Lower South Platte Watershed Plan

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Mark Cronquist, Co-author/Plan Coordinator, Conservation Specialist, Colorado State Conservation Board

Executive Summary

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In 2010, the Colorado Water Quality Control Commission produced its "Integrated Water Quality Monitoring and Assessment Report" on the state's water bodies that do not meet water quality standards for the body's classified use, including the Lower South Platte (LSP) River. The waters of the LSP are impacted by various pollutants. Some of these impairments include salinity, nutrients, manganese, *Escherichia coli*, selenium, ammonia, sediments and pH. The watershed's valuable agricultural industry, including its dominant basin-wide economic impact, as well as the continually increasing demand for water for various uses within and outside the LSP, necessitate the protection and enhancement of water quality in this watershed.

The focus of this watershed plan is the Lower South Platte Watershed (LSPW) located in northeastern Colorado. The purposes of this plan include:

- Providing information about the watershed.
- Presenting information about stakeholders in the watershed.
- Identifying significant water quality concerns in the watershed.
- Providing information about threatened and endangered species and their habitats in the watershed.
- To recommend potential projects for development and implementation by stakeholders in the watershed to address identified water quality issues.

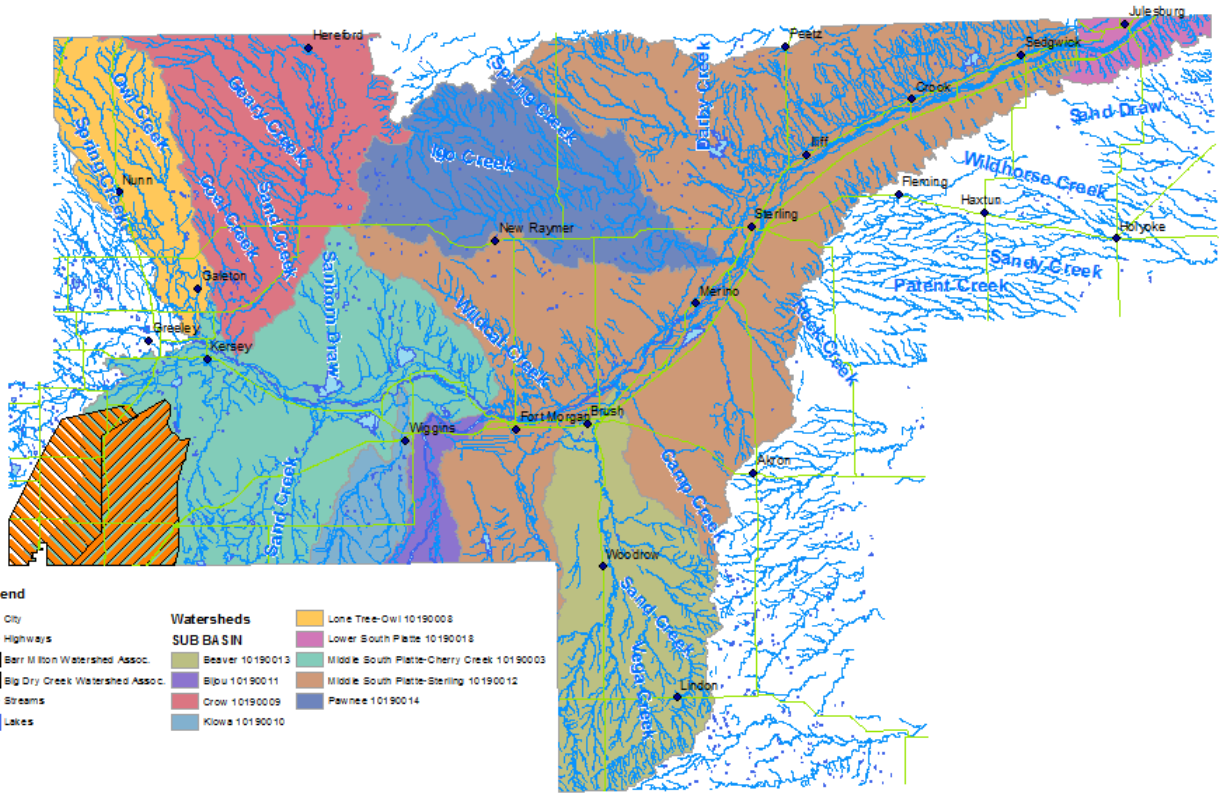
"The goal of the Lower South Platte Watershed Plan is to develop the priorities, partnerships, and resources necessary to improve and protect water quality, land productivity, habitat values, and economic sustainability in the plan area."

