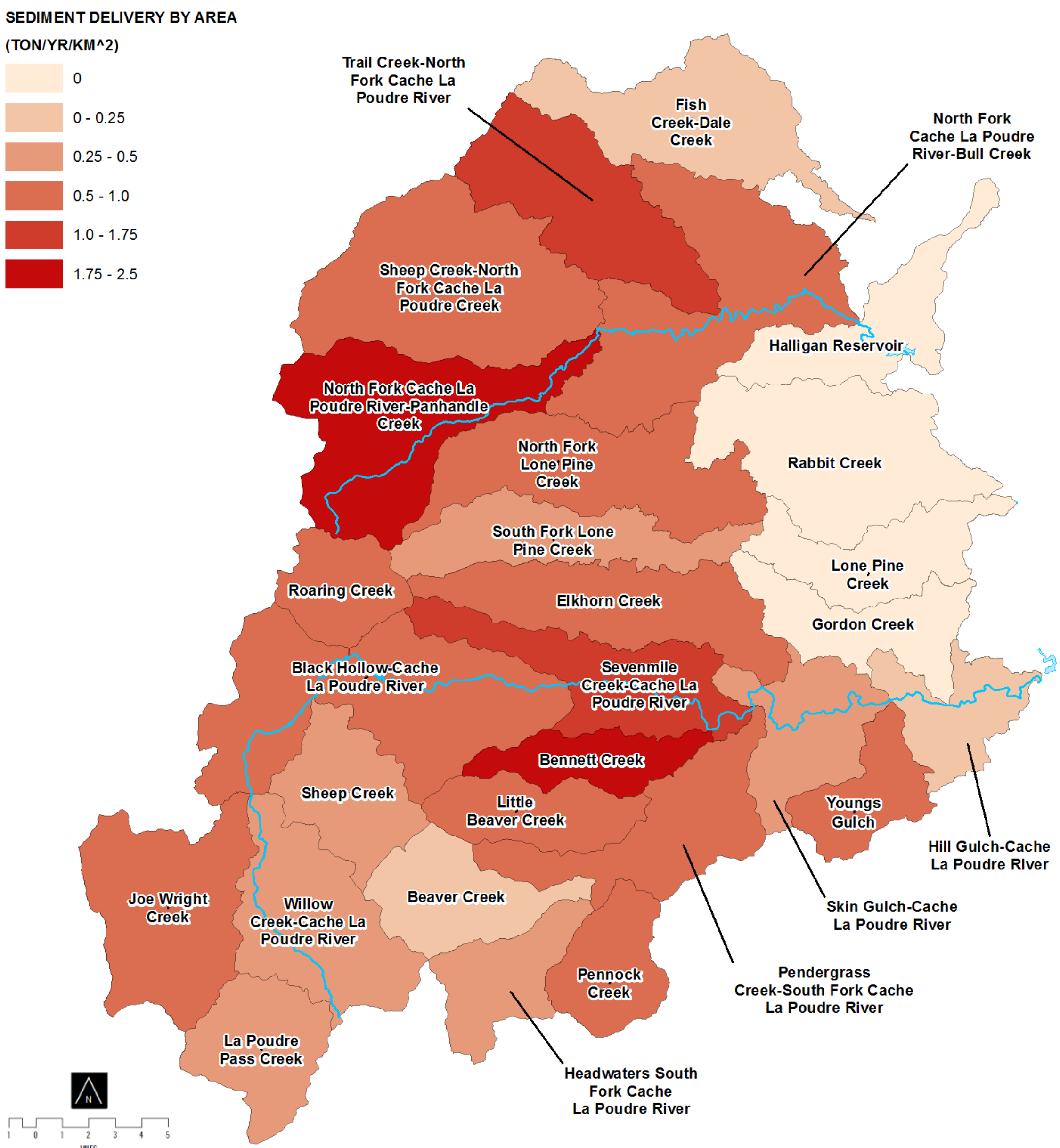



*Figure 5-5 Sediment Delivery by Area from USFS Roads (tons/km2) by HUC12*

### *5.2.2.2.2.1 Sediment Delivery by Road Length*

Sediment delivery by road length can be used to identify watersheds in which roads are delivering relatively higher sediments per kilometer. Sediment delivery by road length was calculated by dividing the total sediment delivery by the length of USFS roads in the HUC12 (Figure 5-6).

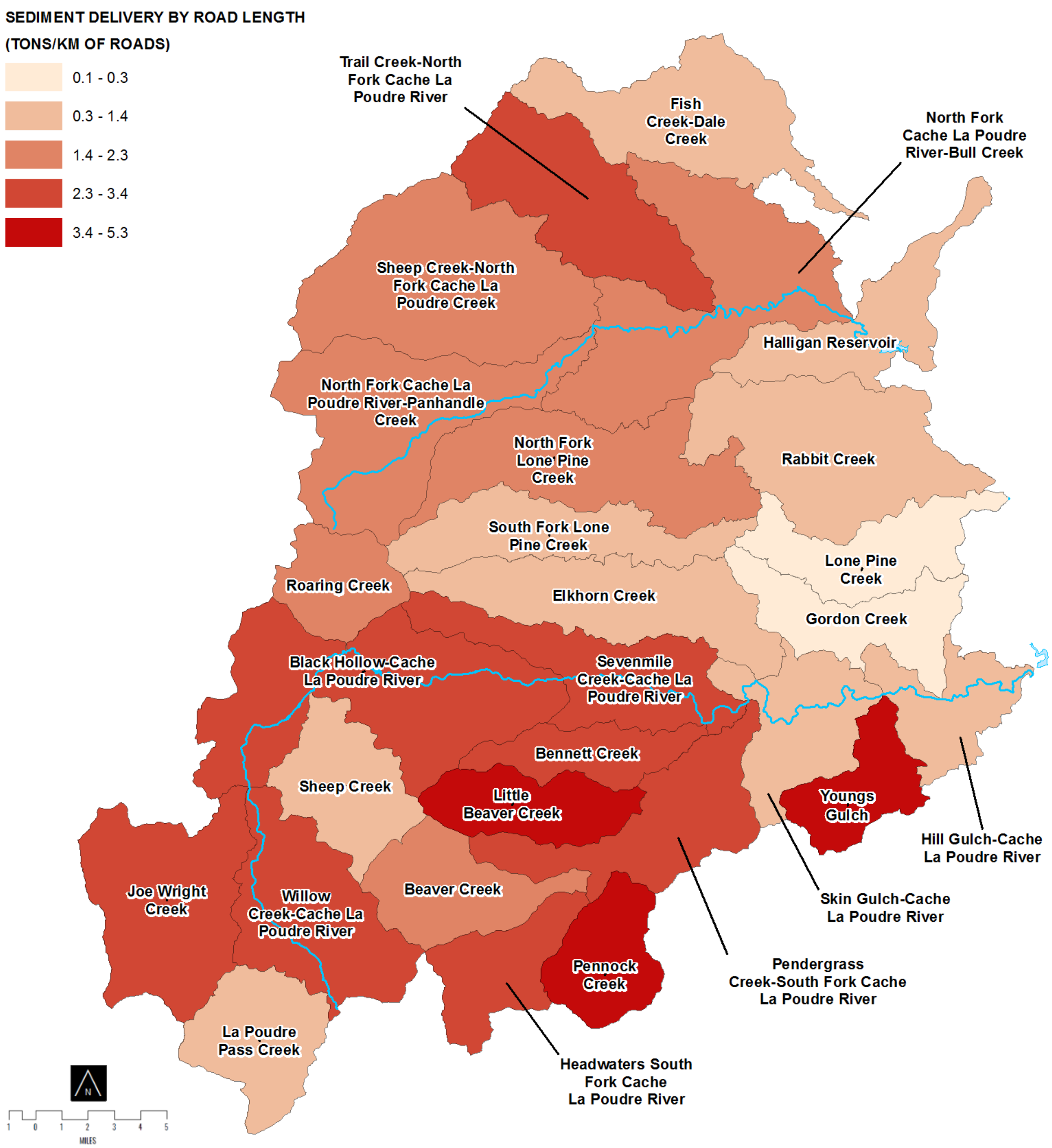



*Figure 5-6 Sediment Delivery by Road Length from USFS Roads (tons/km) by HUC12*

## 5.2.3 Conclusions

GRAIP_Lite estimated sediment delivery to streams for over 650 km of USFS roads in the upper CLP watershed. Results showed that:

- ~1,470 tons per year of sediment delivery per year from USFS in the study area.
- Weighted average of ~2 tons per year of sediment per kilometer of road throughout the study area, with significant regional variation ranging from 0.1 tons to over 5 tons per kilometer per year.

- The impact of USFS roads is greatest in watersheds in the headwaters of the North Fork of the Cache La Poudre River and along a stretch of the CLP headwaters (Black Hollow-Cache La Poudre River, Sevenmile Creek-Cache La Poudre River)

Table 5-4 illustrates the top five HUC12 sediment delivery contributors for each metric. The Trail Creek-North Fork Cache La Poudre River watershed is in the top five for net sediment loading, sediment loading by area and sediment loading by road length. Although North Fork Cache La Poudre River-Panhandle Creek watershed has the largest sediment loading (and the most USFS roads), several other watersheds result in higher relative sediment delivery on an area and road length basis.

*Table 5-4 Top HUC12 Sediment Delivery Contributors*

| Relative Rank | Sediment loading (tons per year) | Sediment loading by area (tons per year/$km^2$) | Sediment loading by road length (tons per year/km of roads) |
|---|---|---|---|
| 1 | North Fork Cache La Poudre River-Panhandle Creek | Bennett Creek | Pennock Creek |
| 2 | Sheep Draw-North Fork Cache La Poudre Creek | North Fork Cache La Poudre River-Panhandle Creek | Youngs Gulch |
| 3 | Black Hollow-Cache La Poudre River | Sevenmile Creek-Cache La Poudre River | Little Beaver Creek |
| 4 | Sevenmile Creek-Cache La Poudre River | Trail Creek-North Fork Cache La Poudre River | Headwaters South Fork Cache La Poudre River |
| 5 | Trail Creek-North Fork Cache La Poudre River | Pennock Creek | Trail Creek-North Fork Cache La Poudre River |

#### 5.2.3.1 Potential Next Steps for Road Sediment Modeling

This section contains potential next steps that may be applied to expand the GRAIP_Lite analysis.

**Include local and private roads-** Local road information is available through the Colorado Department of Transportation (CDOT). In order to include local roads in the GRAIP_Lite model, road attributes required by the model would need to be estimated based on existing data. In addition, there is some overlap between the CDOT local roads data and the USFS roads data (Figure 5-7). This overlap would need to be eliminated before the model was run in order to ensure there is not double counting of roads. Table 5-5 provides the lengths of USFS roads and CDOT local roads.

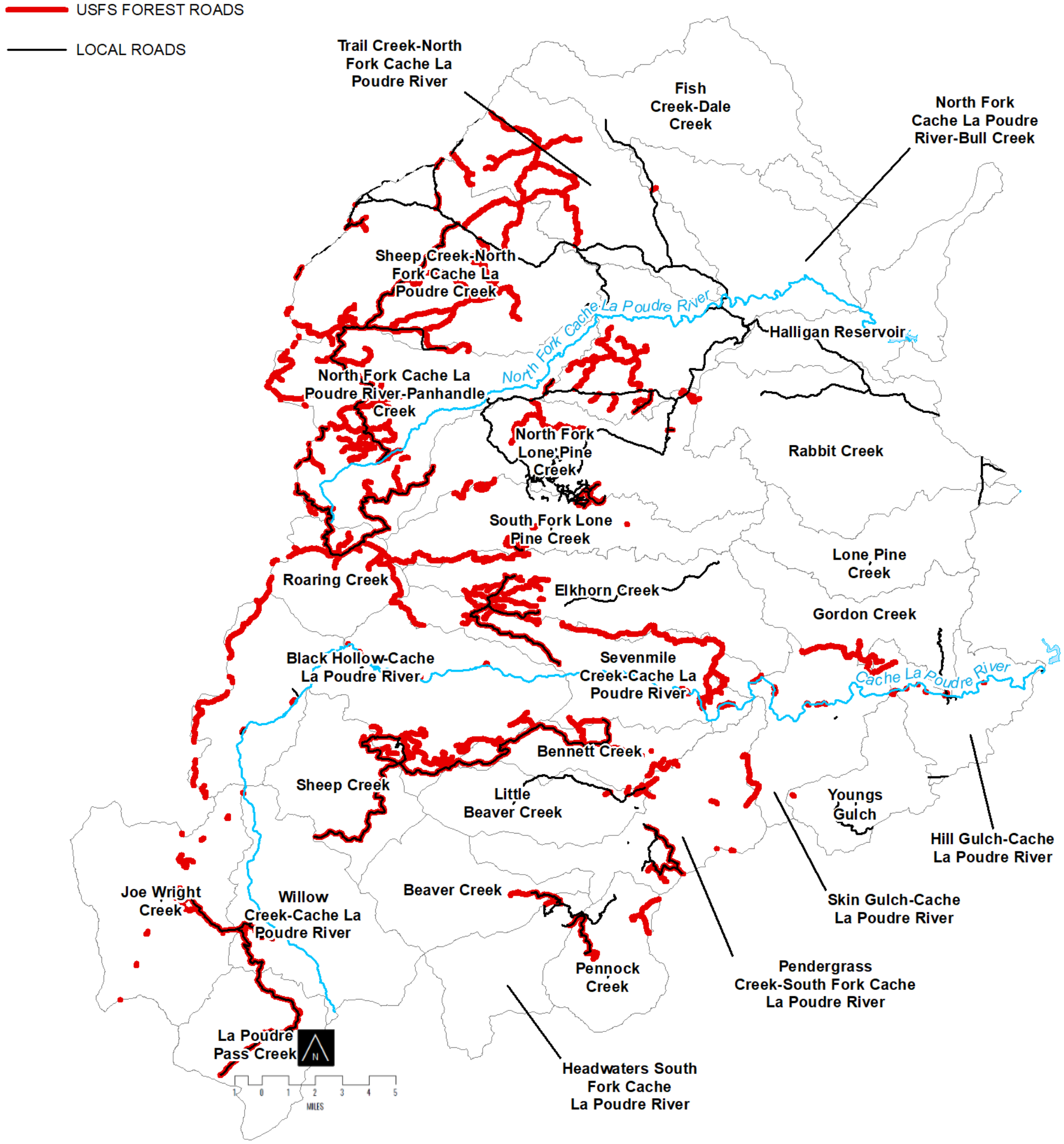



*Figure 5-7 Overlap of USFS and CDOT local roads data in the Upper CLP*

*Table 5-5 Road Lengths in the Upper CLP*

| HUC12 Name | Length of Local Roads (miles) | Length of USFS Roads (miles) |
|---|---|---|
| Beaver Creek | 0.9 | 1.8 |
| Headwaters South Fork Cache La Poudre River | 4.3 | 1.9 |
| Pennock Creek | 4.5 | 5.6 |
| Little Beaver Creek | 4.8 | 1.9 |

| HUC12 Name | Length of Local Roads (miles) | Length of USFS Roads (miles) |
|---|---|---|
| Pendergrass Creek-South Fork Cache La Poudre River | 6.7 | 8.3 |
| La Poudre Pass Creek | 7.2 | 7.2 |
| Joe Wright Creek | 3.5 | 7.5 |
| Willow Creek-Cache La Poudre River | 4.7 | 5.4 |
| Sheep Draw | 9.2 | 10.3 |
| Roaring Creek | 3.7 | 13.5 |
| Black Hollow-Cache La Poudre River | 5.9 | 28.3 |
| Bennett Creek | 10.7 | 14.0 |
| Sevenmile Creek-Cache La Poudre River | 5.6 | 21.2 |
| Elkhorn Creek | 10.7 | 20.2 |
| Youngs Gulch | 2.7 | 0.2 |
| Skin Gulch-Cache La Poudre River | 0.2 | 5.3 |
| Gordon Creek | 3.0 | 3.6 |
| Hill Gulch-Cache La Poudre River | 1.8 | 2.3 |
| North Fork Cache La Poudre River-Panhandle Creek | 23.4 | 49.6 |
| Sheep Draw-North Fork Cache La Poudre Creek | 27.6 | 38.7 |
| North Fork Cache La Poudre River-Bull Creek | 19.3 | 14.2 |
| Trail Creek-North Fork Cache La Poudre River | 12.1 | 19.7 |
| Fish Creek-Dale Creek | 1.5 | 0.0 |
| South Fork Lone Pine Creek | 2.7 | 7.9 |
| North Fork Lone Pine Creek | 29.5 | 11.6 |
| Lone Pine Creek | 0.8 | 0.0 |
| Halligan Reservoir | 4.5 | 0.0 |
| Rabbit Creek | 10.6 | 0.3 |

Private roads were not included in this assessment because digitizing and populating the model attributes (based on field studies and/or aerial data) for these features was beyond the scope of this project. Currently, there is no digitized record of private roads. Therefore, the extent of private roads throughout the watershed and their potential contribution to sediment loading is unknown.  Including local and private roads in the model would increase the estimated total sediment delivery from the study area.

**Identify priority HUCS and road segments-** The results of GRAIP_Lite can be used to help prioritize future actions to reduce sediment delivery from roads. Watersheds can be prioritized using the results table in combination with other factors including potential partnerships and available funding.

Generally, high priority watersheds will have high total sediment delivery and a high value for sediment delivery by road length. These watersheds will have roads that will most dramatically reduce sediment delivery when an intervention is applied and have a large overall impact on total sediment delivery from the study area.

**Consider GRAIP_Lite BMPs and model their impacts-** GRAIP_Lite allows users to model the effects of specific road-related BMPs. The BMPs included in GRAIP_Lite that can be modeled in GRAIP_Lite include the following:

- Decommissioning roads
- Opening/Closing roads temporarily or permanently
- Re-locating roads
- Upgrading surface type
- Changing the maintenance level

**Consider additional BMPs-** In addition to the BMPs in GRAIP_Lite there are other road-related BMPs that could be considered such as planting forest buffers along roads, adding water bars, adding settling basins, and/or adding/enlarging culverts at strategic drainage points.

## 5.3 Nutrients in the lower CLP (STEPL)

### 5.3.1 Model Overview

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was selected for this analysis because it calculates annual nutrient and sediment loading from nonpoint sources and allows managers to model the load reductions that would result from implementing various BMPs. The STEPL model was developed by Tetra Tech Inc. for the U.S. Environmental Protection Agency (EPA). Version 4.4, updated March 2018, was used for this analysis.

STEPL is a customizable spread-sheet based model in Microsoft Excel. It employs simple algorithms to calculate loading and load reductions from BMPs. The pollutant sources considered in the model include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. For each watershed, the annual nutrient loading is calculated based on the runoff volume and pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies. More details on the model calculations, assumptions and application are available in the *User's Guide: Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) Version 4.4* (Tetra Tech, Inc. 2018).

The STEPL model was run for eleven HUC12 level subwatersheds in the Lower Cache La Poudre basin (Figure 5-8).

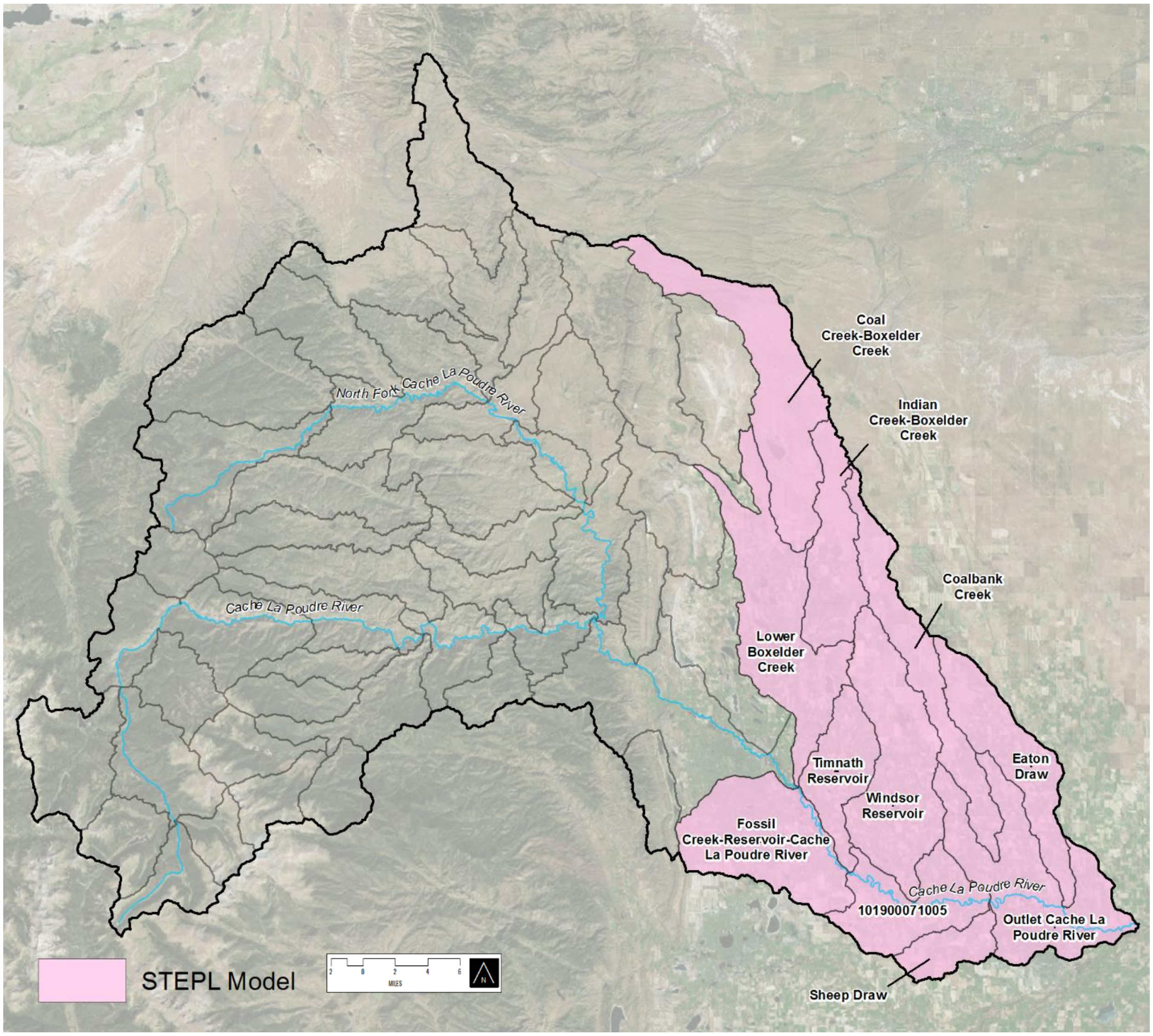



*Figure 5-8 Modeled HUC12 Level Watersheds (STEPL)*

### 5.3.1.1 Model Inputs

In addition to developing the STEPL model, Tetra Tech Inc. created a web-based model inputs data server[8]. Model input data is parsed out by HUC12 watershed. All model input data for the study area was downloaded from the Tetra Tech data server and exported as a .csv file.