Agriculture continues to be the driving economic force in the LSPW, with farmers and ranchers in the plan area's five counties producing over 44% ($2,675,492,000) of Colorado's total value of agricultural products in 2007 (Census of Agriculture, 2007). The availability of good quality water for crop irrigation and livestock production as well as supporting services and domestic use have made this level of agricultural production possible in the watershed.

The 2010 Statewide Water Supply Initiative (SWSI, 2010) estimates a current 379,000 acre-feet per year shortage of irrigation water throughout the South Platte watershed. By 2050, with the loss of irrigated agricultural lands to development and large projected population growth, the South Platte basin will be an additional 274,000 acre-feet short of the water necessary for agricultural irrigation.

With the five-county plan area's population increase of 31.5% from 2000 to 2010 and a projected population boom in the same area during 2010 to 2040 of 123% (Census Data, 2010), increased demand for domestic water resources and land use changes will put significant pressure on all available water supplies and will make protecting their quality an ongoing priority for all watershed stakeholders.

The South Platte River basin in Colorado has a drainage area of about 19,197 mi^2 (Dennehy, 1991). The focus of this plan is the LSP watershed from the confluence of the St. Vrain River and the South Platte River in Weld County south of Platteville to where the river leaves the state just east of Julesburg in Sedgwick County. The plan watershed has a drainage area of approximately 4,276,000 acres (6681 mi^2) in the five counties of Weld, Morgan, Washington, Logan, and Sedgwick and all or parts of nine different 8-digit Hydrologic Units.



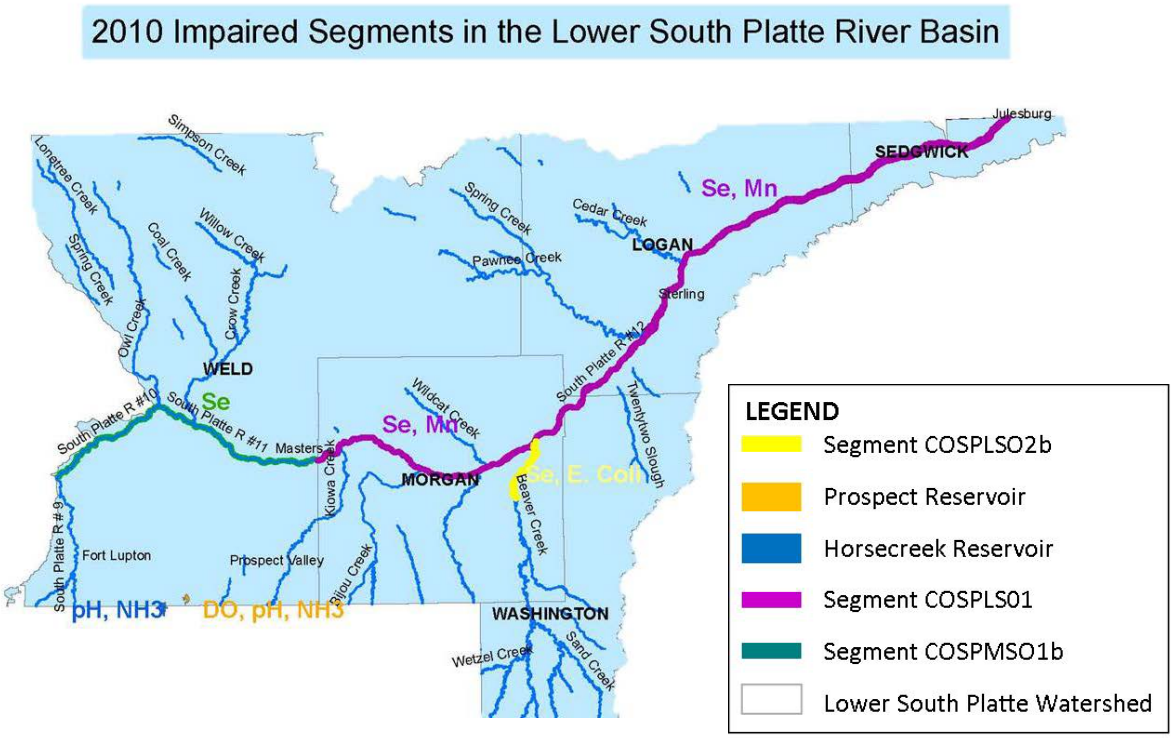
Reasons for identifying the boundaries of the LSP watershed were defined by the Core Advisory Committee including: 1) the tributary nature of the sub-watersheds and connectivity of groundwater resources demonstrated by the hydrology of the plan area; 2) the critical importance of the plan area's agribusiness economy to Colorado's overall agricultural economy. The interdependence of these vital agricultural interests includes protecting and enhancing the water resources in the basin, and; 3) the geopolitical county boundaries are indicators of long-established working relationships between various government agencies which would expedite priority monitoring activities and implementation of best management practices to deal with water quality issues in the plan area.

Vision for the Lower South Platte Watershed

Through the dynamic application of innovative practices, citizen-based water monitoring, and the delivery of broad-based water quality education by committed organizations, agencies and individuals, the quality of water in the watershed will be enhanced and protected for the benefit and enjoyment of future generations.

Regarding water quality in the watershed plan area, Regulation No. 38 (5 CCR 1002-38) of the Colorado Water Quality Control Commission (WQCC) holds the classification and numeric

standards for the South Platte River Basin. The following figure shows the 2010 Impaired Segments in the Lower South Platte River Basin and the impairments in particular segments.



Other potential impairments in the plan area requiring additional monitoring and evaluation per Regulation 93 of the WQCC to determine whether a 303(d) listing is justified include:

Impaired Segment No. and Specific Water Body	Parameter(s) or Use to be Monitored/Evaluated
Middle So. Platte	
7- Horse Cr. Reservoir	Dissolved oxygen (D.O.)
Lower So. Platte	
1- all of So. Platte River in segment	Aquatic Life Use
3- North Sterling Reservoir	Dissolved oxygen
3- North Sterling, Jackson, and Jumbo Reservoirs	Selenium pH

Other water quality concerns in the LSP include the eutrophication of reservoirs, limiting the desired use of those water bodies; nutrients in the South Platte River; excessive nitrates in the South Platte alluvial aquifer; excessive salts in the South Platte River and alluvial aquifer; degraded stream habitats and fish communities; ammonia; dissolved oxygen; *Escherichia coli;* manganese; pH; and selenium. Increased monitoring continues to be a common need in continuing to identify sources for these contaminants and applying appropriate practices to reduce the levels of these substances in the waters of the plan area.

Plan area citizens' and organizations' concerns, Core Advisory Committee input, and available research data, goals and objectives were developed for stakeholders in the LSP watershed to use in dealing with the water quality issues identified in the plan.