#### 5.3.1.1.1 Land Use

Land use is input into the STEPL model as an area in acres. The STEPL model considers six land use types: urban, cropland, pastureland, feedlot, forest, and a user-defined type. For this analysis, user-defined land use was set to zero.

[8] http://it.tetratech-ffx.com/steplweb/steplweb.html

The National Land Cover Database (NLCD) is a national database for land cover generated by the U.S. Geological Survey (USGS) in partnership with other federal agencies. A new version of the NLCD data set is released approximately once every five years. The Tetra Tech online database uses the NLCD 2011 to calculate the land use model inputs. Since a newer version of the NLCD is available, CPRW used the NLCD 2016 to calculate model land use inputs for urban land, cropland, pastureland and forests. The NLCD dataset does not include information on feedlots. The area of feedlots from the Tetra Tech online database was used for this analysis since more recent information for feedlots was not available. Table 5-6 and Figure 5-9 show how NLCD land uses were grouped into the STEPL land use types.

*Table 5-6 STEPL Land Use Model Inputs and Corresponding NLCD Land Use Categories*

| **STEPL Land Use Area** | **NLCD Land Cover Classes** |
|---|---|
| Urban | Developed Open Space (21), Developed- Low Intensity (22), Developed- Medium Intensity (23), Developed- High Intensity (24) |
| Cropland | Cultivated Crops (82) |
| Pastureland | Grassland/Herbaceous (71), Pasture/Hay (81) |
| Forest | Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43) |

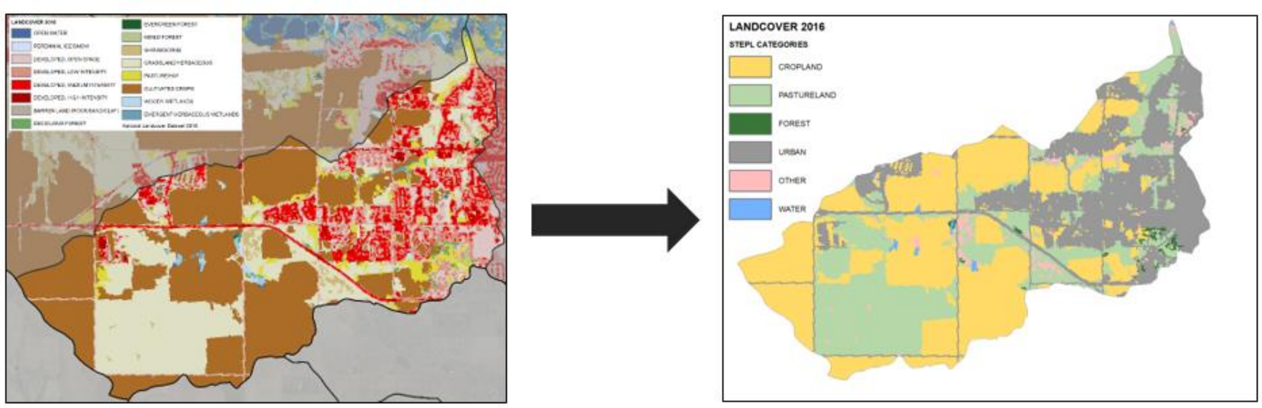



*Figure 5-9 Example of NLCD Data Being Grouped into STEPL Categories*

The NLCD urban land cover classes (such as open space, low intensity development, and high intensity development) have significantly different attributes that control surface runoff and pollutant loading. STEPL calculates the runoff and loading for urban land use types separately and adds the results together to generate a total pollutant load from urban areas.

#### 5.3.1.1.2 Agricultural Animals

STEPL requires the total number of agricultural animals by type and number of months per year that manure is applied to croplands and is applied per watershed. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. The agricultural animal data was acquired through the Tetra Tech online database. The number of months per year that manure is applied to cropland and pastureland was assumed to be 9 and 6 months respectively.

#### 5.3.1.1.3 Septic Systems

STEPL requires the number of septic systems per watershed as well as the population counts that discharge wastewater directly, and reduction percentages on direct wastewater discharge. The septic system data was acquired through the Tetra Tech online database.

### 5.3.2 STEPL Results

The results of the STEPL model are summarized by HUC12 in Table 5-7. Each results column in the summary table is conditionally formatted to indicate values low (white) to high (red).

*Table 5-7 STEPL Model Results for the lower CLP*

| Watershed Name | Acres | Nutrient Loading (lbs/year) | | | Nutrient Loading Density (lbs/acre/year) | | |
|---|---|---|---|---|---|---|---|
| | | Nitrogen | Phos-phorus | Nitrogen + Phos-phorus | Nitrogen | Phos-phorus | Nitrogen + Phos-phorus |
| 101900071005 | 24,711 | 71,574 | 17,408 | 88,982 | 2.90 | 0.70 | 3.60 |
| Coal Creek-Boxelder Creek-101900070903 | 44,196 | 49,814 | 5,984 | 55,798 | 1.13 | 0.14 | 1.26 |
| Coalbank Creek-101900071008 | 27,799 | 55,698 | 12,254 | 67,952 | 2.00 | 0.44 | 2.44 |
| Eaton Draw- 101900071008 | 26,903 | 69,740 | 17,830 | 87,570 | 2.59 | 0.66 | 3.26 |
| Fossil Creek-Reservoir-Cache La Poudre River-101900071005 | 37,952 | 58,485 | 10,907 | 69,391 | 1.54 | 0.29 | 1.83 |
| Indian Creek-Boxelder Creek –101900070903 | 22,951 | 29,311 | 4,903 | 34,213 | 1.28 | 0.21 | 1.49 |
| Lower Boxelder Creek-101900071002 | 45,804 | 114,413 | 24,468 | 138,881 | 2.50 | 0.53 | 3.03 |
| Outlet Cache La Poudre River- 101900030603 | 43,585 | 93,730 | 24,035 | 117,765 | 2.15 | 0.55 | 2.70 |
| Sheep Draw-101900071005 | 9,656 | 19,460 | 4,741 | 24,201 | 2.02 | 0.49 | 2.51 |
| Timnath Reservoir-101900071002 | 18,163 | 48,346 | 10,948 | 59,294 | 2.66 | 0.60 | 3.26 |
| Windsor Reservoir-101900071005 | 41,973 | 84,877 | 19,627 | 104,504 | 2.02 | 0.47 | 2.49 |
| **Total** | **343,691** | **695,448** | **153,104** | **848,552** | **2.02** | **0.45** | **2.47** |

#### 5.3.2.1 Total Nutrient Loading

The total nitrogen and phosphorus loading by HUC12 were calculated individually by summing the load of each pollutant from each land use type (Figure 5-10, Figure 5-11). The total nutrient load per subwatershed was calculated by summing the total nitrogen and total phosphorus loads in each subwatershed (Figure 5-12, Figure 5-13).

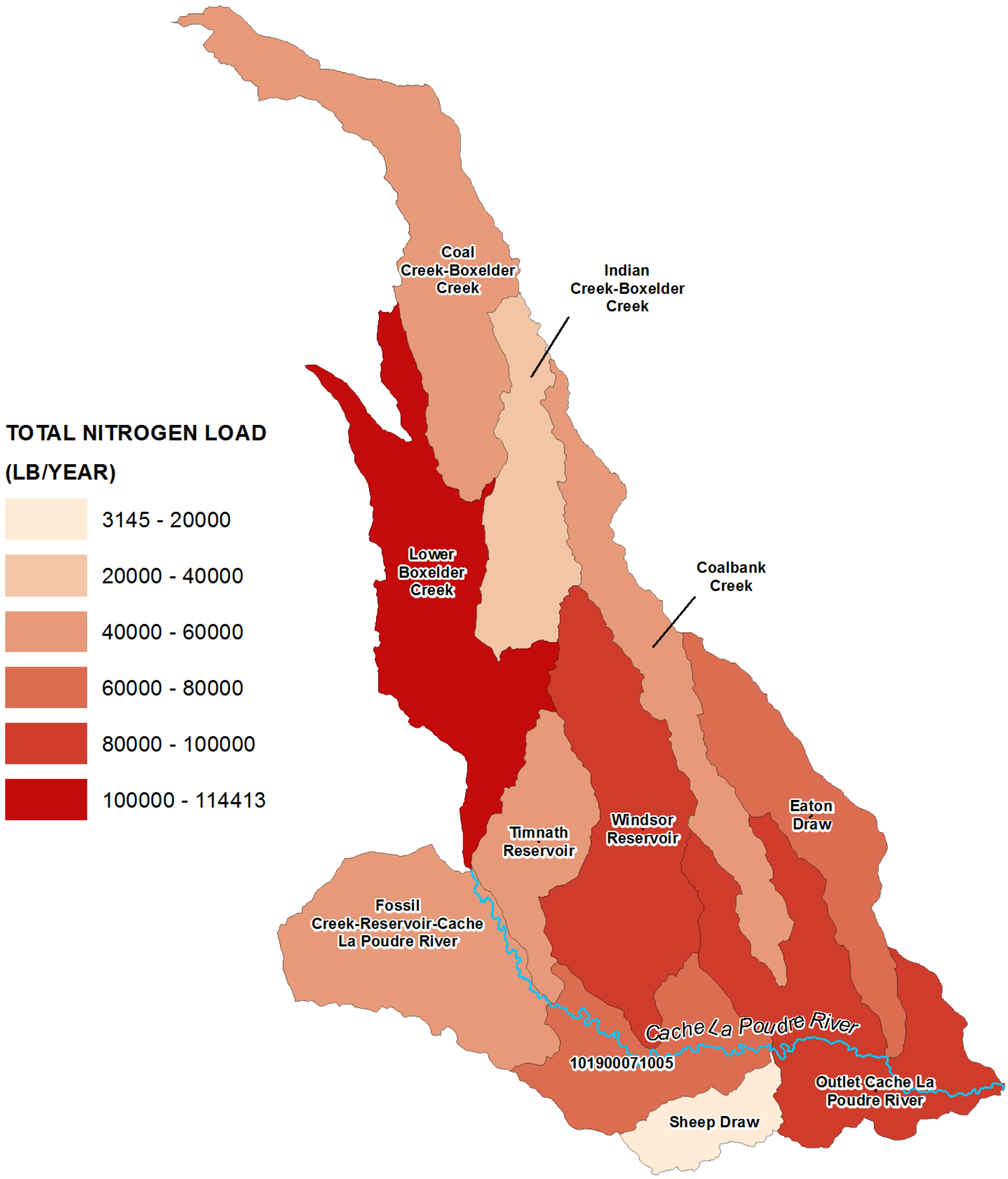



*Figure 5-10 Total Nonpoint Source Nitrogen Loading (lbs/yr) by HUC12*

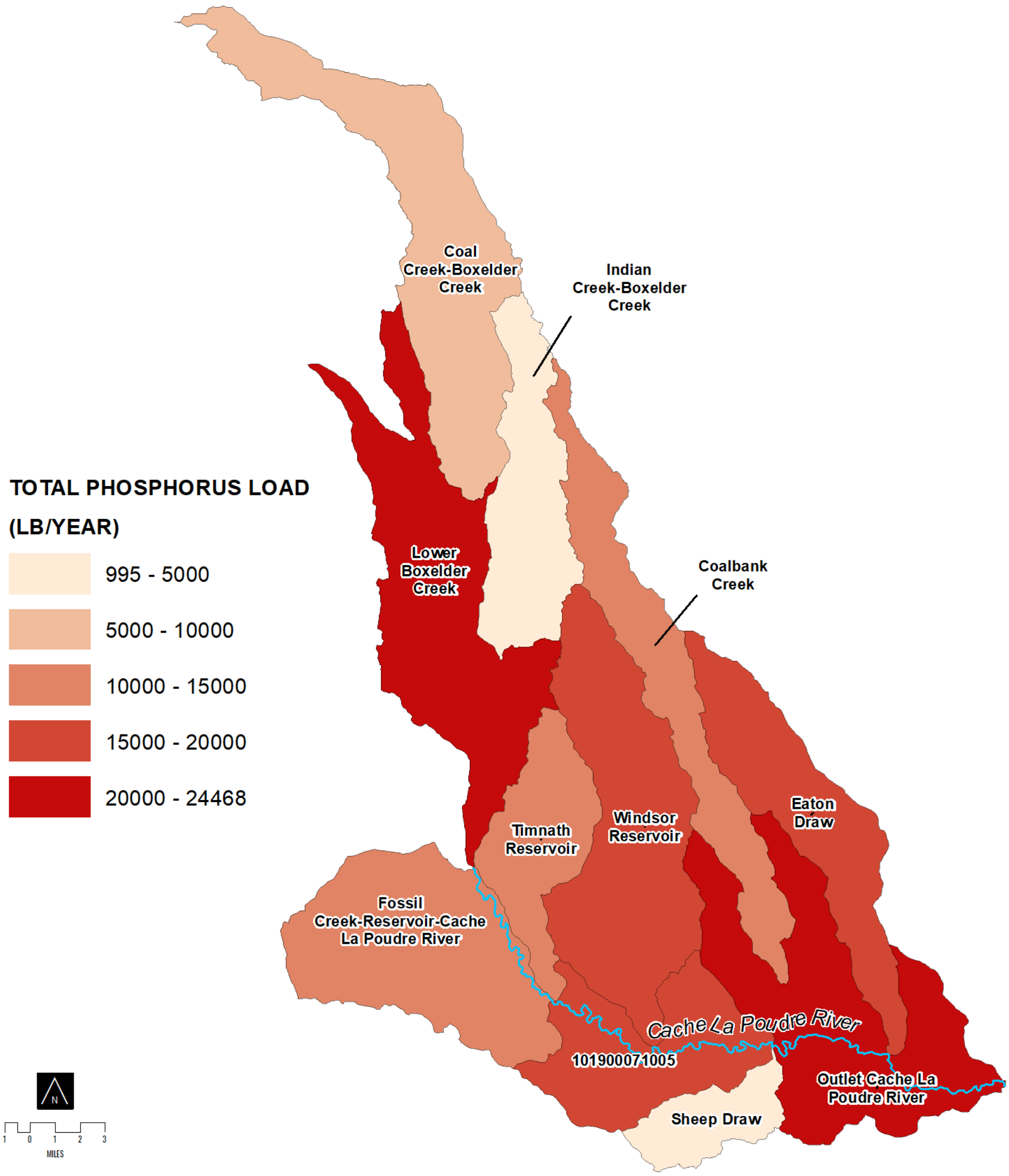



*Figure 5-11 Total Nonpoint Source Phosphorus Loading (lbs/yr) by HUC12*

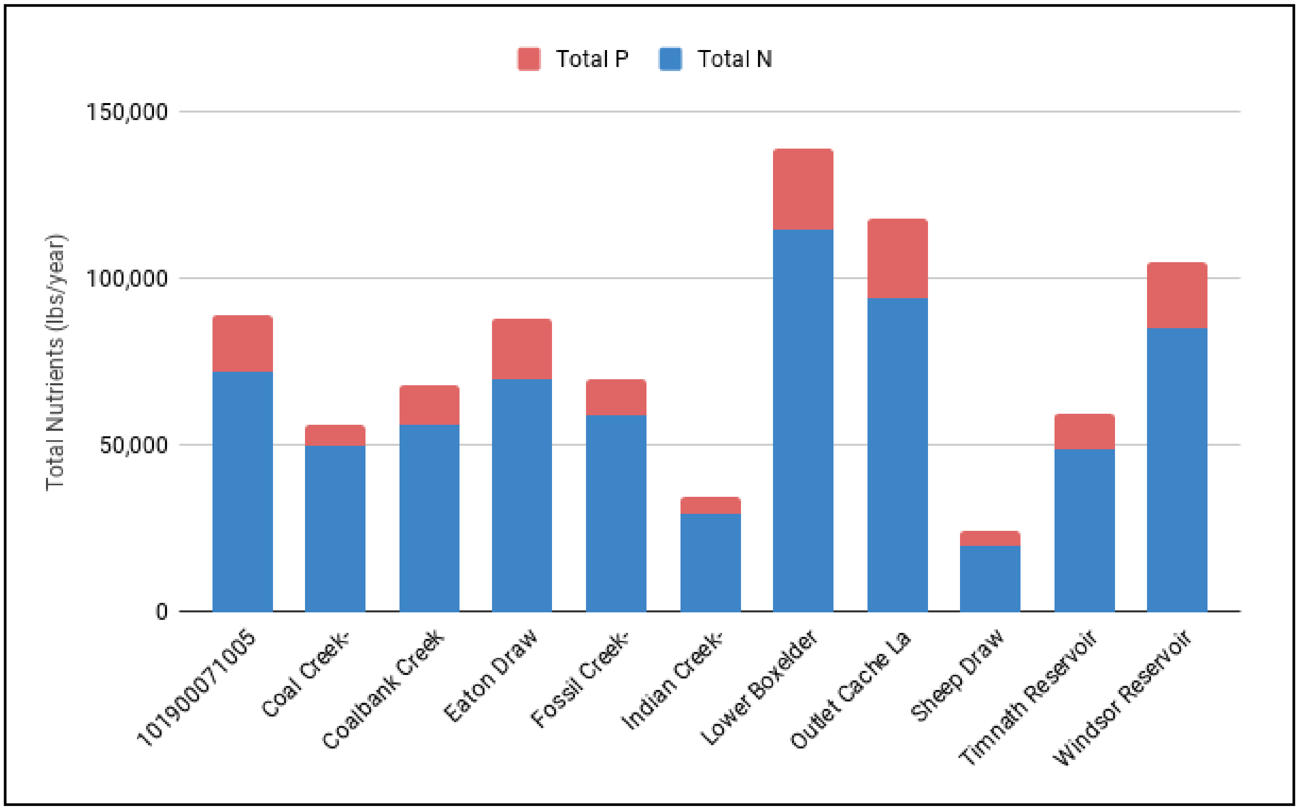



*Figure 5-12 Total Nonpoint Source Nutrient Loading (lbs/yr) by HUC12*

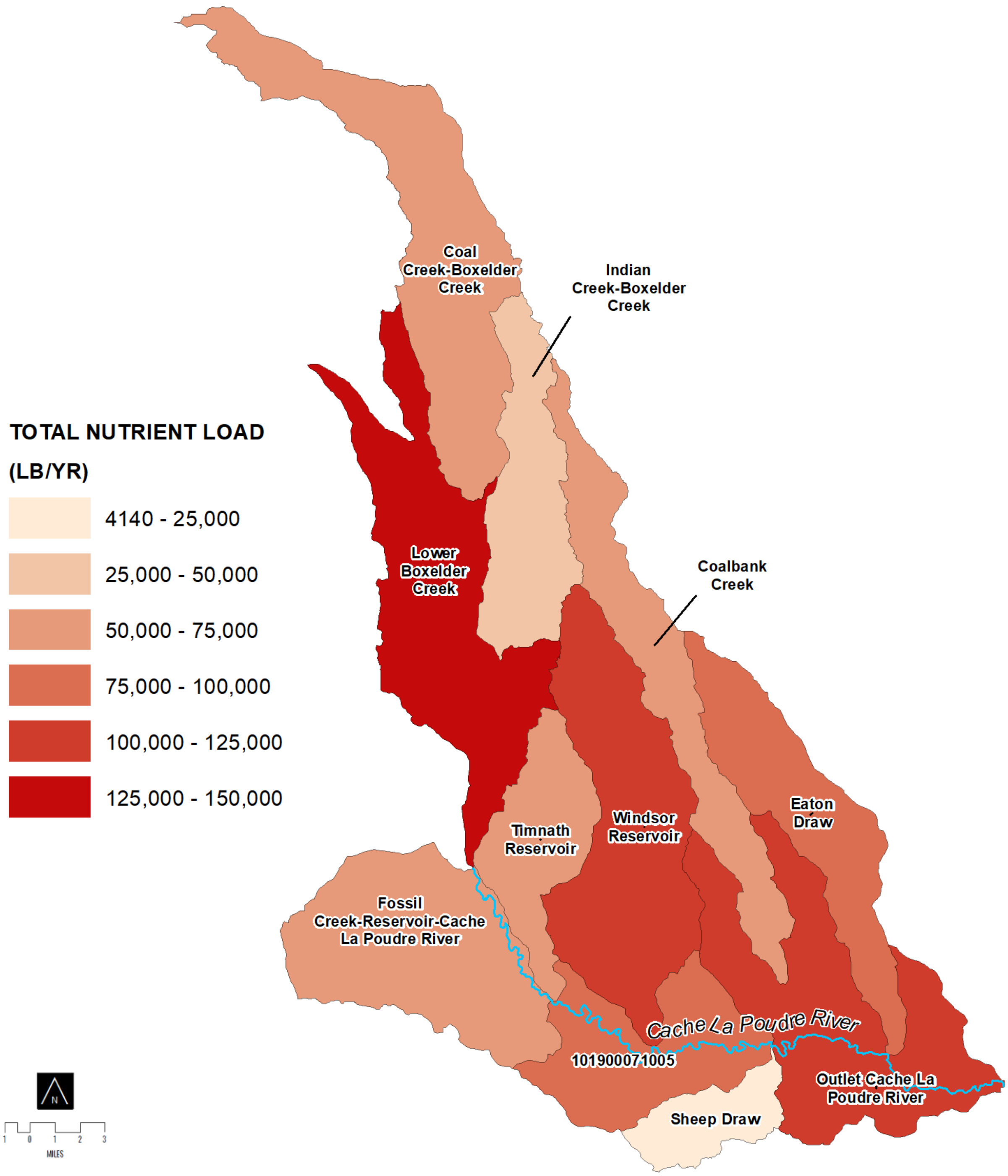



*Figure 5-13 Total Nonpoint Source Nutrient Loading (lbs/yr) by HUC12*

#### 5.3.2.2 Nutrient Loading Density

The nutrient loading density can be used to identify subwatersheds that are generating relatively large amounts of nutrients per unit area. The nitrogen and phosphorus loading density was calculated individually by dividing the load of each pollutant by the area of the subwatershed (Figure 5-14, Figure 5-15). The total nutrient loading density was calculated by dividing the total nutrient load by the area of the subwatershed (Figure 5-16, Figure 5-17)