Goals	Develop awareness and knowledge among citizens throughout the watershed about current and emerging water quality issues.
	Increase the data available from throughout the watershed to guide and support decisions about projects and practices implemented to improve water quality and monitor their effectiveness.
	Improve water quality by implementing best management practices and innovative processes.
Objectives	Educate citizens through coordinated information campaigns.
	Conduct watershed tours focused on methods of water quality enhancement.
	Disseminate information about programs and plan progress through the LSP website.
	Use static and manned displays at community events to make citizens aware of water quality problems and processes to improve watershed resources.
	Initiate coordinated monitoring of water sources in LSP by schools and citizen groups.
	Share collected data from monitoring activities through the Colorado Data Sharing Network.
	Communicate collated data with decision makers in the LSP and the entire South Platte Basin.
	Implement BMPs in source locations to provide the best opportunity for improving water quality.
	Facilitate financial and programmatic incentives through the Conservation organizations for landowners implementing BMPs.

The main agricultural activities that may result in many of the contaminants shown in Section 5 entering waters in the LSPW as nonpoint sources are nitrogen/phosphorus fertilization, irrigation, and confined livestock feeding. Crops are typically fertilized with nitrogen for the purpose of obtaining maximum economic yields. In addition, irrigated crops are fertilized with phosphorus for the same purpose. Manure is often applied to irrigated crop fields, depending on their location relative to feedlots. Manure contains both nitrogen and phosphorus nutrients, as well as high salt levels.

Furrow irrigation can cause excessive soil infiltration and field runoff. Resulting in return flows to the South Platte River and its tributaries possibly harboring nitrogen, phosphorus, selenium, manganese, salts, and E. coli. Sheet and rill erosion from dryland cropland also can carry these pollutants.

Confined animal feeding facilities (e.g., feedlots) may be sources of nitrogen, phosphorus, and E. coli in uncontrolled runoff. They also can be sources of nitrogen in ground water where captured runoff is stored in ponds that seep excessively, especially in areas with shallow ground water.

Several Best Management Practices (BMPs) are available to land managers for use in minimizing nonpoint source pollution of waters in the LSPW via the pathways described above. Colorado State University Extension (CSUE), the USDA- Natural Resources Conservation Service (NRCS), Conservation Districts, irrigation districts, agricultural organizations, and others have published documents describing the BMPs. For example, Colorado State University's "Colorado High Plains Irrigation Practices Guide" has specific BMPs for improving irrigation efficiency and runoff control. The BMPs have been brought to land managers via numerous educational programs (such as field days and seminars) over the past several years. In addition, state regulations specify how confined animal feeding facilities must manage their manure and wastewater.

CSUE conducted a survey in 1997 and 2001 of land managers in the South Platte basin for the purpose of discovering the level of use of BMPs on irrigated lands. Some of the highlights from the 2001 survey (Bauder and Waskom, 2005) include at least 51% of respondents have implemented an irrigation system upgrade; at least 52% of respondents use an irrigation scheduling method; at least 64% of respondents use a nutrient management method; and at least 46% of respondents apply nitrogen fertilizer in the spring.

In the five years following the 2001 survey, some respondents made changes on their farms. The responses suggested that producers are more likely to make changes to manage water, which is their most important input. Some of these producer changes and the percentage of producers making the changes include 36% made a change(s) in their water system; 20% made a change in their crop management system; and 14% made change(s) in their water management system.

Smith et al. (1996) related that improved irrigation strategies have been adopted on a continual basis in recent times throughout the South Platte basin. The adopted measures include both structural improvements in conveyance structures and irrigation systems, use of information management techniques, improved crop management, and changes in crops being grown.

The Colorado Division of Water Resources ((Wolfe, 2007) has observed the following changes (among others) by farmers in the South Platte basin in response to well regulation and water supply changes: increased use of the South Platte aquifer for retiming of water depletions from well pumping; increased use of surface rights in sprinkler systems; increased use of surface water supplies, especially early in the year due to the cost of pumping wells; and increased installation of sprinkler systems (but reduces return flows).

Dennehy et al. (1998) indicated that water quality in the South Platte River basin is a product of its environmental setting and hydrologic conditions. Environmental conditions that affect the water quality include natural factors such as physiography, climate, geology, and soils. Human factors are water use, population, land use, and water management practices.