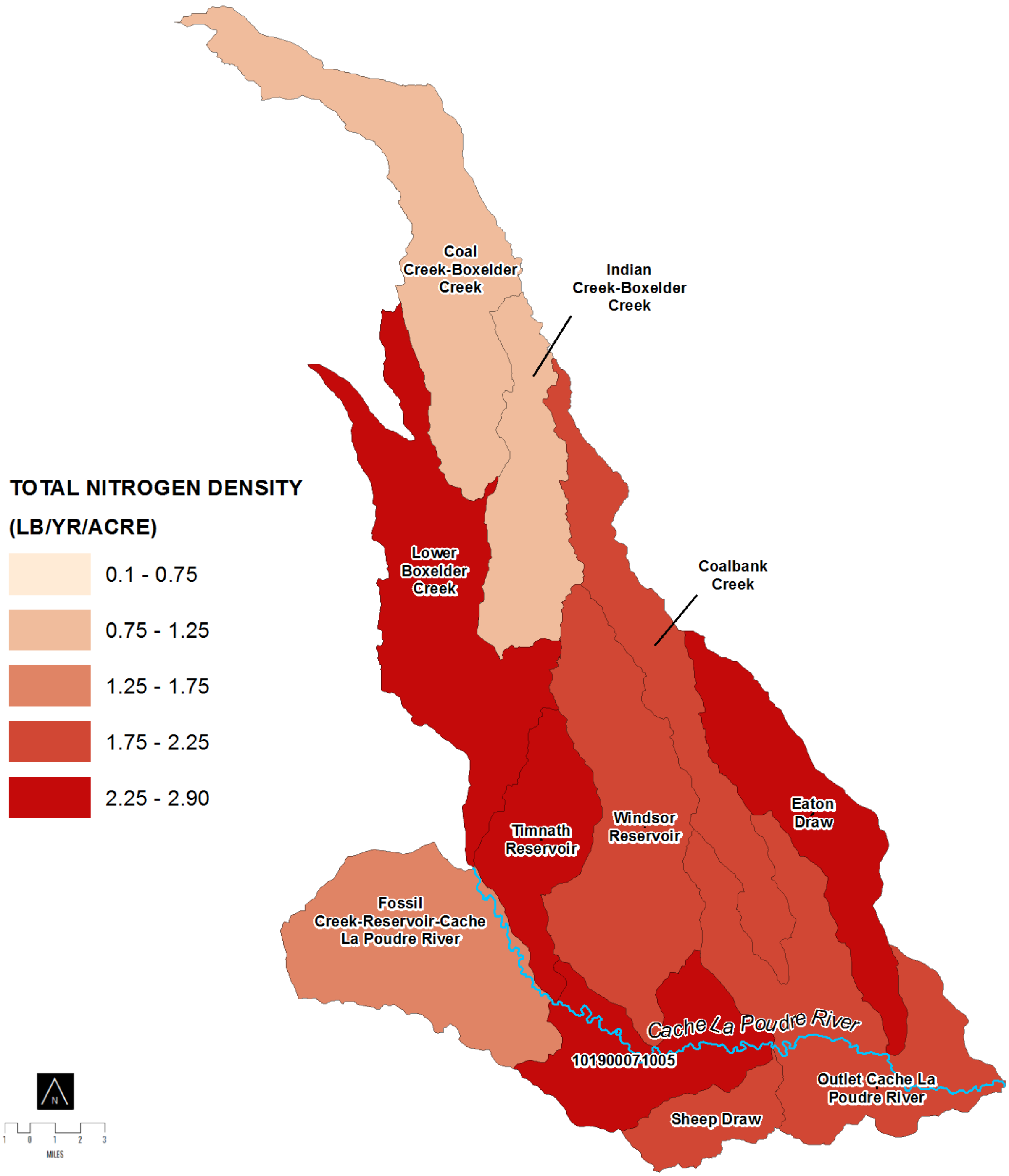



*Figure 5-14 Total Nonpoint Source Nitrogen Loading Density (lbs/acre/yr) by HUC12*

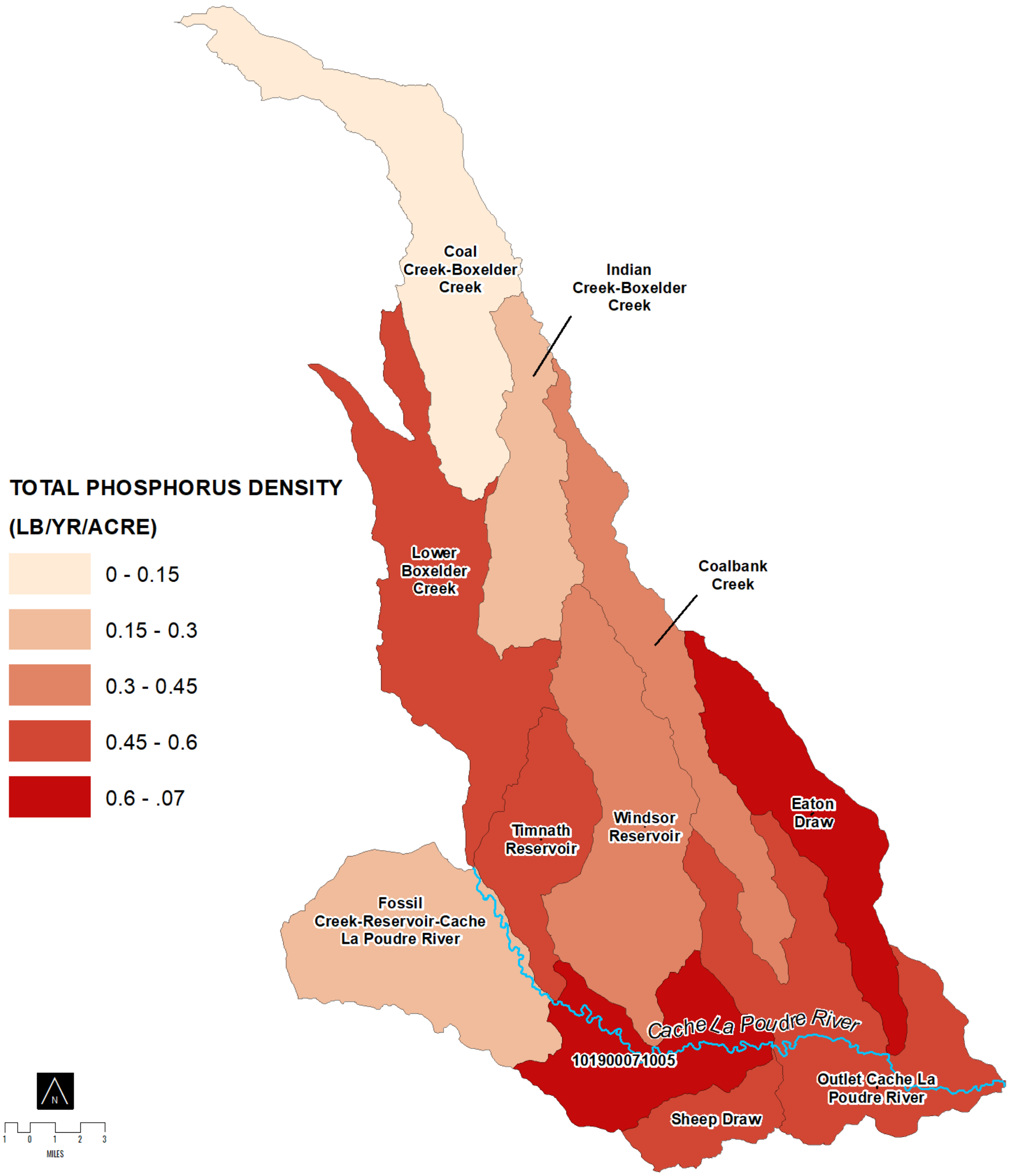



*Figure 5-15 Total Nonpoint Source Phosphorus Loading Density (lbs/acre/yr) by HUC12*

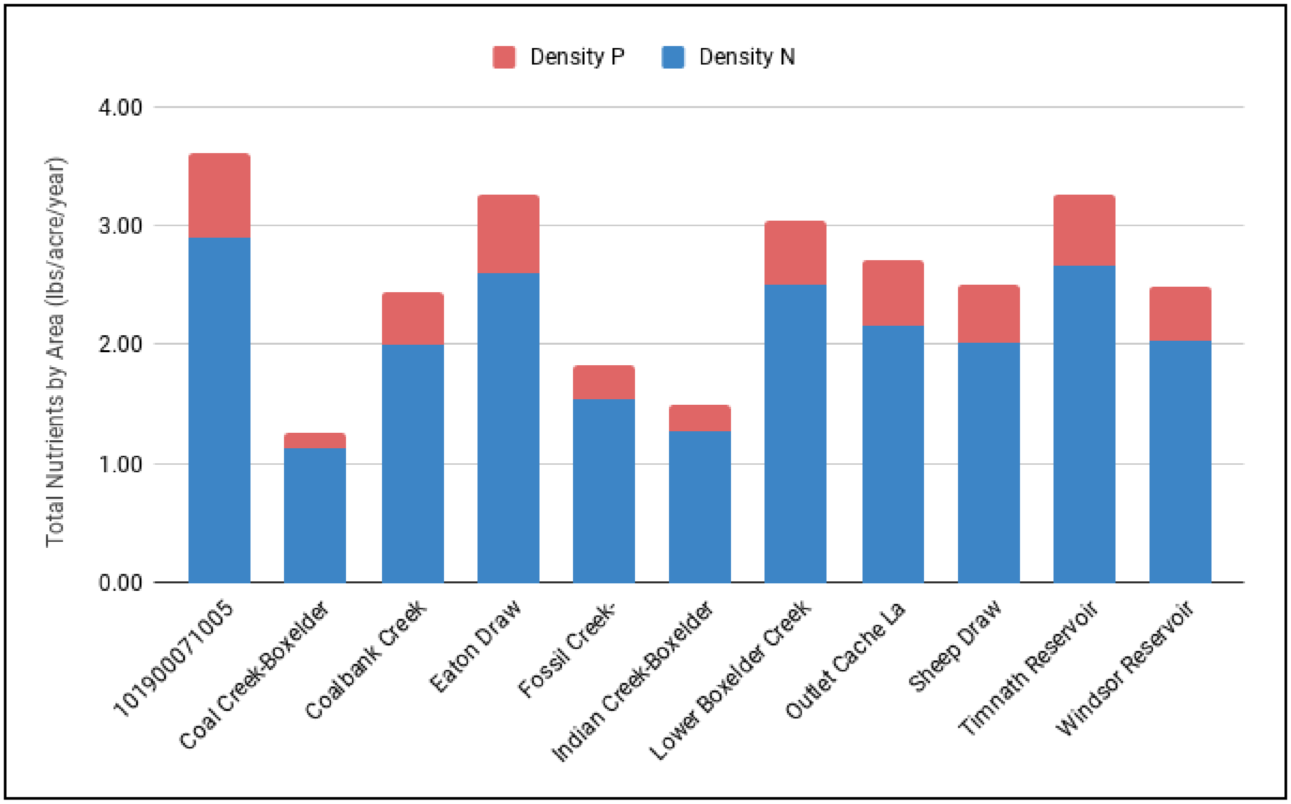



*Figure 5-16 Total Nonpoint Source Nutrient Load Density (lb/acre/yr) by HUC12*

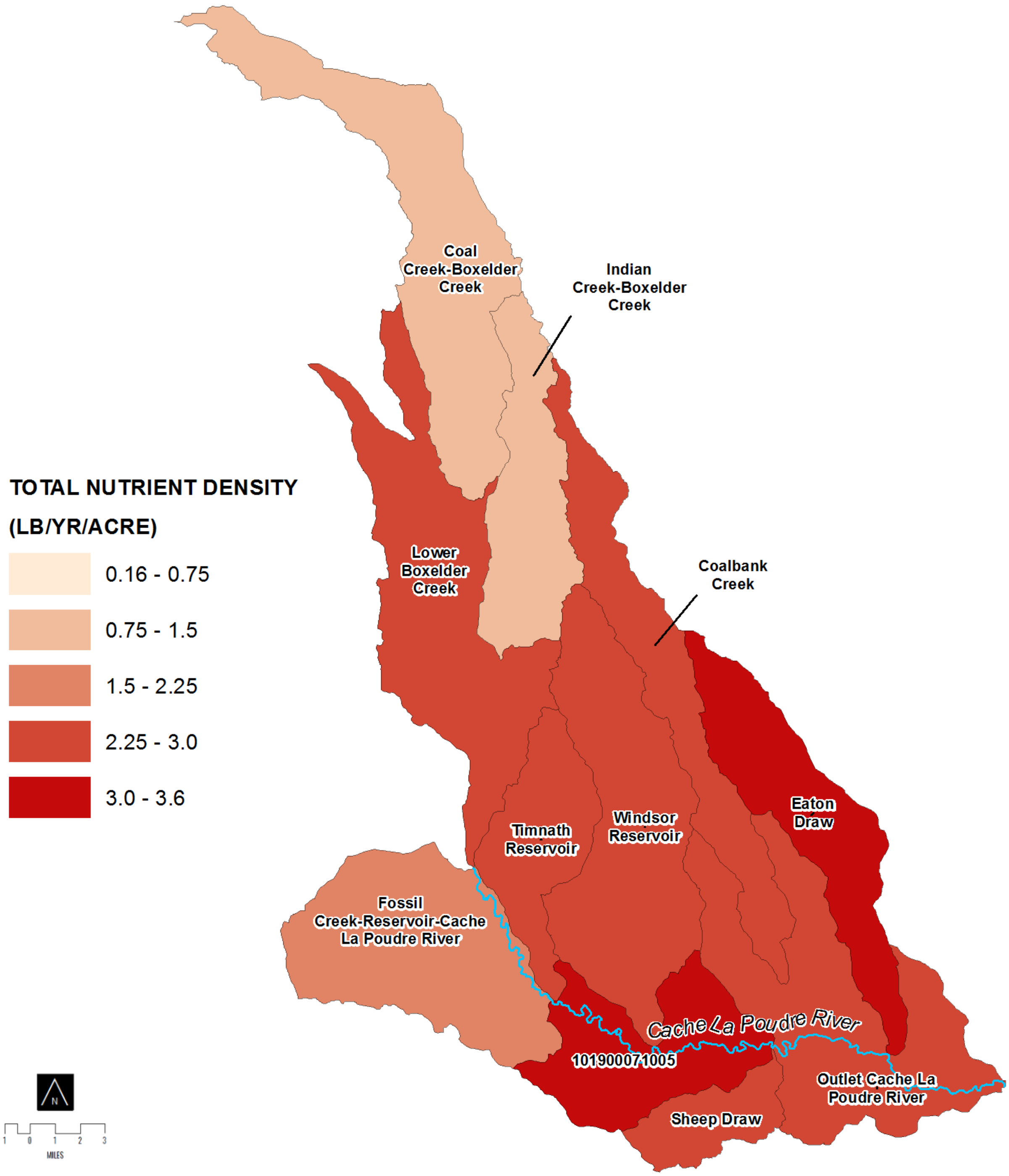



*Figure 5-17 Total Nonpoint Source Nutrient Load Density (lb/acre/yr) by HUC12*

#### 5.3.2.3 Nutrient Loading by Land Use Type

STEPL differentiates nonpoint source loading by land use type. This information can be used to determine which land use types are contributing the most pollution overall or in a priority watershed. Examining nutrient loading by land use type also allows managers to select and implement BMP actions on the land use types where they will be most effective.

Nutrient loading by land use type was calculated for nitrogen and phosphorus individually (Figure 5-18, Figure 5-19) and for total nutrient loading (Figure 5-20).

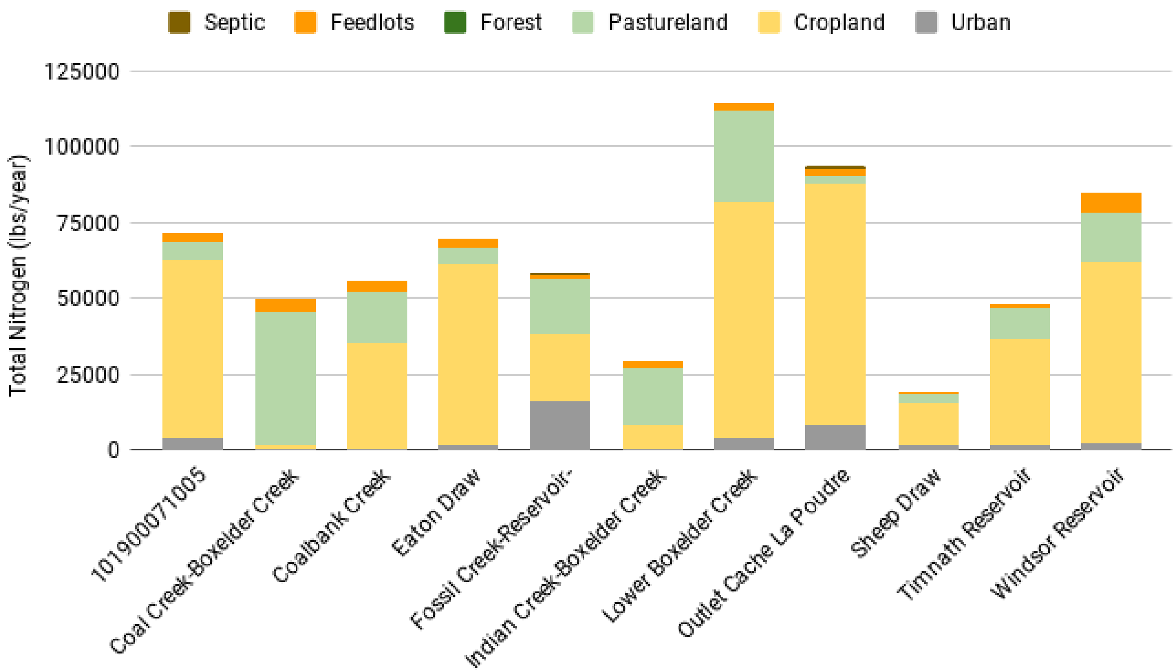



*Figure 5-18 Nonpoint Nitrogen Loading (lbs/yr) by Land Use Type*

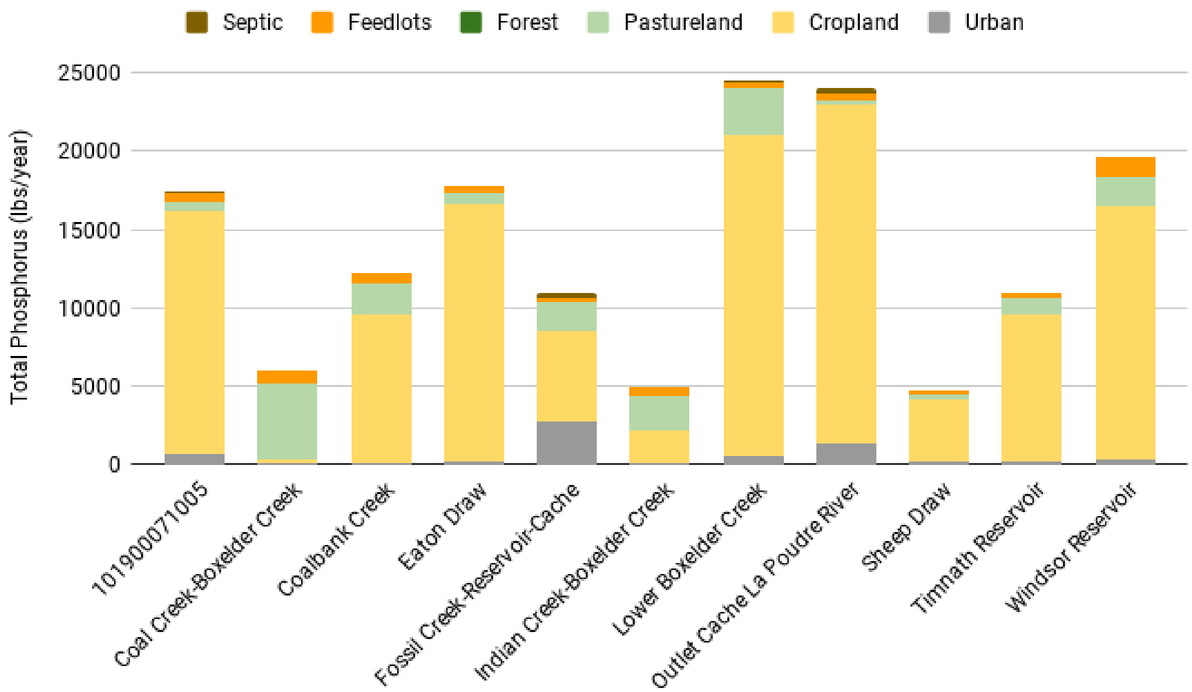



*Figure 5-19 Nonpoint Phosphorus Loading (lbs/yr) by Land Use Type*

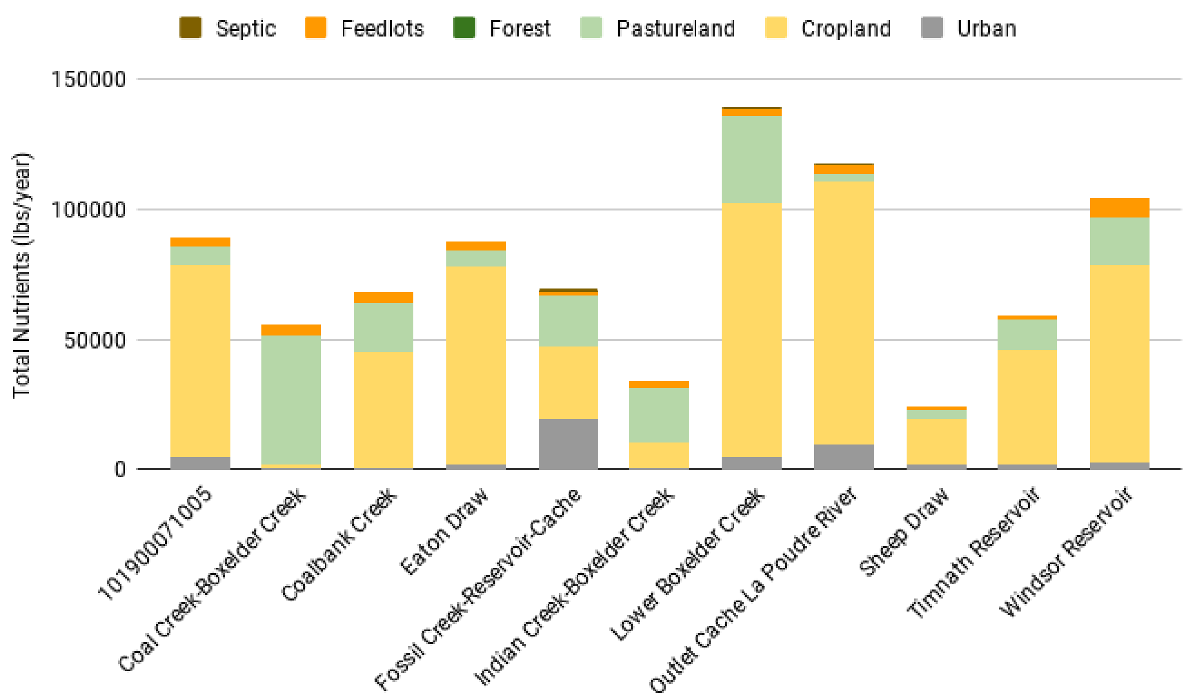



*Figure 5-20 Total Nonpoint Nutrient Loading (lbs/yr) by Land Use Type*

### 5.3.2.4 Nutrient Loading Density by Land Use Type

The nutrient loading density was broken out by land use type. The nutrient loading density by land use type can be used to identify land use types that are generating relatively large amounts of nutrients per unit area.

The nutrient loading density from septic systems cannot be calculated because there is not an area associated with septic systems; The STEPL model uses a count of septic systems to calculate the nutrient loading from failing septic systems.

Feedlots are also excluded from this calculation. The area of feedlots in the study area were estimated from the Tetra Tech online database and are very small (<5 acres). The small size of feedlots compared to the nutrient loading from feedlots results in a nutrient loading density that is several orders of magnitude greater than the nutrient loading density from other land use types. While feedlots are an important source of nutrients, they are not a current priority source for CPRW as they are regulated as point sources by the State of Colorado (CDPHE 2015).

Nutrient loading density by land use type was calculated for nitrogen and phosphorus individually (Figure 5-21, Figure 5-22) and for total nutrient loading (Figure 5-23).

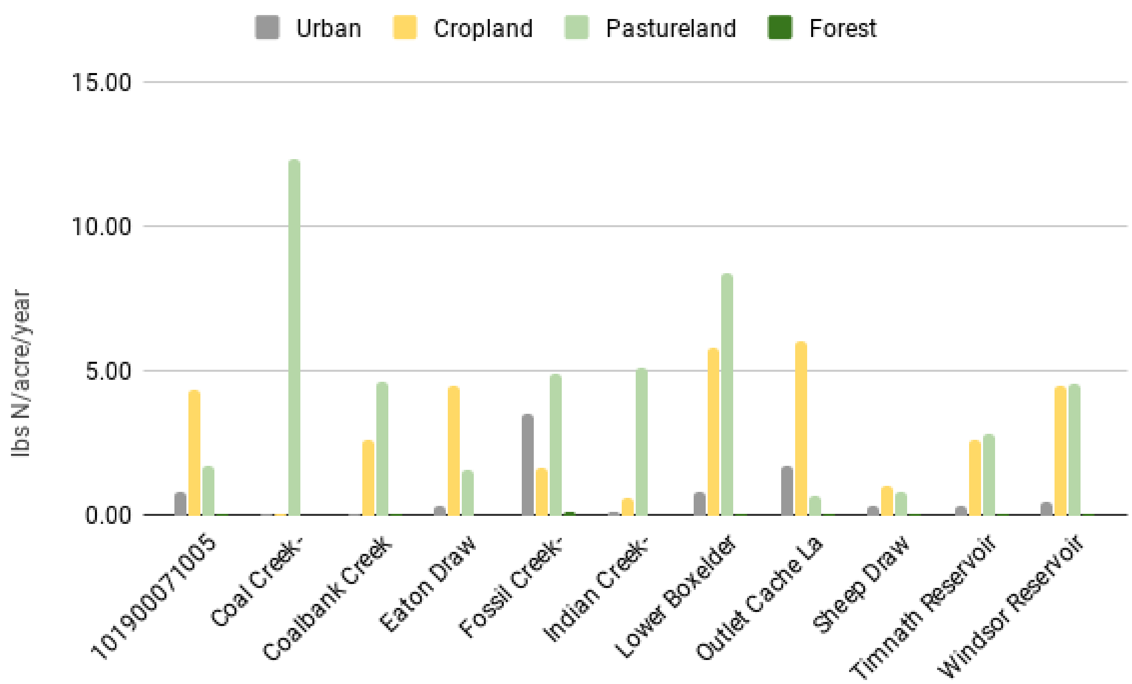



*Figure 5-21 Nonpoint Nitrogen Loading Density (lbs/yr) by Land Use Type*

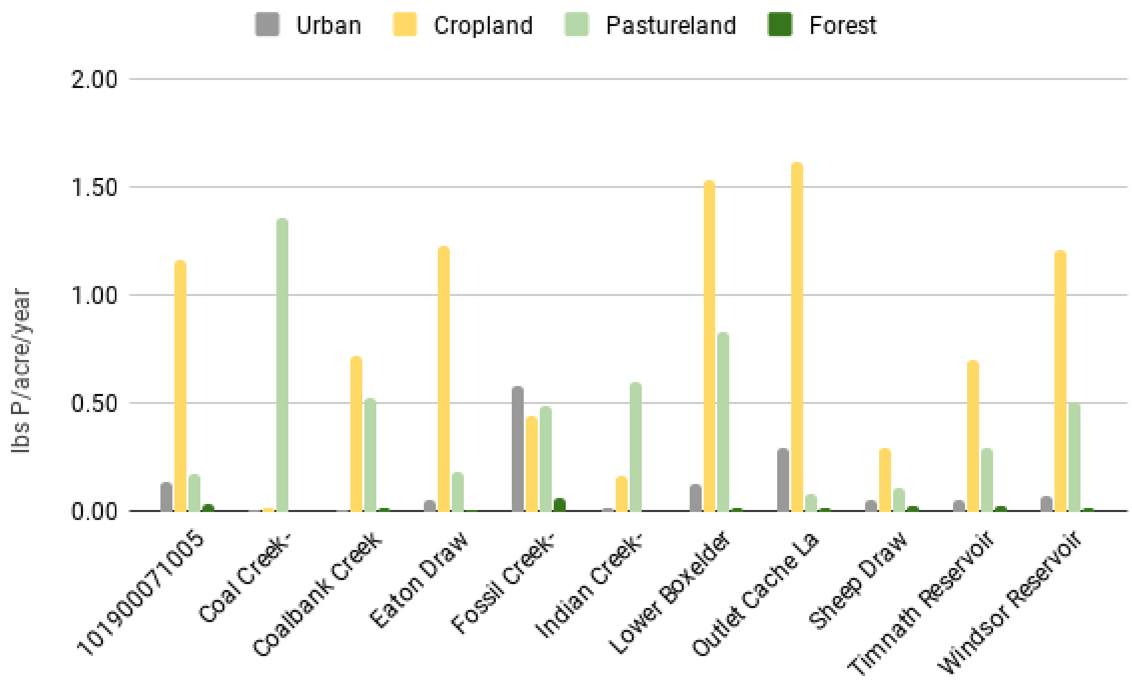



*Figure 5-22 Nonpoint Phosphorus Loading Density (lbs/yr) by Land Use Type*

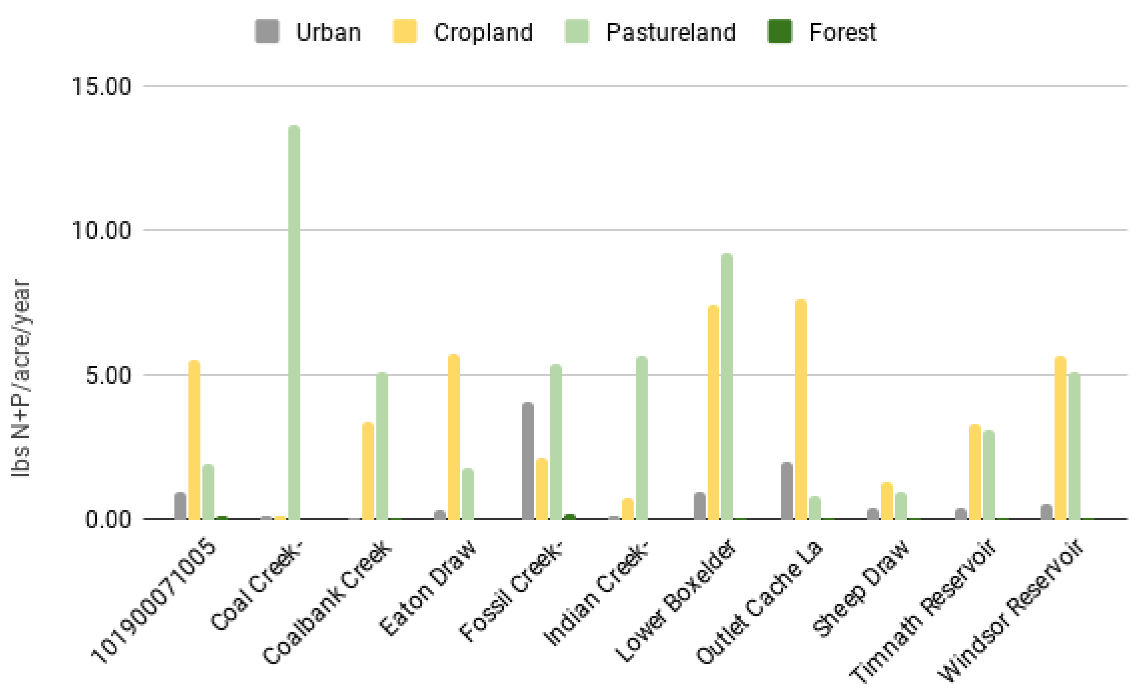



*Figure 5-23 Total Nonpoint Nutrient Loading Density (lbs/yr) by Land Use Type*

### 5.3.3 Conclusions

STEPL estimated nonpoint source nutrient loading to streams for over 360,000 acres of land in the lower CLP watershed. Results showed:

- ~695,000 lbs per year of nitrogen and ~150,000 lbs per year of phosphorus are released from nonpoint sources in the lower CLP
- The total nonpoint source nutrient loading to the lower CLP is estimated to be ~850,000 lbs per year
- Throughout the study area the weighted average of nitrogen loading was found to be ~2 lbs of nitrogen per acre of land per year, with regional variation ranging from 1 lbs to over 3 lbs per acre per year.
- Throughout the study area the weighted average of phosphorus loading was found to be ~0.4 lbs of phosphorus per acre of land per year, with regional variation ranging from 0.1 lbs to 0.7 lbs per acre per year.

Table 5-8 and Table 5-9 illustrate the top five HUC12 nutrient delivery contributors for each metric. Lower Boxelder Creek, the Outlet Cache La Poudre River, and Windsor Reservoir are in the top three for nitrogen, phosphorus and total nutrient loading. 101900071005, Eaton Draw, and Timnath Reservoir are in the top 3 for weighted averages of nitrogen, phosphorus and total nutrient loading per acre.

*Table 5-8 Top HUC12 Nutrient Delivery Contributors*

| Relative Rank | Nitrogen loading (lbs/yr) | Phosphorus loading (lbs/yr) | Total nutrient loading (lbs/yr) |
|---|---|---|---|
| 1 | Lower Boxelder Creek | Lower Boxelder Creek | Lower Boxelder Creek |
| 2 | Outlet Cache La Poudre River | Outlet Cache La Poudre River | Outlet Cache La Poudre River |
| 3 | Windsor Reservoir | Windsor Reservoir | Windsor Reservoir |
| 4 | 101900071005 | Eaton Draw | 101900071005 |
| 5 | Eaton Draw | 101900071005 | Eaton Draw |

*Table 5-9 Top HUC12 Weighted Average Nutrient Delivery Contributors*

| Relative Rank | Nitrogen loading density (lbs/yr/acre) | Phosphorus loading density (lbs/yr/acre) | Total nutrient loading density (lbs/yr/acre) |
|---|---|---|---|
| 1 | 101900071005 | 101900071005 | 101900071005 |
| 2 | Timnath Reservoir | Eaton Draw | Timnath Reservoir |
| 3 | Eaton Draw | Timnath Reservoir | Eaton Draw |
| 4 | Lower Boxelder Creek | Outlet Cache La Poudre River | Lower Boxelder Creek |
| 5 | Outlet Cache La Poudre River | Lower Boxelder Creek | Outlet Cache La Poudre River |

## 5.4 Focus HUC Selection

CPRW selected North Fork Lone Pine Creek in the upper CLP and Sheep Draw watershed in the lower CLP as priority HUCs for further evaluation. Although these watersheds were not among the highest contributors of sediments and nutrients based on modeling results, they were selected based on stakeholder input, the ability to leverage existing work in the area, partnering opportunities and other logistical considerations. The HUCs with the highest contributions of sediments from roads and nutrients identified in Table 5-8 and Table 5-9 may be a part of the next phase of study.

### 5.4.1 Upper CLP: North Lone Pine Creek

North Lone Pine has large proportions that are considered a high priority in the Upper Poudre Resiliency Plan and will continue to be a focus of forest management by both CPRW and the USFS. It drains into the North Fork of the Poudre downstream of Halligan but upstream of Seaman Reservoir, thus influencing a significant water supply source in the watershed. It has private lands and residential areas, with potential for increased density, making it an interesting area for identifying opportunities for implementing best management practices that may protect water quality into the future.

As a part of the Upper Poudre Resilience Plan, soil and geology of the upper watershed was used in the prioritization. The North Fork Lone Pine Creek watershed ranked the soil/geology hazard high due to the presence of granitic soils. There is a high potential for soil erodibility due to the granitic parent material which also poses a higher risk for the dirt roads in the watershed (JW Associates 2017).

### 5.4.2 Lower CLP: Sheep Draw

Although Sheep Draw was not the sub drainage with the highest concentrations of nutrients, CPRW, in consultation with its stakeholders, opted for a deeper examination of this drainage for several reasons. First, it produces an above average amount of nitrogen and phosphorus per acre of land and it is immediately upstream of reaches in the Lower Poudre with potential impairments for nutrients, thus controlling concentrations in this area could help reduce loading downstream. The watershed has both agricultural land uses and is expected to see its urban/suburban areas expand in the coming years. This points to a need to consider preventing nonpoint source pollution in advance of those changes but also offers the opportunity to explore multiple types of best management practices. It is a small enough area that it is tractable and practical for a pilot study area. This area was identified as a high priority (top 8) in CPRW's 2017 Lower Poudre River & Flood Resiliency Master Plan for planning and identifying restoration actions. It has also been an area of interest by the City of Greeley for other riparian improvements and open space planning. The area had also been considered as a potential site for a pilot test of a water quality trading program that the City of Greeley had been researching (see below).

**Investigating Water Quality Trading**

In 2015, the City of Greeley worked with The Freshwater Trust to explore the potential for a permit-based water quality trading program. The three-part study was designed to review potential opportunities to assist the City of Greeley in understanding the potential for a trading program to assist with nutrient and temperature regulations and help meet regulatory changes resulting from Regulation 85. The first phase reviewed potential policy barriers to or considerations for establishing a water quality trading program. The first phase confirmed that water quality trading for nutrients and/or temperature is a viable approach to Clean Water Act compliance in both Colorado and Weld County. The second phase examined current and projected future pollutant loadings to estimate future exceedances and thus the potential volume of future credits that would be needed to offset pollutant loads. The third phase, which is not yet complete, is intended to analyze the supply of credits and explore the needed size and potential costs of a trading program.

Although the study was focused on exploring a best management practice (water quality trading) for assisting managing a point source of pollution, the study is still relevant for any discussion of opportunities for protecting and improving water quality in the lower Poudre. Any best management practices that can be leveraged to benefit both point and nonpoint source pollution merits evaluation. In the phase two report, The Freshwater Trust identified the need for additional nutrient monitoring but also noted that restoration actions, such as riparian vegetation, flow augmentation, instream restoration and treatment wetlands could be evaluated for their effectiveness within the context of a trading program. These best management practices can also be leveraged to mitigate nonpoint source pollutant loadings as well, offering the potential for increasing the cost-effectiveness of these practices.

# 6 Management Strategies & Potential Load Reductions

The modeling efforts described in Section 5 estimate the nonpoint source pollutant loading of sediments and nutrients through the CPW watershed. CPRW can apply this information to target specific areas and sources on which to focus management efforts. This section describes Best Management Practices (BMPs) that CPRW may implement within the watershed to reduce sediments and/or nutrients from key nonpoint sources.

## 6.1 Proposed CPRW Management Strategies

The intent of this plan is to highlight different BMPs that may positively affect water quality in the Poudre and include the flexibility for the future application of an expanded set of BMPs in the future, as areas of focus and partnering opportunities expand and shift through the expansive CLP watershed area.

As a small nonprofit organization, CPRW aims to plan and implement restoration projects at a large enough spatial scale to positively impact the Poudre watershed. To do this, we focus on cross-jurisdictional opportunities where we can leverage partnerships for the design and implementation of nonpoint source pollution reduction projects and other restoration activities. (Section 7.1.1 provides additional specifics on current and future partnering opportunities). CPRW is well positioned to work with private and public landowners on the design and implementation of on-the-ground riparian restoration work that promotes water quality protection and improvements. Certain best management practices, for example significant land use zoning or policy changes, would largely be outside of CPRW's purview. CPRW can work with partners on education and outreach needs with respect to water quality protection best management practices and can thus still support implementation of those BMPs that may not be CPRW's niche/area of expertise.

The primary drivers of project selection include: project feasibility (defined by landowner willingness, minimal conflicts with current and future land use, and interested partners such as farmers ranchers, cities, counties, other land owners, or conservation organizations), water rights or other legal constraints, available grant and other sources of funding, and the ability to leverage multiple objectives/goals and other ongoing mitigation, planning priorities, and management efforts where appropriate in the basin.

For this initial planning effort, CPRW has chosen to focus its efforts on reducing nutrients in the lower CLP. STEPL results indicated that nonpoint source nutrient loading is driven by cropland and pastureland in these areas, thus this initial focus is on BMPs that can be applied on crop and pasture lands in areas where there is existing activity with partners. For the upper CLP, CPRW is interested in sediment reduction BMPs, including those related to roads, ongoing fire rehabilitation efforts, and other BMPs associated with forests as discussed below; this may become the next focus area for CPRW.

## 6.1.1 BMPs

This section describes the initial set of BMPs under consideration by CPRW and its stakeholders for reducing nutrients in the lower CLP (EPA 2018).

### 6.1.1.1 BMPs included in the STEPL Model

Reductions from these BMPs can be modeled utilizing the STEPL model. This list of BMPs is not exhaustive and is constrained by which BMPs are included in the STEPL model.

#### 6.1.1.1.1 Current cropland and pastureland directed BMPs in consideration include:

**Animal Trails and Walkways**
Animal trails and walkways are facilities designed to allow livestock or wildlife to move through difficult or ecologically sensitive terrain. They are intended to reduce erosion by providing or improving animals' access to forage, water, or shelter; improving grazing efficiency and distribution; and diverting travel away from ecologically sensitive or erosive sites.

**Forest Buffer**
An area predominantly of trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies. The riparian area serves to create shade to lower or maintain water temperatures to improve habitat for aquatic organisms; create or improve riparian habitat and provide a source of detritus and large woody debris; reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow groundwater flow; reduce pesticide drift entering the waterbody; restore riparian plant communities; and increase carbon storage in plant biomass and soils.

**Grass Buffer**
A newly established area along a waterbody that intercepts overland flow and is used to maintain bank stabilization, reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals to supply food, cover and thermal protection to fish and other wildlife. To achieve these results, the recommended minimum width is 35 feet wide and should include native grass(es).

**Conservation Cover**
Conservation cover is the practice of establishing and maintaining perennial vegetative cover to protect soil and water resources on land that has been retired from agricultural production. It reduces soil erosion and sedimentation, improves water quality, and creates or enhances wildlife habitat.

**Critical Area Planting**
Critical area planting is the planting of grasses, legumes, or other vegetation to stabilize slopes in small, severely eroding areas. The permanent vegetation stabilizes areas such as gullies, over-grazed hillsides and terraced backslopes. Although the primary goal is erosion control, vegetation can also provide nesting cover for birds and small animals.

**Grassed Waterway**
A grassed waterway is a natural or constructed channel that is shaped or graded and planted with suitable vegetation for the stable conveyance of runoff without causing erosion of the channel.

**Land Retirement**
The process of taking land out of production and replacing it with permanent vegetative cover such as shrubs, grasses, and/or trees.

**Stream Channel Stabilization**
Stream channel stabilization means stabilizing the channel of a stream with suitable structures to prevent erosion or siltation of the channel. A channel is considered stable if the channel bottom remains essentially at the same elevation over long periods of time. Stream channel stabilization methods include modifying the channel capacity, channel armoring (riprap lining), providing channel crossings for livestock, and seeding (vegetating or planting the channel to prevent erosion).

**Streambank Protection**
Streambank protection helps to prevent streambank erosion. Streambank protection methods are essentially the same as stream channel stabilization methods. They include modifying the channel capacity, channel armoring (riprap lining), providing channel crossings for livestock, and seeding (vegetating or planting the channel to prevent erosion).

**Streambank Fencing**
Fencing is used to restrict livestock access to streambanks because animal traffic erodes streambanks, increases sediment load, and contributes animal waste in and near the stream, impairing water quality.

**Wetland Detention**
Wetland detention uses a detention basin planted with wetland vegetation. The wetland vegetation improves the quality of stormwater released from the basin more effectively than dry detention and typical wet detention because the wetland vegetation reduces nutrients like nitrate nitrogen and phosphorus by as much as 90 percent, and settling and mechanical filtration by wetland plants also reduce suspended solids and turbidity.

6.1.1.1.2 Current forest and road BMPs in consideration for the Upper CLP include:

**Soil Stabilization Measures (Forests Site Preparation)**
The following measures can be used to stabilize soils for forest site preparation and road construction:

- Hydromulch
- Straw
- Crimping
- Seeding

- Fertilizer
- Transplanting
- Nets

**Road Dry Seeding and Hydraulic Seeding**
Two basic methods for spreading seed are dry seeding and hydraulic seeding. Dry seeding is a method the U.S. Forest Service uses to revegetate inactive roads to provide long-term erosion control. In dry seeding, seeds are broadcast or planted without mixing them with water or other liquid. Dry seeding and fertilizing along roads are usually done with cyclone-type rotary seeders. In hydraulic seeding (hydroseeding), a wet slurry of seed, mulch, and fertilizer is typically applied from a pump truck or portable trailer to steep slopes or areas where erosion rates are high.

**Road Grass and Legume Seeding**
Grass and legume seeding is a form of revegetation of bare soils used to prevent erosion. Native plants, domesticated native plants, and introduced agronomic species are all useful for rehabilitation and revegetation.

**Road Hydromulch (Hydromulch)**
Hydraulic mulching is a process by which wood fiber mulch, processed grass, hay or straw mulch is applied with a tacking agent in a slurry with water to provide temporary stabilization of bare slopes or other bare areas. This mulching method provides uniform, economical slope protection. It may be combined with hydroseeding as a revegetation method.

**Road Straw Mulch**
Straw mulch is applied on slopes to hold the soil and prevent loss of grass seed. Straw mulch provides erosion control and moisture conservation, and it prevents soil crusting.

**Road Tree Planting**
Tree planting is used for erosion control on permanently closed or decommissioned forest roads to return the site to forest and timber production. Where necessary, compacted or rock-surfaced roads are loosened to reduce surface runoff and promote seedling survival.

**Wildfire Mitigation and Hazard Mitigation Planning**
To complement and support reducing sediment delivery from roads, stakeholders should also consider the large-scale implementation of forest restoration/wildfire mitigation work to ensure that future wildfires do not also become a significant source of sediment delivery and water quality degradation. The US Forest Service National Best Management Practices for Water Quality Management on National Forest System Lands technical guide details a variety of BMP's to reduce sediment delivery and protect water quality both pre-and post-wildfire including the use of prescribed fire, wildland fire control and suppression, and wildfire damage rehabilitation (USDA 2012).

In addition, the State of Colorado's Hazard Mitigation Plan (HMP) supports and aligns with this analysis and watershed plan. The HMP recognizes that watershed groups are important to bring together local, state, non-profits, federal agencies, and private landowners to implement projects to increase watershed resilience to natural hazards (HMP: 4-15). Partners across watersheds also play important roles including Conservation Districts that focus on improving soil health, water quality, water conservation, wildlife habitat, forest health and wildfire mitigation (HMP 4-66). Partnering with agencies like the Conservation Districts is key to prioritize, fund and design outreach programs for protecting water quality through wildfire mitigation strategies.

Because this plan identified sediment issues in the headwaters, there are important strategies identified in the HMP to consider. Strategies include improving soil health by developing grazing systems to tolerate drought, reducing the potential for dust storms and increasing the demonstration and adoption of farming methods to improve soil health and water holding capacity so agricultural land will be more resilient to drought (HMP: 5-31).

Wildfires are also a major source of non-point source pollution when they result in large increases in runoff and erosion which affect drinking water supplies, water treatment plant operations, irrigation systems, fisheries and other aquatic life. This analysis supports and aligns with the Colorado Wildfire Mitigation Plan (WMP). This plan identifies several wildfire mitigation strategies to incorporate including prioritizing mitigation projects across landownership boundaries, increase awareness for informed decision making and action for mitigating wildfire threats, and informed decision making from individual landowners and at a local community level for effective hazard mitigation in wildland areas (CO WMP Summary of Recommendations Table). The WMP also highlights other related funding strategies that align with this analysis and CPRW's approach to reducing fire risk in the Wildland Urban Interface including: reducing hazardous fuels/restoring fire-adapted ecosystems by implementing fuel treatments in or adjacent to fire-prone communities to reduce the threat of catastrophic wildfire; improving education to communities in the WUI, and the creation of Community Wildfire Protection Plans (pg 19-20 CO WMP). Other strategies identified are preserving old and large trees of ecological and scientific value, replanting trees in deforested areas and reducing the threat of high intensity wildfires (pg 21 CO WMP).

#### 6.1.1.2 Additional BMPs not included in the STEPL model

As development continues to expand into agricultural areas, urban sources may have a greater contribution to the watershed, especially in the lower CLP. Additionally, there are BMPs that are not included in STEPL but may be valuable to study further. Some of those potential BMPs include but are not limited to:

- Detention ponds
- Bioretention cells
- Wet meadow/beaver mimicking habitat restoration
- Modifying or increasing capacity of culverts or crossings
- Additional outreach and education for private landowners/HOA managers, business landowners, and agricultural operators
- Land use planning, zoning, or other policy changes

- Incorporation of low impact development or other green infrastructure BMPs for managing urban stormwater
- Geotextiles
- Permanent conservation/conservation easements that prohibit grazing/ag in sensitive locations
- Holistic grazing methods

#### 6.1.1.3 BMP Cost Estimates

The cost of BMP implementation and maintenance is variable and will be project specific. The following cost estimates are provided to get a sense of the magnitude of cost for BMPs that might be implemented in the Cache La Poudre Watershed.

The STEPL Web Tool created by Purdue University[9] provides implementation and maintenance costs as well as an estimate for the design life for several BMPs (Table 6-1). Cost data is from 2014.

*Table 6-1 STEPL Web Tool CMP Cost Estimates.*

| Landuse | BMP Name | Establishment Cost[1] ($ per acre) | Annual Maint. Cost (% of Est $) | BMP Design Life (years) |
|---|---|---|---|---|
| Cropland | Contour farming | 6.00 | 1 | 1 |
| Cropland | Filter strip | 8.69 | 10 | 10 |
| Cropland | Reduced tillage systems | 2.72 | 1 | 1 |
| Forest | Site preparation/hydro mulch/seed/fertilizer | 1,500.00 | 1 | 10 |
| Forest | Site preparation/straw/crimp/net | 14,359.00 | 1 | 10 |
| Feedlots | Filter strip | 8.69 | 4 | 10 |
| Urban | Alum Treatment | 450.00 | 0 | 1 |
| Urban | Bioretention facility | 2,494.00 | 3 | 10 |
| Urban | Dry Detention | 11,000.00 | 3 | 10 |
| Urban | Grass Swales | 700.00 | 5 | 10 |
| Urban | Infiltration Basin | 3,000.00 | 3 | 10 |
| Urban | Infiltration Trench | 9,000.00 | 5 | 10 |
| Urban | LID/Infiltration Swale | 2,700.00 | 3 | 10 |
| Urban | Porous Pavement | 239,580.00 | 1 | 10 |
| Urban | Sand Filter/Infiltration Basin | 2,700.00 | 3 | 10 |
| Urban | Sand Filters | 10,500.00 | 12 | 10 |
| Urban | Vegetated Filter Strips | 8.69 | 4 | 10 |
| Urban | Weekly Street Sweeping | 6,049.00 | 7 | 1 |
| Urban | Wet Pond | 6,529.00 | 3 | 5.7 |
| Urban | Wetland Detention | 2,500.00 | 2 | 10 |

[9] https://engineering.purdue.edu/mapserve/ldc/STEPL/?

Ranges of costs for BMP implementation in the Chesapeake Bay Region were documented in a comprehensive Nutrient Trading Economic Study completed in 2012 (VanHouten et al. 2012) (Table 6-2). Cost data is reported in 2010 dollars.

*Table 6-2 Agricultural BMP Cost Estimates – Chesapeake Bay*

| Best Management Practice | Annualized Total Costs ($/acre/year) | BMP Time Horizon |
|---|---|---|
| Riparian Forest Buffer | $98–$903 | 15 |
| Riparian Grass Buffers | $44–$632 | 15 |
| Wetland Restoration | $318–$887 | 15 |
| Tree Planting | $56–$840 | 15 |
| Land Retirement | $19–$624 | 10 |
| Livestock Exclusion | $88–$693 | 10 |
| Cover Crop Early Drilled Rye | $35 | 1 |
| Continuous No-Till Agriculture | $20–$40 | 1 |
| Enhanced Nutrient Management | $19 | 1 |
| Decision Agriculture | $13–$30 | 1 |
| Off Stream Watering | $32 | 10 |
| Upland Prescribed Grazing | $9–$33 | 1 |
| Upland Precision Intensive Rotational Grazing | $53–$93 | 1 |

The costs of the agricultural BMPs in Table 6-3 were estimated by the Delaware Department of Natural Resources and Environmental Control Division of Water Stewardship using data gathered by the United States Department of Agriculture (USDA) Natural Resources & Conservation Service (NRCS) staff at the county and state level.

*Table 6-3 Agriculture BMP Costs – Delaware Division of Water Stewardship*

| Table 3. Agriculture BMP Costs | | | | |
|---|---|---|---|---|
| | **Installation Cost / Acre** | **Lifespan (years)** | **Total Maintenance Costs over Lifespan** | **Total Costs/ Acre** |
| **Cover Crops** | $49.33 | 1 | $5 | $54.33 |
| **Ponds** | $3,758.50 | 10 | $5 | $3,808.50 |
| **Grassed Waterways** | $16,404.24 | 10 | $5 | $16,454.24 |
| **Filter Strips/Wildlife Habitat** | $495.24 | 10 | $5 | $545.24 |
| **Forest Buffers** | $495.24 | 10 | $5 | $545.24 |
| **Riparian Buffers** | $502.00 | 10 | $5 | $552.00 |
| **Wetland Restoration** | $4,374.50 | 10 | $5 | $4,424.50 |
| **Field Border** | $495.24 | 10 | $5 | $545.24 |
| **Critical Area Planting** | $7,229.24 | 10 | $5 | $7,279.24 |
| **Conservation Tillage** | $17.33 | 4 | $5 | $37.33 |
| **NMP** | $5.70 | 1 | - | $5.70 |

## 6.2 Sheep Draw: Potential Nutrient Reductions

This section illustrates how CPRW can quantify potential nutrient load reductions within a selected HUC12 watershed area. As detailed in Sections 3.1 and 5.4, the Sheep Draw watershed was selected as the priority implementation HUC for this initial planning effort; load reductions for priority BMPs can be estimated using a custom calculator tool that leverages the STEPL model.

### 6.2.1 Sheep Draw Characterization

Sheep Draw is the smallest watershed in the lower CLP (9,656 acres) and is located in the southeast portion of the CLP (Figure 6-1). The majority of land in the Sheep Draw is privately owned cropland and pastureland (Figure 6-4). Along the river corridor, the City of Greeley owns a large amount of property including Signature Bluffs Natural Area (Lynker 2017). Weld County also owns several thousand acres of the basin that have not been annexed by the City of Greeley. There are several large private landowners who own property along the river corridor, and the rest of the watershed is a mix of housing developments and parks (Anderson Consulting Engineers 2006). There are several suburban areas located in the eastern portion of the watershed. Significant development has occurred within the eastern portion of the Sheep Draw watershed, while the western part of the watershed has remained largely undeveloped. The area in the watershed that is developed consists of low-high density housing development, industry/commercial, parks/golf courses and schools.

Sheep Draw Basin also lies within the City of Greeley's Long Range Expected Growth Area Limits which represents the expected 20-year growth area boundary (Anderson Consulting Engineers 2006). Sheep Draw is a major drainage channel to the Poudre River. There are several minor tributaries in the watershed. The channel varies from a broad poorly defined to a well-defined low flow channel. There are two irrigation ditches in Sheep Draw including the Boomerang Ditch and the Greeley No. 3 Ditch. The ditches convey irrigation flows within the watershed (Anderson Consulting Engineers 2006)

Figure 6-2 shows an aerial map of the watershed, and Figure 6-3 and Table 6-4 shows the land use within the watershed. Figure 6-5 shows MS4 boundaries and zoning in the vicinity of the Sheep Draw Watershed. Based on data available in the Weld County GIS Property Portal[10], Sheep Draw does not include any MS4 boundaries. In 2006, the City of Greeley updated the drainage plan for the Sheep Draw watershed. This drainage plan could be used to help inform projects around stormwater infrastructure (City of Greeley 2006).

[10] Weld County Property Portal: https://www.co.weld.co.us/maps/propertyportal/

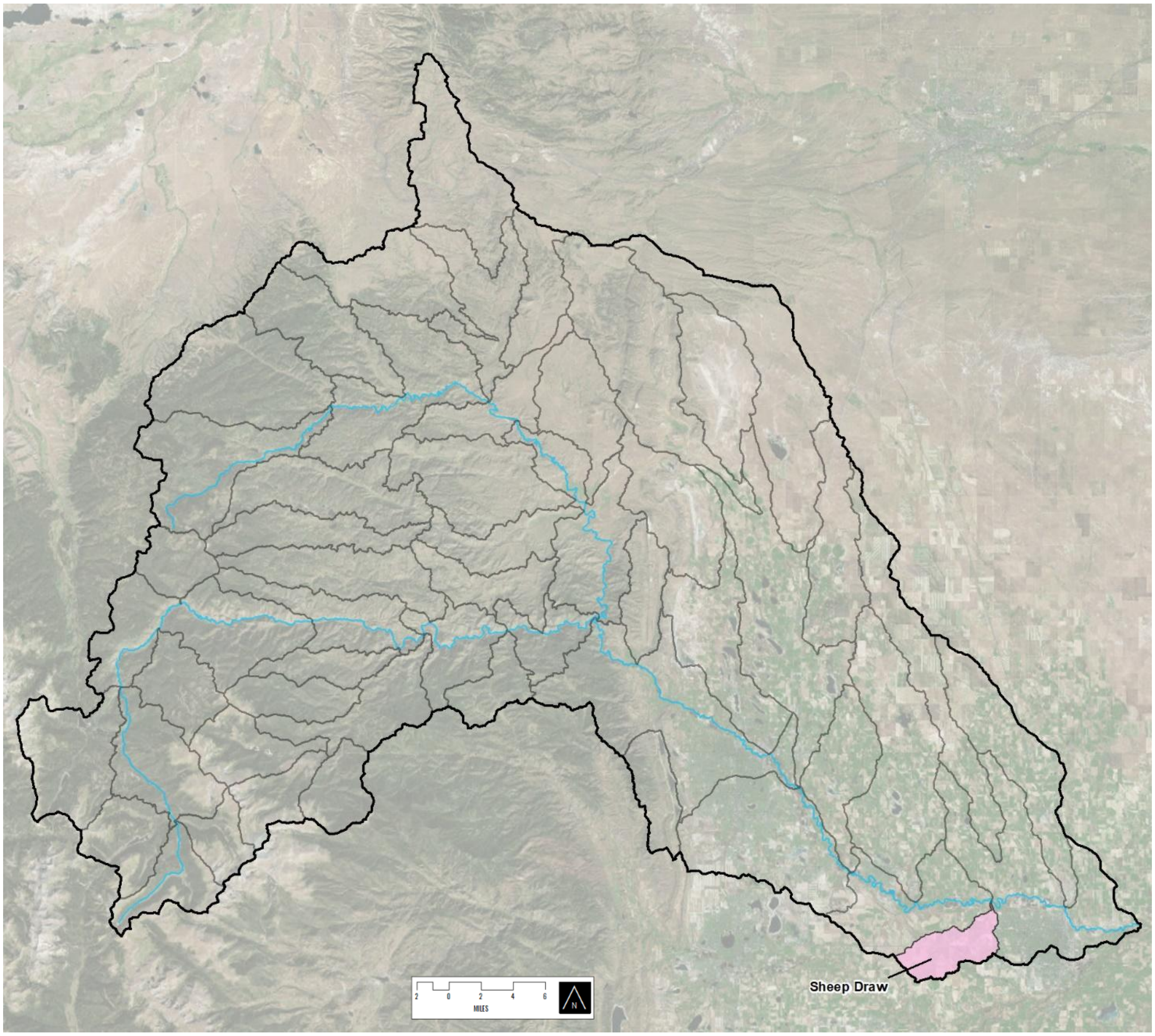



*Figure 6-1 Sheep Draw Watershed*

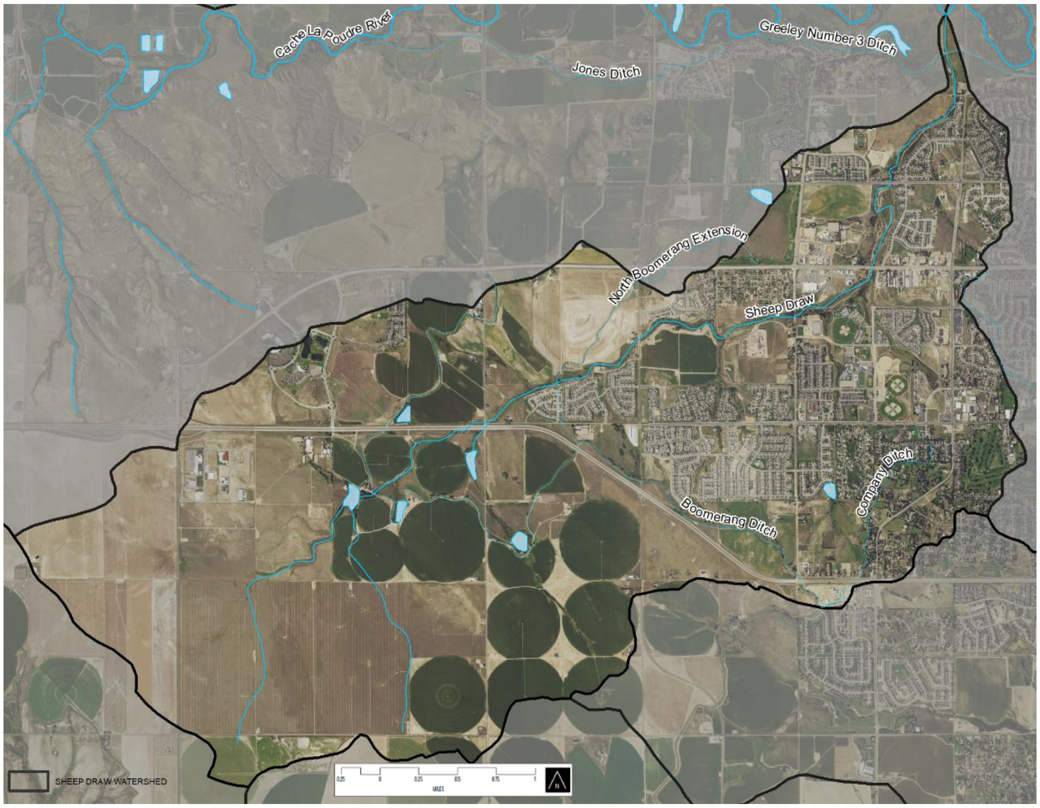



*Figure 6-2 Aerial Map of the Sheep Draw Watershed*

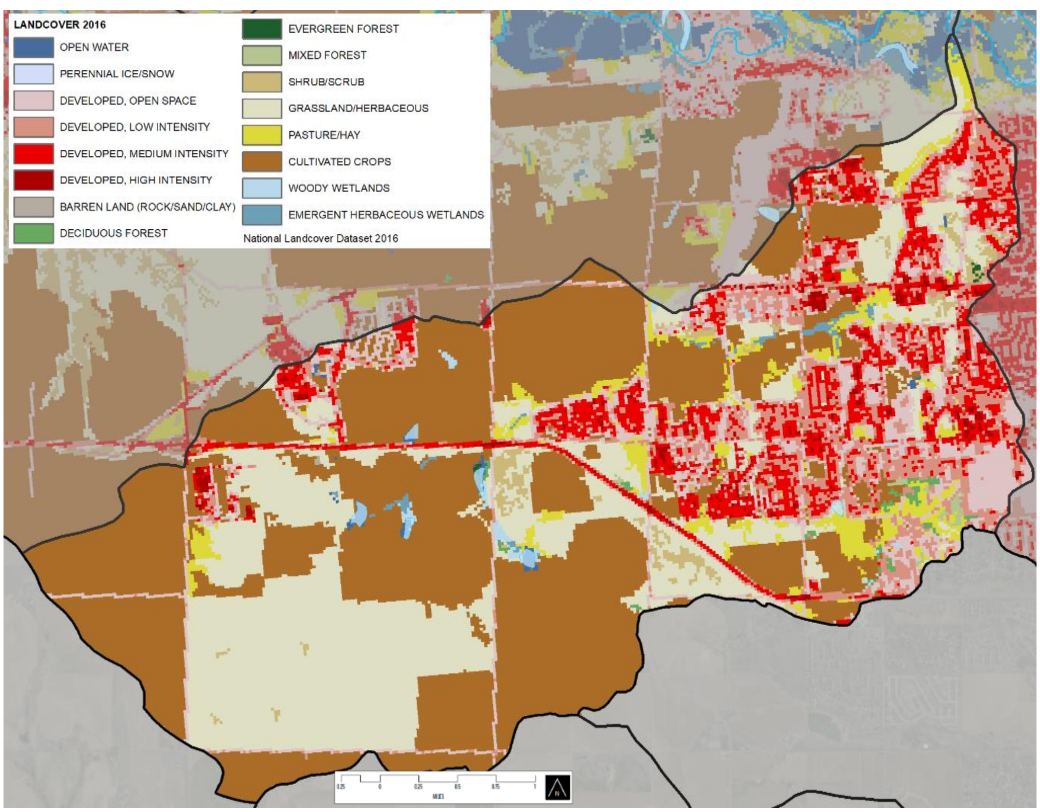



*Figure 6-3 NLCD 2016 Land Use in Sheep Draw Watershed*

*Table 6-4 Sheep Draw Watershed Land Use Categories and Percentages*

| NLCD Land Use Classification | STEPL Classification | Acres | % of Total |
|---|---|---|---|
| Developed Open Space | Urban | 819 | 8.5% |
| Developed- Low Intensity | Urban | 963 | 10.0% |
| Developed- Medium Intensity | Urban | 829 | 8.6% |
| Developed- High Intensity | Urban | 128 | 1.3% |
| Cultivated Crops | Cropland | 4049 | 41.9% |
| Grassland/Herbaceous | Pastureland | 2239 | 23.2% |
| Pasture/Hay | Pastureland | 360 | 3.7% |
| Deciduous Forest | Forest | 30 | 0.3% |
| Evergreen Forest | Forest | 4 | 0.04% |
| Mixed Forest | Forest | 16 | 0.2% |
| Others | Others | 218 | 2.3% |
| All | All | 9,656 | 100 |

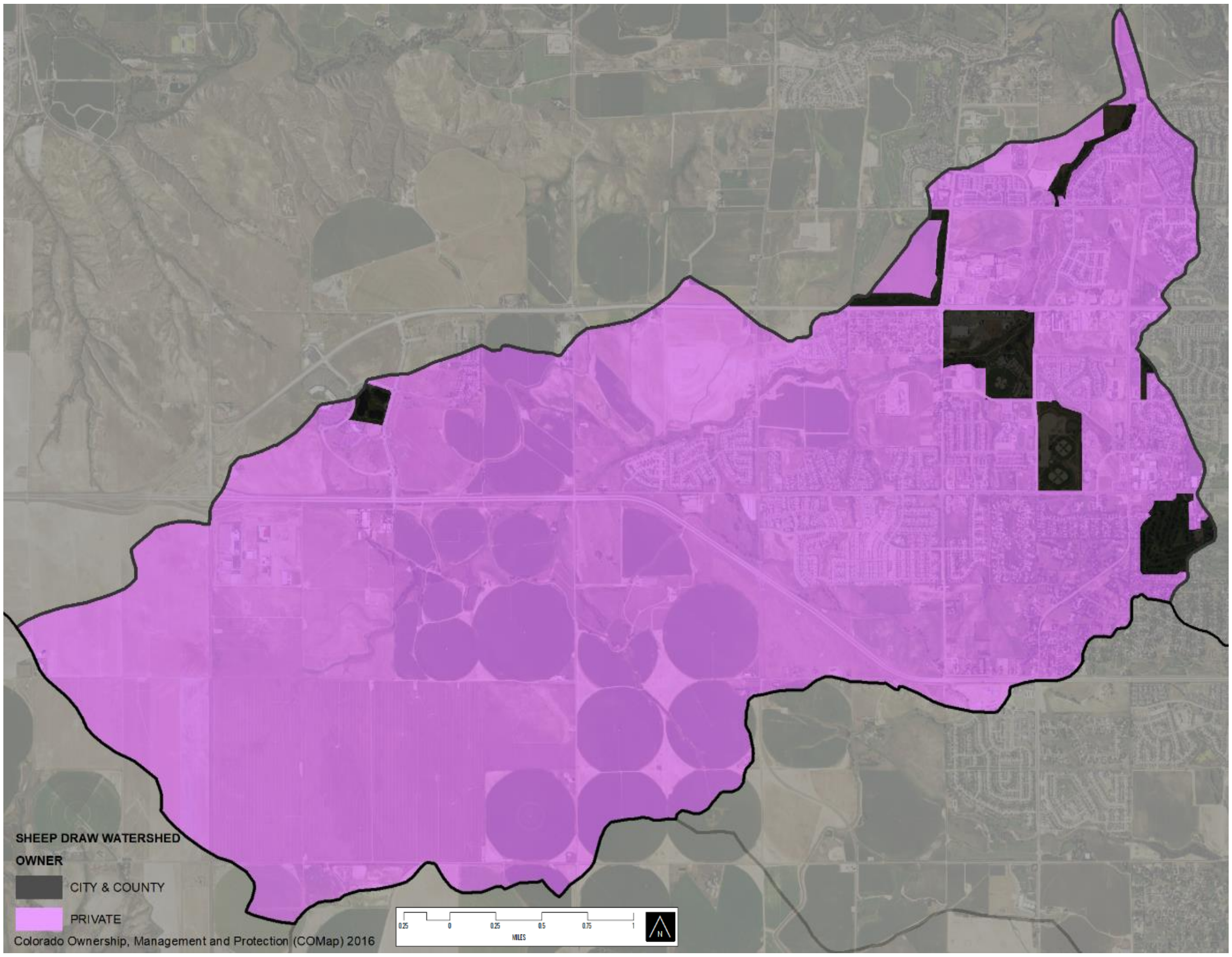



*Figure 6-4 Land Ownership in Sheep Draw Watershed*

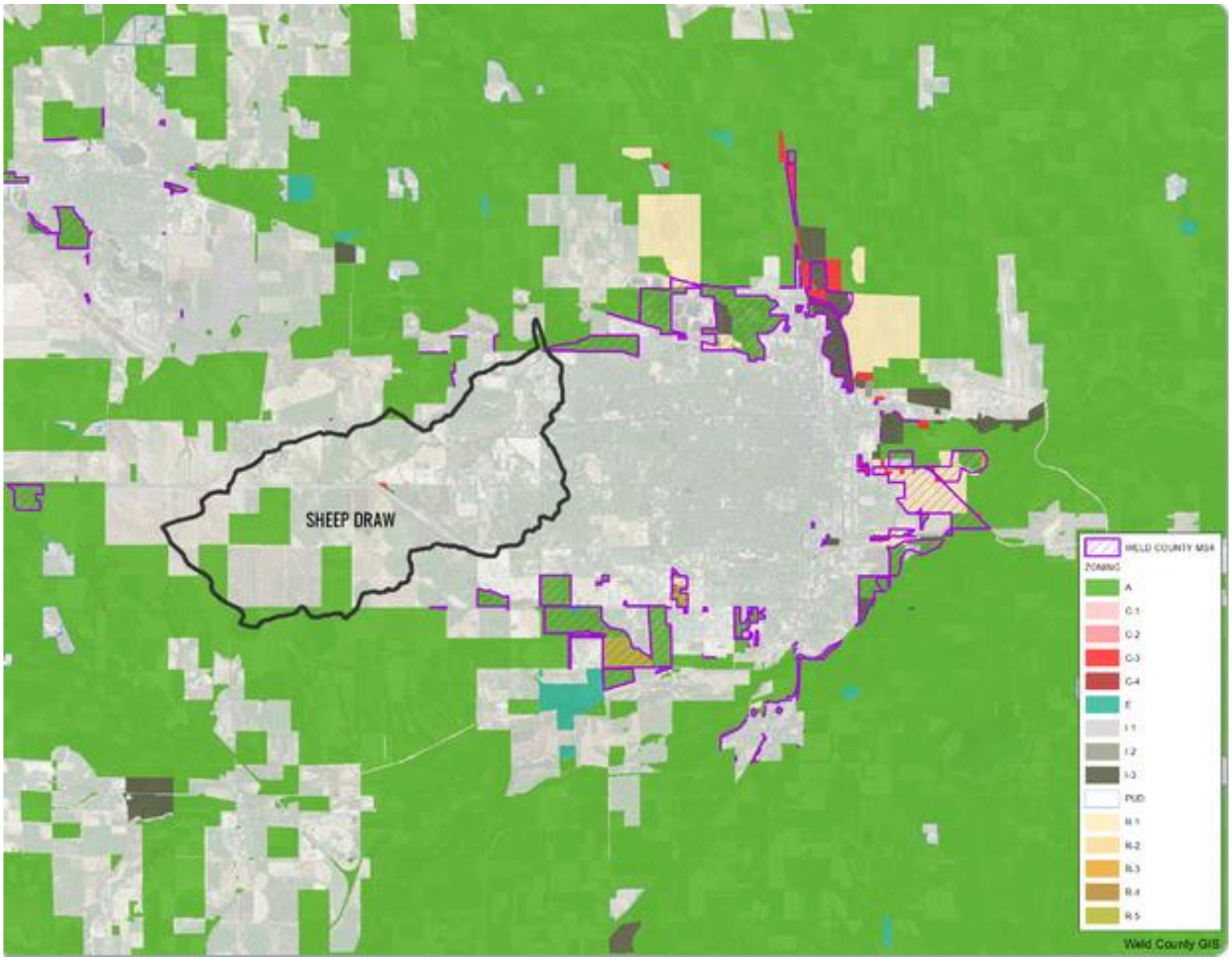



*Figure 6-5 MS4 Area and Zoning in the Vicinity of Sheep Draw*

#### 6.2.1.1 Summary STEPL Results for Sheep Draw

The STEPL model estimated the following nutrient loading values for the Sheep Draw watershed:

- 24,200 total pounds of nutrients per year (19,500 pounds of phosphorus and 4,700 pounds of nitrogen)
- 2.3 pounds of nutrients per acre per year
- The majority of total nutrients come from cropland (75%) and pastureland (15%). The urban areas in Sheep Draw contribute ~8% of the total nutrient load.

### 6.2.2 Estimating Nutrient Reduction Load Reductions

Based on the STEPL results, nutrient reduction strategies targeted at reducing nutrients from cropland and pastureland would provide the greatest relative benefit. CPRW is working with stakeholders and partners to identify the specific management action(s) they will pursue in the

Sheep Draw.  CPRW can apply the STEPL tool to estimate the potential reductions from selected BMPs.

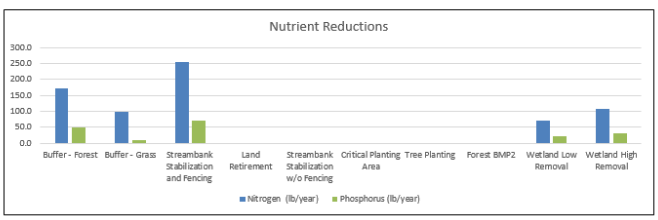
## Tool Highlight:  BMP Load Reduction Calculator

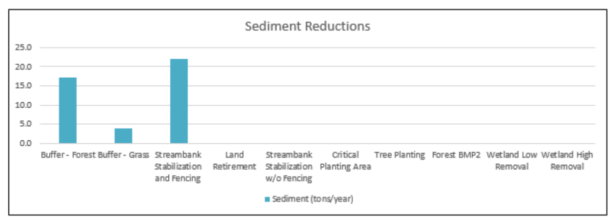
The BMP Reduction Calculator allows CPRW to estimate the load reductions of selected BMPs within the Sheep Draw watershed.  The Calculator leverages the STEPL spreadsheet model functionality and results. The interface (shown in Figure 6-5) is user friendly, in that it allows CPRW to enter the number of acres on which BMP(s) are applied[11] and can be used to compare multiple BMPs.  Although the Calculator is customized for Sheep Draw characteristics and priority BMPs, it was designed to be easily adapted to different watersheds and other sets of BMPs, so that CPRW could use the Sheep Draw example as a model for future evaluations. (For example, a North Fork Lone Pine Creek calculator was also developed and applied to estimate sediment load reductions (Section 6.3.2)

**Watershed: Sheepdraw**

| | *Input BMP area (in acres)* | | |
|---|---|---|---|
| | Cropland (4050 acres) | Pastureland (2600 acres) | Forest (50 acres) |
| Buffer- Forest | 100 | 0 | |
| Buffer- Grass | 0 | 100 | |
| Streambank Stabilization and Fencing | 100 | 0 | |
| Land Retirement | | | |
| Streambank Stabilization w/o Fencing | | | |
| Critical Planting Area | | | |
| Tree Planting | | | |
| Forest BMP2 | | | |
| Wetland Low Removal | 100 | | |
| Wetland High Removal | 100 | | |

| | **BMP Reductions** | | | | | |
|---|---|---|---|---|---|---|
| | *Nitrogen* | | *Phosphorus* | | *Sediment* | |
| | (lb/year) | % | (lb/year) | % | (tons/year) | % |
| Buffer - Forest | 172.8 | 0.9 | 48.8 | 1.0 | 17.3 | 1.2 |
| Buffer - Grass | 98.7 | 0.5 | 10.4 | 0.2 | 3.8 | 0.3 |
| Streambank Stabilization and Fencing | 255.2 | 1.3 | 71.6 | 1.5 | 22.1 | 1.6 |
| Land Retirement | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Streambank Stabilization w/o Fencing | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Planting Area | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tree Planting | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Forest BMP2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Wetland Low Removal | 71.3 | 0.4 | 21.9 | 0.5 | 0.0 | 0.0 |
| Wetland High Removal | 108.2 | 0.6 | 32.5 | 0.7 | 0.0 | 0.0 |



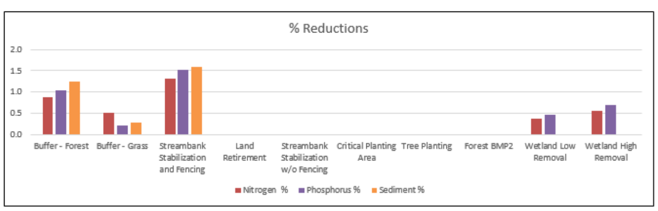




*Figure 6-6 Sheep Draw Watershed BMP Reduction Calculator Interface*

Figure 6-6 illustrates the Sheep Draw Watershed BMP Reduction Calculator interface.  CPRW can enter the number of acres of potential BMPs on selected land use types to evaluate both the net and relative load reductions of both nutrients and sediments.  In some cases, BMPs can only be applied to one land use type (e.g. fencing out livestock is specific to pasture lands). In

[11] STEPL requires that users enter the relative percentage of a specific land use type in the watershed.

other cases, a BMP may be applied to multiple land uses (e.g. buffer strips can be applied to both pasturelands and croplands). BMPs included in Sheep Draw-customized calculator include:

- Buffer – Forest
- Buffer – Grass
- Streambank Stabilization with Fencing
- Streambank Stabilization without Fencing
- Land Retirement
- Critical Planting Area
- Tree Planting
- Wetland (low and high removal efficiency)

BMP removal efficiencies, with the exception of low and high wetland estimates, are built into the STEPL model. The tool uses wetland removal efficiencies obtained from Land et al. 2016, a study that reviews the nutrient removal rates in 203 constructed wetlands in Europe and North America. The BMP Calculator can be modified to include removal from additional BMPs relevant to Sheep Draw and/or a different set of BMPs for a different watershed with different characteristics and types of BMPs, as illustrated for North Lone Pine Creek below. Additional BMPs and associated removal efficiencies can also be added by CPRW (as illustrated with the wetland example) for future projects, if required.

CPRW can apply the calculator to conduct the following types of evaluations they work with stakeholders to continue to refine their target BMP selection and location, including:

- Estimate the load reductions for a specific size BMP
- Compare the efficiencies of a single BMP on different land types
- Compare different BMPs on a single and/or different land type

## 6.3 North Fork Lone Pine Creek: Potential Sediment Reductions

This section illustrates how CPRW can quantify potential sediment load reductions within a selected HUC12 watershed area. As detailed in Section 5.4.1, the North Lone Pine Creek watershed was selected as the priority implementation HUC for this initial planning effort; GRAIP_Lite could be applied to quantify the sediment reductions from specific roads, as discussed in Section 5.2.3.1. Partnering with stakeholders to select a specific road segment and associated BMP is beyond the scope of this initial planning effort. STEPL can be applied to estimate sediment loads from land use sources including forests, cropland and pastureland. Thus, CPRW developed a North Fork Lone Pine Creek-specific BMP Calculator to estimate sediment load reductions on a more general scale to help inform future actions.

## 6.3.1 North Lone Pine Creek Characterization

The 25,290-acre North Lone Pine Creek watershed is centrally located in the upper CLP watershed (Figure 6-7) and contains the Red Feather Lakes, a popular recreation location. North Fork Lone Pine Creek is primarily undeveloped forest land, and land ownership is characterized by a checkerboard pattern with alternating National Forest and private lands. There is low to moderate development surrounding the Red Feather Lakes area. There are some areas of more broken ownership and areas that are more consolidated including a large area of private land at Red Feather Lakes. There are no wilderness areas in North Fork Lone Pine Creek (JW Associates 2017). North Fork Lone Pine Creek is a perennial tributary to the North Fork of the Cache la Poudre. There are no major diversions or reservoirs on the North Fork of Lone Pine Creek.

Figure 6-8 shows an aerial map of the watershed, and Figure 6-9 and Table 6-5 show the land use within the watershed. Approximately 60% of the North Fork of Lone Pine Creek watershed is owned by the USFS - Arapaho & Roosevelt National Forest. The remaining 40% is privately owned, as illustrated in Figure 6-10. Although, as illustrated in Figure 3-9, North Fork Lone Pine Creek has not been impacted by major wildfires, the region has been identified as an region of high risk and a focus area for projects to increase watershed resiliency (JW Associates 2017)

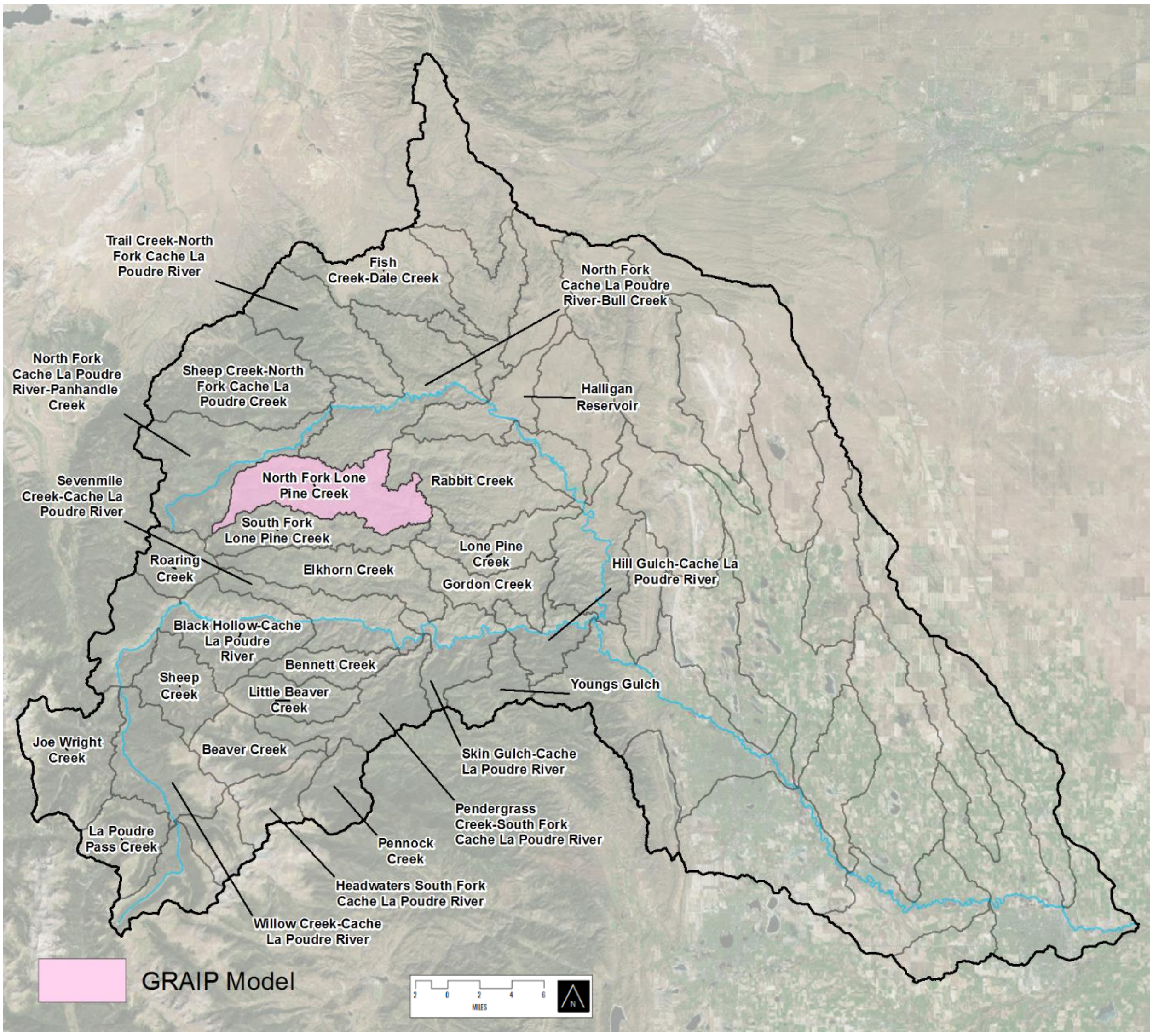



*Figure 6-7 North Fork Lone Pine Creek Watershed*

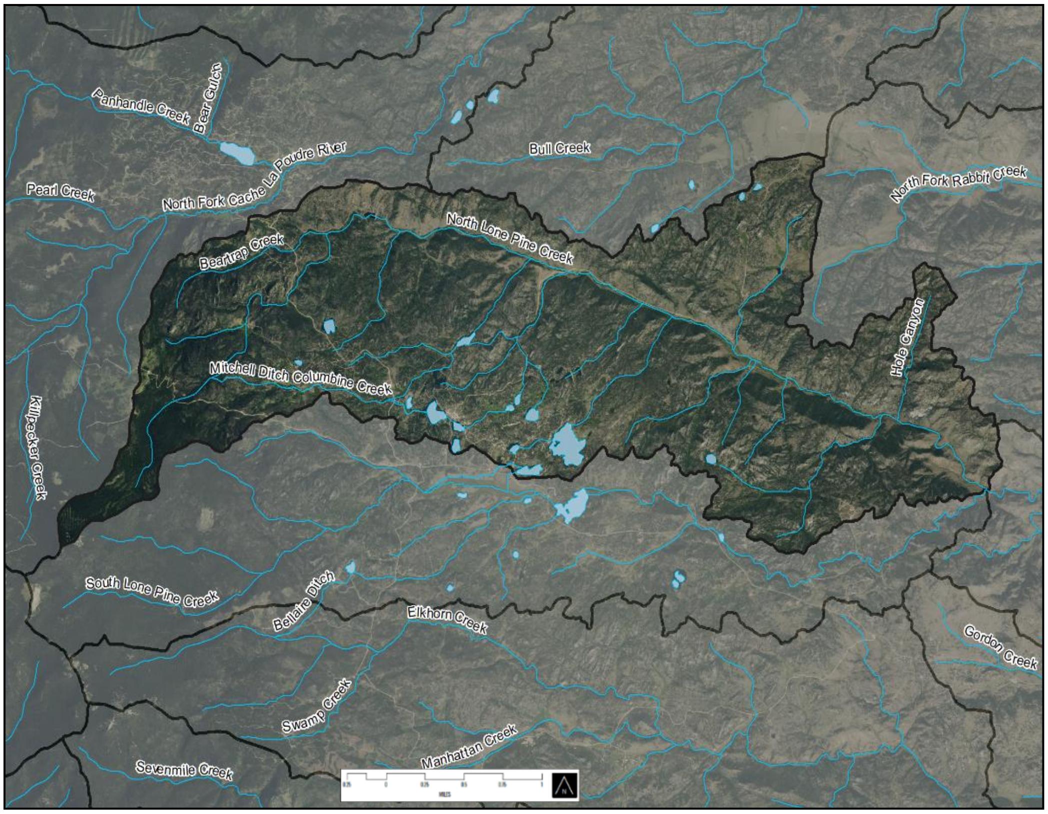



*Figure 6-8 Aerial Map of the North Fork Lone Pine Creek Watershed*

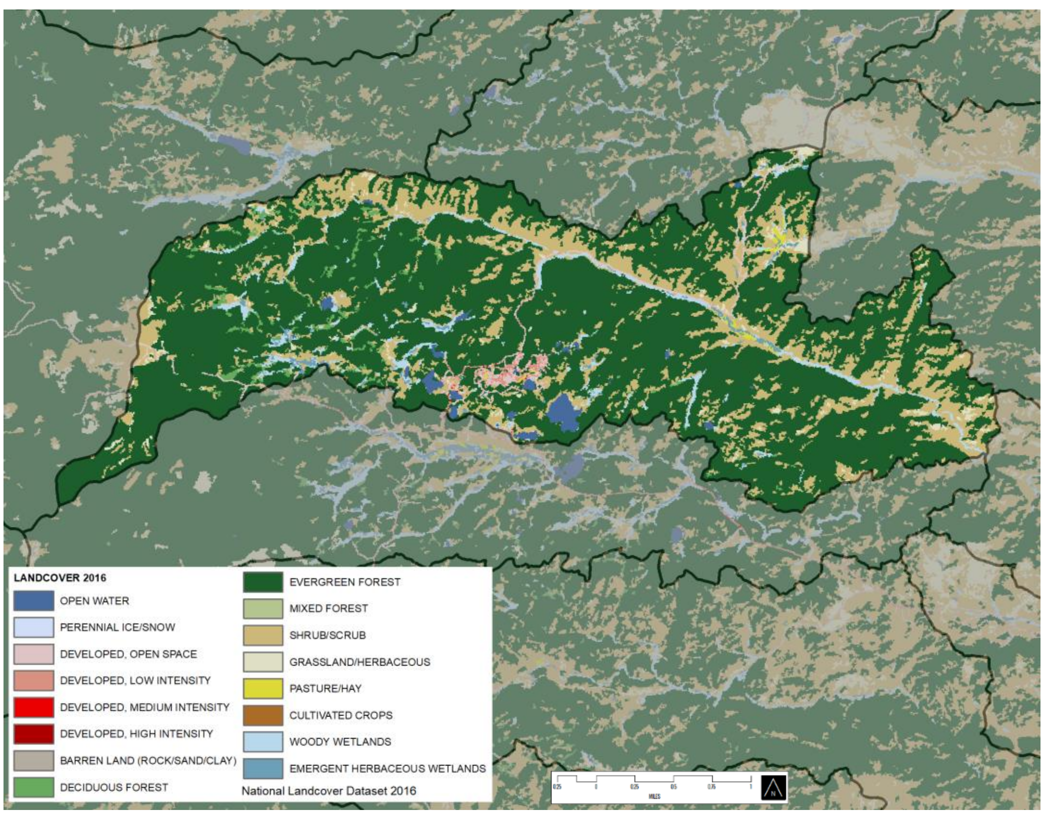



*Figure 6-9 NLCD 2016 Land Use in North Fork Lone Pine Creek Watershed*

*Table 6-5 North Fork Lone Pine Creek Land Use Categories and Percentages*

| NLCD Land Use Classification | STEPL Classification | Acres | % of Total |
|---|---|---|---|
| Developed Open Space | Urban | 310 | 1.2% |
| Developed- Low Intensity | Urban | 106 | 0.4% |
| Developed- Medium Intensity | Urban | 3 | 0.01% |
| Cultivated Crops | Cropland | 54 | 0.2% |
| Grassland/Herbaceous | Pastureland | 339 | 1.3% |
| Pasture/Hay | Pastureland | 54 | 0.2% |
| Deciduous Forest | Forest | 326 | 1.3% |
| Evergreen Forest | Forest | 18,045 | 71.2% |
| Mixed Forest | Forest | 11 | 0.04% |
| Others | Others | 6,095 | 24.1% |
| All | | 25,343 | 100% |

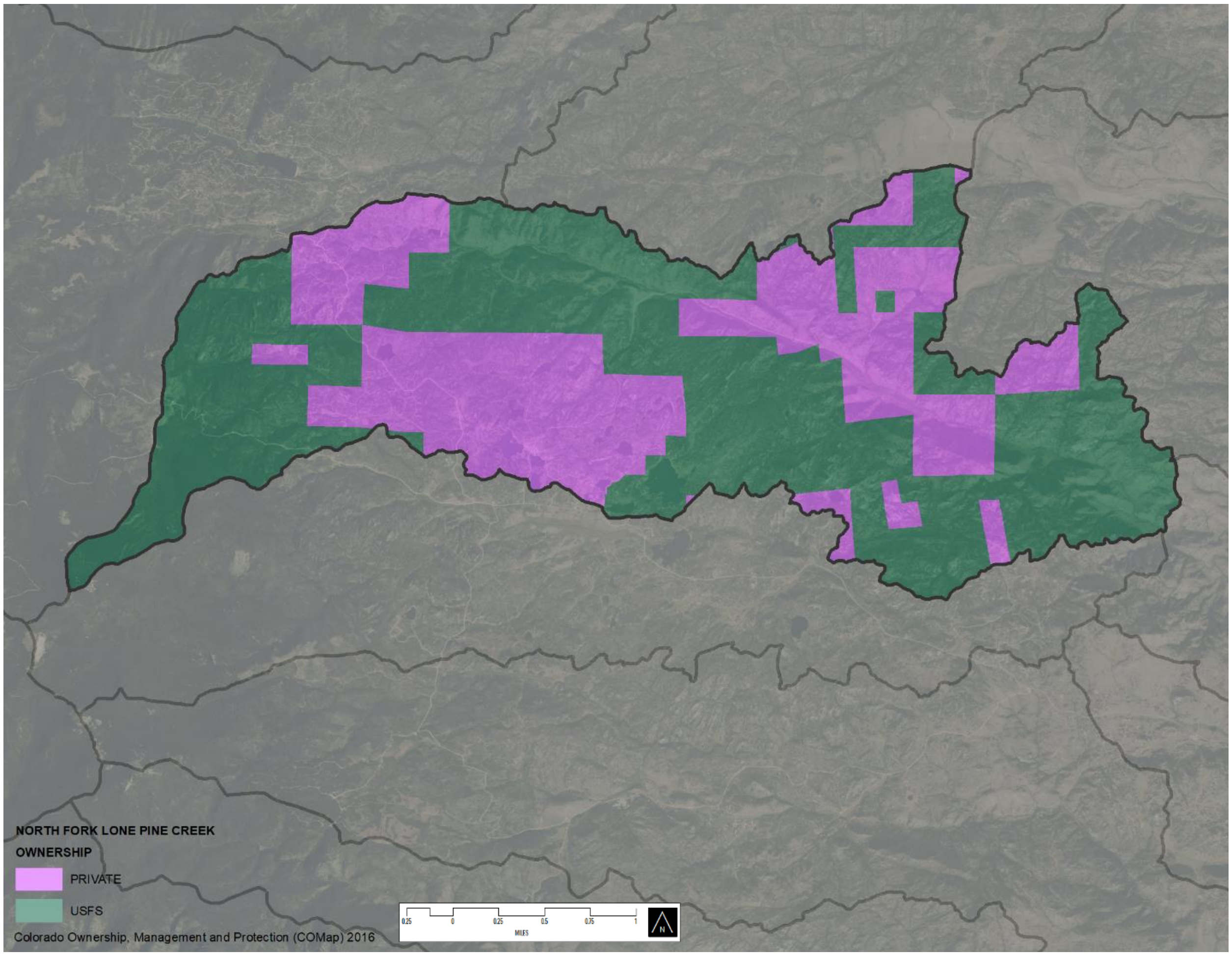


*Figure 6-10 Land Ownership in North Fork Lone Pine Creek Watershed*

#### 6.3.1.1 Summary Model Results for North Lone Pine Creek

The GRAIP_Lite model estimated the following sediment loading values for North Lone Pine Creek from the 46 kilometers of USFS roads within the watershed:

- 89 tons per year sediment delivered from roads
- 1.9 tons per year per km of roads
- 0.9 tons per year per $km^2$

Figure 6-11 shows the sediment delivery by USFS road segment throughout the watershed. USFS roads are grouped around the Red Feather Lakes and provide access to Lake Erie just northeast of the Red Feather Lakes.

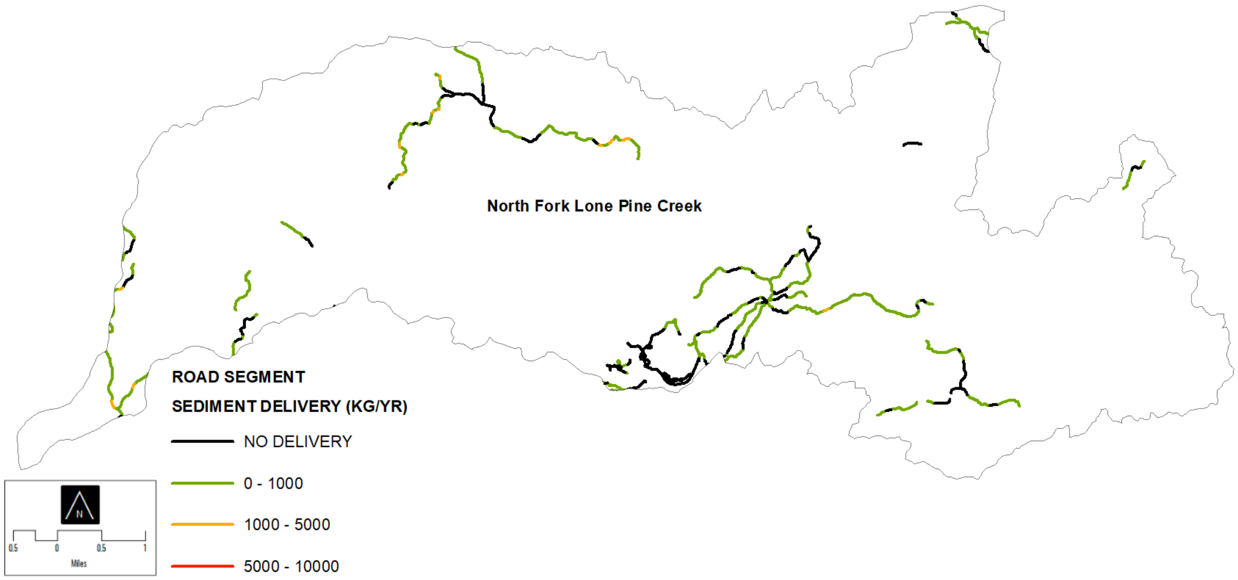



*Figure 6-11 Sediment Delivery by USFS Road Segment (kg/yr)*

#### 6.3.1.2 Contribution of Total Sediment Load Delivered from USFS Roads Compared to Other Nonpoint Sources

To help contextualize the amount of sediment coming from roads, the STEPL model was applied in the North Lone Pine Creek watershed to quantify land use based nonpoint sources. The STEPL model estimated the following sediment loading values for the North Lone Pine Creek watershed:

- 300 tons of sediment per year
- 0.1 tons of sediment per acre per year
- The majority of the sediments come from forest land

Assuming that STEPL does not account for sediments from roads, the total amount of sediment produced by nonpoint sources in North Fork Lone Pine Creek is ~390 tons/year. Figure 6-12 illustrates the relative net contribution of broken out by source.

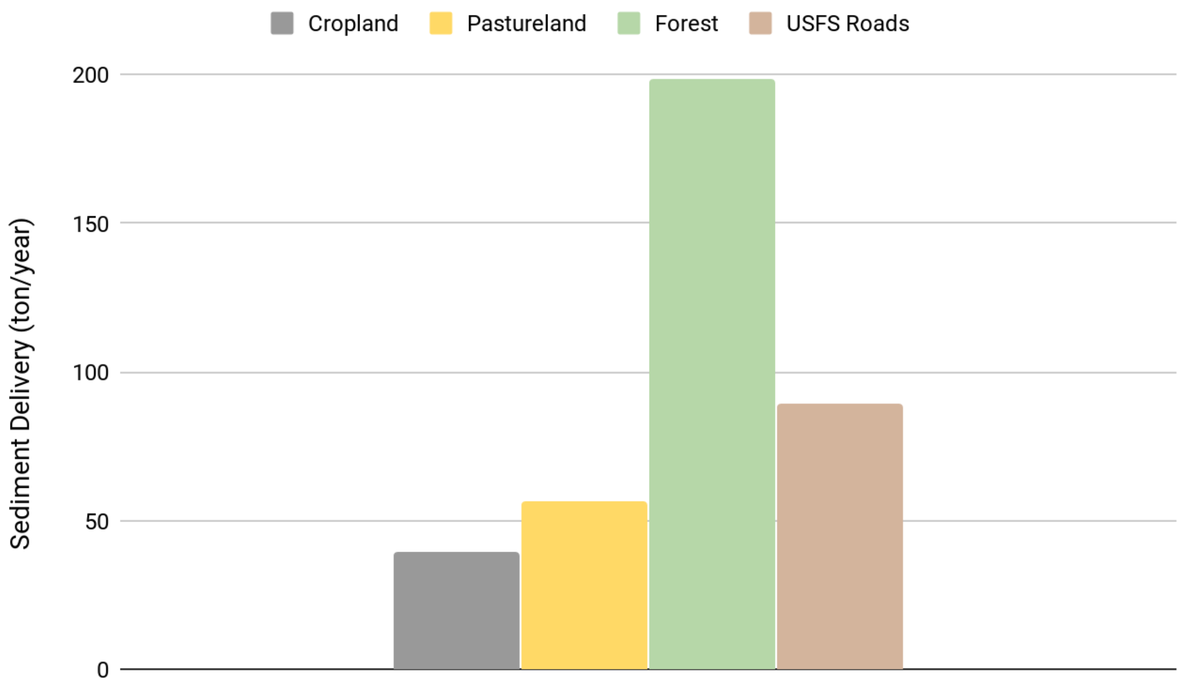



*Figure 6-12  Nonpoint Source Sediment Loading by Source (ton/year) in North Lone Pine Creek Watershed*

To better understand the relative impact of each source, the total load from each land use was divided by the total area of each land use to determine the loading density (tons/acre) from each land use type (Figure 6-13). The area of forest roads was estimated by multiplying the average width of forest service roads (12 ft) by the length of roads in the watershed. Compared to the other land uses, roads produce significantly more sediment per acre than other sources. Cropland has the second highest density (~0.75 tons/acre). Forest lands produce a very low amount of sediment per acre.

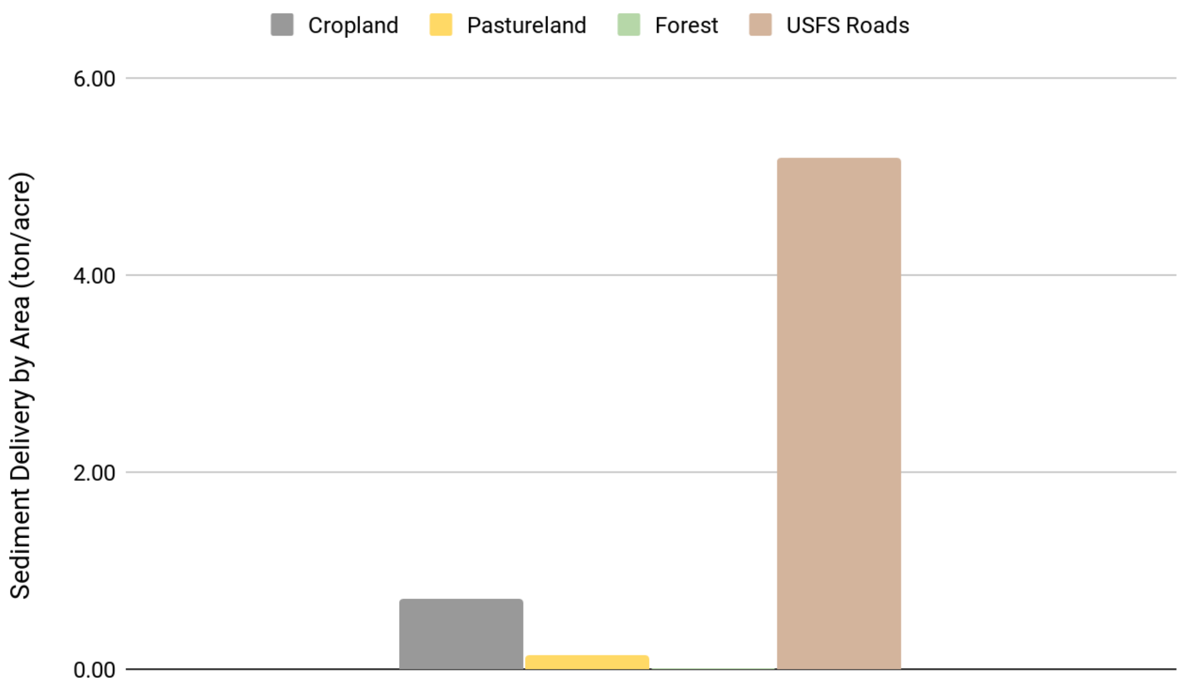



*Figure 6-13 Nonpoint Source Sediment Loading Density by Source (ton/Acre) in North Lone Pine Creek*[12]

## 6.3.2 Estimating Sediment Reduction Load Reductions

As indicated by the modeling results above, both roads and forests are key sources of sediment in the watershed. Generally, the road segments in the watershed that contribute large amounts of sediment per kilometer year are not long stretches of road. BMPs that are efficient on small stretches of roads such as adding culverts or drainage points may be appropriate in the North Fork Lone Pine Creek watershed. Likewise, CPRW could work with the USFS to identify potential road segments for decommissioning or modified maintenance activities (i.e. upgrading pavement or managing traffic levels). Selecting and targeting selected BMPs to specific road segments is beyond the scope of this initial assessment. To estimate nonpoint load reductions on a wider scale, a BMP Reduction Calculator Template for North Fork Lone Pine Creek Watershed was developed.

Figure 6-14 illustrates the North Fork Lone Pine Creek BMP Reduction Calculator interface. BMPs included in North Fork Lone Pine Creek-customized calculator include:

- Re-planting decommissioned roads
- Site-preparation for new roads

[12] A recent analysis conducted by consultants for CPRW estimated sediment yields in North Fork Lone Pine Creek that may result from high intensity wildfires. The analysis showed that pre-burn, sediment yields in North Fork Lone Pine Creek would be ~4 ton/ha/yr, while post high intensity wildfires, could expect sediment yields of ~1100 ton/acre/yr, a 300% increase. (SolSpec 2019)

- Site-preparation post-fire

The BMP Calculator can be used to estimate the reductions from selected BMPs in the North Fork Lone Pine Creek watershed.

**Watershed: North Fork Lone Pine Creek**

| | *Input BMP area (in acres)* | | |
|---|---|---|---|
| | **Cropland** (54 acres) | **Pastureland** (393 acres) | **Forest** (18,382 acres) |
| Re-vegetating Decomissioned Roads | 0 | 0 | 500 |
| Site Preperation (Hydromulch) | 0 | 0 | 500 |
| Site Preperation (Crimp) | 0 | 0 | 500 |

| | **BMP Reductions** | | | | | |
|---|---|---|---|---|---|---|
| | *Nitrogen* | | *Phosphorus* | | *Sediment* | |
| | (lb/year) | % | (lb/year) | % | (tons/year) | % |
| Re-vegetating Decomissioned Roads | 7.1 | 0.2 | 2.7 | 0.3 | 2.2 | 0.7 |
| Site Preperation (Hydromulch) | 11.9 | 0.4 | 4.6 | 0.5 | 3.7 | 1.2 |
| Site Preperation (Crimp) | 16.4 | 0.5 | 6.3 | 0.6 | 5.1 | 1.7 |

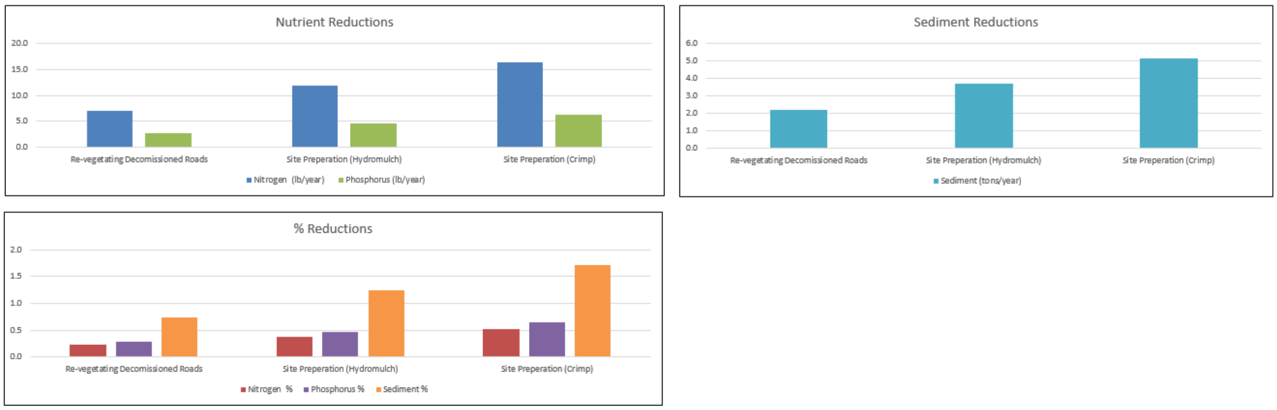



*Figure 6-14 North Lone Pine Creek Watershed BMP Reduction Calculator Interface*

Additional BMPs can be added to the tool when selected, or more intensive modeling using GRAIP_Lite or another appropriate watershed model can be conducted in the future.

# 7 Implementation Considerations

CPRW can utilize the characterization and modeling efforts presented in this initial watershed plan to work with partners and stakeholders to select and implement priority BMPs in the selected HUCs for sediments and nutrients, as well as to inform future projects in other watershed areas and/or parameters and BMPs of interest. The sections below present implementation elements and considerations that will guide CPRW during future project phases.

### 7.1.1 Partnering Opportunities & Potential Funding Sources

As a watershed coalition that has no jurisdiction or agency, CPRW can only achieve planning goals through strategic, cooperative partnership opportunities. Since our formation, CPRW has successfully worked with the US Forest Service, and with the Colorado State Forest Service, local water utilities, local businesses, The Nature Conservancy, youth corps groups, other nonprofits, and private landowners to plan and implement forest restoration, post fire rehabilitation and forest restoration to help protect water quality (among other goals) in the Upper Poudre. CPRW continues to work towards implementation of river restoration projects in the Lower Poudre but is coordinating and partnering with local government representatives to facilitate and achieve river corridor implementation goals. To further the goals of this NPS plan, CPRW would continue to work with similar partners but will also need to work more deeply with additional potential partners. Among those important partners to add to this effort would be the Natural Resources Conservation Service (NRCS) in both the upper and lower Poudre. In the Lower Poudre, CPRW needs to work more closely with river adjacent businesses including ditch companies, agricultural businesses, gravel mining and other extractive industries.

Although the scope of this NPS plan is relatively limited, project implementation will still require additional funding to implement and sustain its goals. There are a range of funding sources that are good candidates for providing some or all the necessary funding to continue planning and implementing the necessary BMPs to enact the goals of this plan. Below are a selection of potential funding sources for some NPS actions.

**CDPHE NPS 319 Program:**
The Clean Water Act Section 319(h) funds are provided for state and tribal agencies to implement their approved nonpoint source management programs. 319(h) funding decisions are made by the states. Nonpoint source programs include a variety of components, including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Upon the completion and approval of this watershed plan, projects developed under this watershed plan will be eligible for 319(h) funds from the State of Colorado for nonpoint source project implementation.

**Natural Resources Conservation Service (NRCS) Conservation Stewardship Program (CSP):**
The CSP provides conservation program payments to private landowners that improve resource conditions such as soil quality, water quality, water quantity, air quality, habitat quality, and

energy. CSP participants will receive an annual land use payment for operation-level environmental benefits they produce. Under CSP, participants are paid for conservation performance. CSP is a voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner. CSP is available on Tribal and private agricultural lands and non-industrial private forest land.

**NRCS EQIP Conservation Innovation Grants (CIG)**
The CIG awards competitive grants that stimulate the development and adoption of innovative approaches and technologies for conservation on agricultural lands.

**Colorado Water Conservation Board Watershed Restoration Grant Program**
Colorado Watershed Restoration Grant Program provides grants for watershed/stream restoration and flood mitigation projects throughout Colorado. Funds can support planning and engineering studies, implementation measures, and technical needs for watershed restoration and flood mitigation projects throughout the state. Special consideration is reserved for planning and project efforts that integrate multi-objectives in restoration and flood mitigation.

**Colorado Department of Public Health and Environment Water Quality Planning Design and Engineering Grants and the Nonpoint Source Pollution Grants**
CDPHE provides grants to small communities to help cover costs associated with the State Revolving Fund pre-application requirements. Design and engineering grant applicants will be considered by project needs assessment submissions by approved disadvantaged communities. The nonpoint source program also funds projects that help restore and protect waterbodies from nonpoint source pollution impacts.

Identifying non grant sources of funding will be essential to ensuring success for future implementation. For example, CPRW has been working with local jurisdictions to identify available funding to support high priority projects that protect in the upper watershed that help protect water quality and delivery where our goals overlap with those of the local jurisdictions.

## 7.1.2 Outreach & Education

Community collaboration is core to CPRW's mission and is essential to accomplish our work. Informing and educating the community about the issues impacting the watershed and obtaining their input is a high priority. By bringing together multiple perspectives, we are able to incorporate environmental needs, water quality and protection/restoration of watershed health, while balancing human needs into our planning and implementation work.

### 7.1.2.1 Goals

Our overall goal is to engage and educate watershed stakeholders, landowners and the community about water resources and watershed health in the Cache la Poudre watershed. As we move forward with implementing this plan, we will continue to involve our diverse stakeholder group and provide valuable information to the public regarding the health of the watershed and how our work aims to protect and improve the watershed. By continuing to

convene our stakeholder group and involve the community, we will be able to further our work on collaboratively monitoring, planning, and assessing conditions in our basin.
Specific outreach goals are as follows:

- Increase the public awareness of water quality issues in the watershed and how land use/upland activities are related to maintaining/protecting water quality
- Work closely with our watershed stakeholders to identify and address water quality concerns

### 7.1.2.2 Outreach Activities

CPRW has organized and maintained various events, meetings and to work towards our education and outreach goals.

<u>Bi-monthly Upper & Lower Poudre Steering Committee Meetings (starting from 2013 to present)</u>

Since our formation in 2013, we have met on a regular basis with our Upper Poudre Stakeholder group. This group has provided guidance for both our implementation and planning work. The Upper Poudre Resiliency Plan was developed through a review and revision process with the upper Poudre stakeholder group. This group includes representatives from the City of Fort Collins and Greeley, US Forest Service, Co State Forest Service, Larimer County, Natural Resource Conservation Service, researchers at Colorado State University and the USFS-Rocky Mountain Research Station, private citizens, nonprofits like The Nature Conservancy, Wildlands Restoration Volunteers and Trout Unlimited. They also provided direction on key scientific issues related to the plan, reviewed analysis results and recommended additional analyses.

In 2017, CPRW worked with stakeholders and a technical team to develop a river flood recovery & resiliency master plan for the lower Cache la Poudre River (east of Interstate 25 to the confluence with the South Platte). The focus of this project was to prioritize reaches of the river that had the greatest need for restoration & resiliency building, analyze sediment transport issues, and begin developing a strong stakeholder network to support decision making. CPRW established an initial steering committee composed of representatives from local jurisdictions (City of Greeley, Town of Windsor, Larimer County, Weld County) and held multiple community meetings with landowners, river-based business operators, ditch operators, oil & gas industry representatives.

We continue to meet on a regular basis with both the Upper and Lower stakeholder groups and they continue to provide guidance and support for our work. For this watershed plan, we presented preliminary analysis results to both stakeholder groups and obtained input on their water quality concerns and experience with BMPs for sediment and nutrients.

<u>Educational tours & events</u>

Throughout the year, we hold a variety of educational tours and events to increase people's understanding of watershed health and river resiliency. For these events, we focus on specific communities that are proximate to our planned implementation work.

Stakeholder water quality survey

As a part of this watershed plan, we created a simple survey to gauge landowners and stakeholders watershed values and concerns regarding water quality. While not a statistically valid survey, it still provided valuable insight into people's knowledge and issues. The survey was distributed at community and or stakeholder meetings and at public outreach events. We received 35 total responses. Results from this survey indicated that in general, people feel that the water quality where they live is high to moderate. Respondents' major concerns for water quality in the watershed include high temperature, low river flows, sediment (especially from roads), nutrients and runoff from agricultural fields.

Lower Poudre Community Meetings

Starting in 2016, we began conducting targeted outreach in the lower Poudre as a part of the Lower Poudre Resiliency Master Plan effort. This outreach effort included community meetings with interactive mapping exercises to obtain the public's feedback on river values, concerns and areas of the river that were threatened.

Monthly e-newsletter, website and social media

We have a monthly digital newsletter and share information via our Facebook page. Our website also keeps people up-to-date on our programs, events and projects.

Local newspaper articles

We work with a local newspaper, the North 40 News to feature articles on watershed and forest health.

Annual Poudre RiverFest

CPRW is on the planning committee of the annual Poudre RiverFest that aims to "Educate, Celebrate and Restore the Poudre River". The festival is held in the late spring and is designed to provide engaging ways for the local community to learn about all facets of the river: its role in water law, what water is used for, recreational safety, and the ecology/watershed health of the Poudre.

#### 7.1.2.3 Audience

As a watershed coalition, we operate through stakeholder collaboration. Our stakeholder teams are diverse and collaborative. Together, we work on watershed resiliency planning & implementation, river assessments, restoration planning & implementation, and planning our monitoring needs. Our upper CLP stakeholder team has met regularly for five years and includes representatives from the US Forest Service, Colorado State Forest Service, local conservation districts, local nonprofits, Colorado State University, water utilities, and community groups. We advertise the meetings publicly, so anyone is welcome to participate. Similarly, for

our work in the lower CLP, we work with natural resource experts, local county and municipal representatives from the City of Greeley and Weld County. For this project we set a goal to expand the group to include more nonprofits, agriculture, water utilities, and local university representatives. Those additional groups include Ducks Unlimited, Rocky Mountain Flycasters-Trout Unlimited, Poudre Runs Through It Working Group, the Natural Resource Conservation Service and Colorado Parks and Wildlife.
Some of our specific target audiences in the watershed include:

- Forest landowners in the upper watershed
- Landowners with river corridor property
- Farmers/Ranchers in the lower watershed
- Local recreation groups
- Ditch companies and operators
- Oil/gas companies

## 7.1.3 Evaluation Criteria & Milestone Considerations

Once CPRW selects a specific project, it will develop an implementation schedule, associated milestones, benchmarks and associated monitoring. The sections below list the steps that CPRW can apply. In addition, Appendix A contains a list of milestones and associated timelines. As prioritized projects are implemented, this Watershed Plan and Appendix A will be updated to reflect project specifics.

### 7.1.3.1 Implementation schedule

The schedule component of a watershed plan involves turning goals and objectives into specific tasks. The schedule will include a timeline of when each phase of the step will be implemented and accomplished, as well as the agency/organization responsible for implementing the activity. The implementation schedule will be broken down into increments that can be reasonably tracked and reviewed and coordinated with project and stakeholder needs. For example, prior to the triennial water quality standards review or the biennial 303(d) listing process, CPRW can submit information regarding local projects in place or in process and estimated load reductions. It will likely be difficult for CPRW to estimate when water quality standards will be achieved due to the small scale of the potential project(s) compared to the larger program, or in the case of nutrients, where standards are still in development. Instead, CPRW will estimate the load reduction as a percentage of total load of the basin (as illustrated with the BMP Load Reduction Calculation) as an alternate predictor of success.

### 7.1.3.2 Milestones

When designing the implementation schedule, CPRW will establish interim milestones to help measure the implementation of activities in the watershed plan. It is helpful to develop milestones using relevant time scales such as: short-term (1 to 2 years), mid-term (2 to 5 years), and long-term (5 to 10 years or longer). Additional considerations when developing schedules and interim milestones include accounting for: weather and seasonal factors when implementing BMPs or performing other field work, the time needed to complete environmental permitting, acquire funds to complete the project, and time to coordinate with necessary volunteers and landowners, and obtaining landowner permission for work or access to private property, and/or other stakeholder participation.

The first step in developing milestones is outlining the subtasks involved and the level of effort and funding requirements associated with each to establish a baseline for time estimates. Then milestones can be provided that can be reasonably accomplished within those short-term, mid-term, and long-term time frames.

#### 7.1.3.3 Benchmarks

Benchmarks are used to track progress through monitoring. While these interim targets can be direct measurements that reflect a water quality condition (e.g. concentrations of nutrients, fecal coliform or turbidity), indirect indicators of load reduction (e.g. area of buffer strip implemented, acres of wetlands created, length of stream corridor treated/restored/protected, participation in a water quality trading program) may be better benchmarks on smaller scale projects that involve nonpoint source pollutants such as sediment and nutrients.

Due to the relatively small-scale projects that are anticipated under this watershed plan, it may not be appropriate to revise the watershed plan until several projects have been implemented and the effectiveness of projects can be determined, qualitatively or quantitatively. When watershed plans are updated, consideration will be directed at changing management practices, updating/reevaluating critical source areas/loading analyses, and reassessing the time it takes for pollution concentrations to respond to treatment.

### 7.1.4 Monitoring Considerations

There are many ways to monitor water quality conditions. These can include chemical or physical tests, biological assessments, or comparison to the indirect indicators of load reduction established in the benchmarks section. One option is to conduct monitoring to verify a model load reduction estimation (e.g., from GRAIP_lite and/or STEPL) and then once verified, modify and/or apply that model in lieu of wet chemistry monitoring. Some projects will be better suited to direct measurements while others will be more appropriately measured against benchmarks such as area of buffer strip implemented, acres of wetlands created, length of stream corridor treated/restored/protected, and other BMPs.  This is analogous to the difference between permit requirements such as effluent limits versus technology-based treatment requirements. Both are effective in reducing pollutants.

Monitoring programs can be designed to track progress in meeting load reduction goals and attaining water quality standards and other goals. Measurable progress is useful to ensure continued support of watershed projects. Monitoring programs should include baseline (before), and post-project (after) monitoring. For larger projects, it may be useful to also include project-specific (during) monitoring. In addition to monitoring programs of others, trained volunteers are able to provide important data for watershed management. For example, CPRW has begun to use volunteers to help collect valuable water quality data in the upper watershed. In early 2019, with partners at the USFS-Rocky Mountain Research Station and CSU, CPRW launched a citizen science water quality monitoring program in the upper CLP. The aim of this program is to collect defensible, science-driven data to better understand the critical connection between forest health and water quality. Figure 7-1 shows citizen science water quality monitoring sites in the Cherokee Park, Red Feather and Highway 14 regions of the watershed. Typically, these have been used to help characterize completed and planned prescription burns. Likewise, future efforts could be targets towards monitoring the implementation of implementation projects in North Fork Lone Pine Creek, Sheep Draw and other CPRW implementation areas.

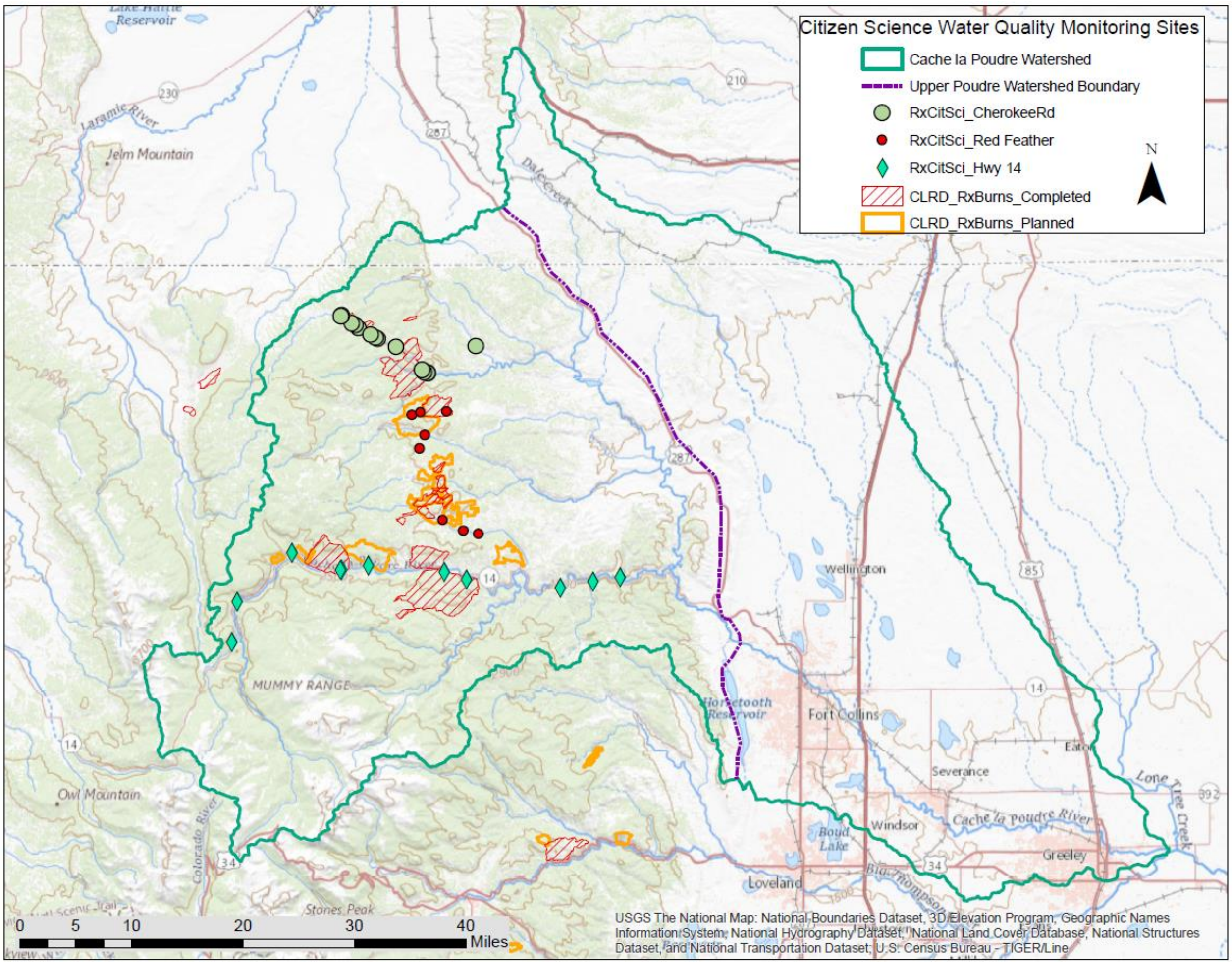



*Figure 7-1. Citizen Science Water Quality Monitoring Sites*

To reduce the risk of severe wildfire, protect communities and water quality, forest managers in the Poudre watershed and across the West are increasingly relying on prescribed fire as a management tool. Concurrently, researchers and managers recognized a lack of data regarding how prescribed fire may impact water quality. Citizen science is appropriate for water quality monitoring because it minimizes costs of sample collection, sample collection is feasible for volunteers with training, and provides a unique opportunity to increase community engagement with land management decisions. Our plan is to expand this program to collect baseline water quality data in the watershed, to monitor water quality related to our future forestry and river projects and to potentially identify emerging water quality trends and threats.

Local universities and community colleges may also be interested in participating in monitoring programs and/or may be able to advise/provide state of the art monitoring techniques (e.g. *E. coli* dip strips).

Questions to consider while designing a monitoring plan can include:

- What questions are we trying to answer?
- What techniques will be used?
- Should we account for the effects of weather and other sources of variation?
- With what precision will our monitoring design allow us to attribute changes in water quality to the implementation program?

Two water quality monitoring programs discussed in Section 4.3.1, Northern Water Conservancy District's Water Quality Monitoring Program and The Upper CLP Collaborative Water Quality Monitoring Program, are ongoing and could potentially be used to establish baseline water quality conditions as part of a project's monitoring program. For example, UCLP site PCM monitors water quality at Lone Pine Creek mouth, as illustrated in Figure 7-2. Depending on the specific project implementation location, CPRW would establish specific monitoring points up and downstream to quantify impacts.

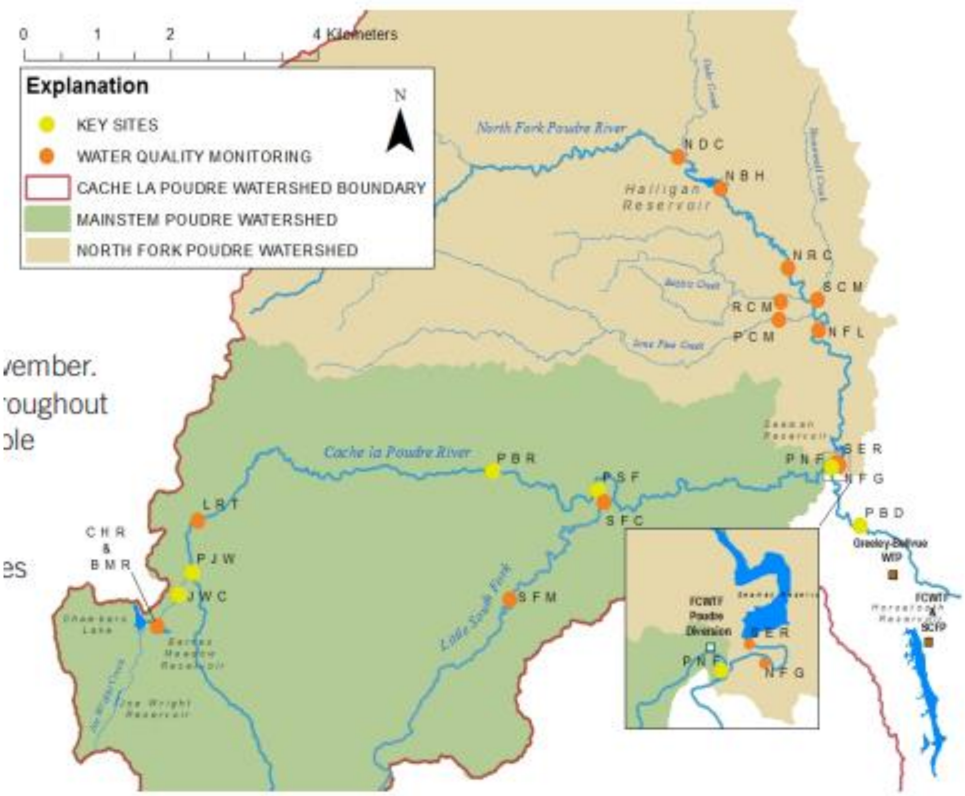



*Figure 7-2 Upper Cache la Poudre Collaborative Monitoring Program Sampling Locations*

In addition, a Poudre River Monitoring and Data Sharing group has been established that includes Northern Water Conservancy District, City of Fort Collins, City of Greeley and other industrial, commercial and non-profit entities interested in river health and monitoring.  The group's purpose is to discuss opportunities for data sharing and for coordination of temperature and water quality monitoring in the Poudre River watershed.  CPRW will work with this group to understand and leverage ongoing monitoring activities as well as coordinate efforts and share knowledge related to implementation projects.

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## *Appendix A: Implementation Milestones*

| TASK<br>Sub Task | Sediment | Nutrients | Other | Timeline |
|---|---|---|---|---|
| **Expand and refine dashboard tools for other sub drainages across basin** | | | | |
| Work with stakeholders to id & prioritize other sub-drainages to apply dashboard tools | x | x | | 2021 - 2022 |
| Work with stakeholders to define other NPS pollutants of interest | | | x | 2022 - 2023 |
| Conduct outreach to other key stakeholder groups to ensure diverse input (ag, rec, business, etc) | x | x | x | 2020 - 2025 |
| Continue to track other on-going NPS-related processes in basin (*E. coli*, temperature) | | | x | |
| **Prioritize roads for sediment management/rehab** | | | | |
| Work with FS staff to id and prioritize FS to assist with decommissioning of priority roads | x | | | 2021 - 2022 |
| Coordinate volunteer events to assist with decommissioning | x | x | | 2022 - 2023 |
| Collect necessary baseline data on non-federal road systems to refine estimates of sediment loading | x | | | 2021 - 2022 |
| **Develop comprehensive multi objective resiliency plans for priority sub-drainages in consultation with landowners and stakeholders** | | | | |
| In Sheep Draw, continue to work with key agency stakeholders and landowners to identify project opportunities | | x | x | 2020 - 2021 |
| In Lone Pine, develop forest treatment plans and landowner agreements to implement 1-3 priority projects representing 300 ac of watershed protection | x | x | | 2020 - 2021 |
| Thin fuels to decrease wildfire behavior from severe to moderate or lower on priority parcels to reduce post fire erosion & sediment loading in future wildfires | x | x | | 2020 - 2025 |
| When developing forest management plans, work with relevant landowners to identify funding to upgrade/improve road & crossing conditions on those private parcels | x | x | | 2020 - 2025 |
| work with stakeholders to prioritize additional project opportunities & objectives within Lone Pine forest projects and Sheep Draw nutrient projects to achieve multi objective opportunities | x | x | x | 2022 - 2025 |
| work with stakeholders to define BMPs for projects in new sub basing | x | x | x | 2022 - 2025 |
| define load reductions as projects are defined | x | x | x | 2021 - 2025 |
| **Refine and Expand Monitoring Program** | | | | |
| Complete RHAF refinement of long term monitoring reaches across basin | x | x | x | 2020 - 2022 |

| TASK<br>Sub Task | | Sediment | Nutrients | Other | Timeline |
|---|---|---|---|---|---|
| | Complete refinement of RHAF indicator SoPs | x | x | x | 2021 - 2022 |
| | Implement the next round of RHAF across basin | x | x | x | 2022 - 2025 |
| | Continue to develop and refine cit sci program | x | x | x | 2020 - 2025 |
| | Create project specific monitoring tools and SoPs | x | x | x | 2020 - 2025 |
| | Create comprehensive tracking site for river related monitoring in Poudre Basin | x | x | x | 2020 - 2025 |
| **Develop funding strategies for remaining planning and implementation** | | x | x | x | 2020 - 2025 |