Stressors on water quality within the LSPW focus on the continued high demands on the water. Dennehy et al. (1998) highlighted the following water supply-related issues:

- Allocating water between urban and agricultural demands
- Managing growth without deterioration of water quality
- Restoring degraded riparian habitat and fisheries in the plains
- Developing future water supplies without affecting the environment

- Protecting existing drinking water supplies

The Colorado Water Conservation Board estimates that a 22 percent gap will exist in 2030 in the South Platte Basin in meeting demands for municipal and industrial water needs unless certain projects are accomplished to satisfy the shortfall (SWSI, 2004). For the Lower Platte area (Morgan, Washington, Logan, and Sedgwick counties), a shortfall of 8,000 acre-feet/year is projected. A decline in water quantity can result in concentration of contaminants in waterways.

A continued decline in irrigated acreage is projected to continue, with 100,000 to 200,000 acres being dewatered by 2030, primarily as a result of diversion to municipal/industrial uses. Less irrigated land will reduce irrigation return flows to waterways.

Water rights laws will remain a highly significant factor in how water is managed and used in the LSPW, and can trump implementation of projects such as water storage and some best management practices intended to improve water quality (such as irrigation water conservation measures). Irrigation return flows remain as a very important part of the LSPW's hydrology and to downstream water rights holders and water habitats.

As a result of water stressors in the South Platte Basin, the South Platte Basin Roundtable has adopted the following priorities to address the issues (https://cwcb.state.co.us/water-management/basin-roundtables/Pages/SouthPlatteBasinRoundtable.aspx):

- Address potential impacts of agricultural transfers and find alternatives to permanent agricultural dry-up.
- Address agricultural supply shortages for both surface and ground water users.
- Identify opportunities to optimize existing and future water supply infrastructure.
- Successfully implement endangered species program to protect existing and future in-basin uses.
- Develop new water storage facilities.
- Ensure adequate water for future needs.

Project Recommendations

Based on the water quality impairments and concerns identified in this Plan, recommendations are provided below as next steps towards improving the water quality in the LSPW. As resources become available, these are some initially identified potential projects, but are not limited to this short list. It is expected this list will expand based on resources and needs identified in the future.

Beaver Creek watershed

The lower section of Beaver Creek between the Fort Morgan Canal and the South Platte River (segment no. 2b) has a high priority for developing a TMDL for addressing the following two contaminants: *Escherichia coli* and selenium (Se). In addition, the confluence of Beaver Creek and the South Platte River is highly degraded for stream and fish community health. As a result, it is recommended that the Beaver Creek watershed be the target for a project(s) that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) remove segment no. 2b from the 303(d) list before a TMDL is finalized; 2) identify what contribution, if any, the upper watershed is contributing to the contaminant load; 3) possibly have the Se standard for the watershed be changed by the Colorado Water Quality Control Commission (WQCC) to one that reflects background Se levels; and, 4) create good stream habitat and fish community health conditions at the confluence of Beaver Creek and the South Platte River. The contamination levels may now be lower than the concentration thresholds as a result of completion of the projects put in place under the 2005 Beaver Creek Watershed Plan.

Citizen-based water monitoring throughout the Plan area

During the public input process, there was a consistent message from the stakeholders of wanting more monitoring by local citizens to provide information on water quality throughout the Lower South Platte basin. Implementation of the vetted, citizen-based "River Watch Program", in cooperation with the Colorado Water Quality Monitoring Council, would meet this need.

Constructed Wetlands Demonstration Project

Several of the impairments to water quality identified in this plan, including nitrogen, phosphorus, nitrates, and selenium, have been shown to be significantly reduced through the implementation of constructed wetlands in strategic locations to mitigate water quality issues (Lin and Terry, 2003 and Kovacic et al, 2000). With other stakeholders and partners, identify potential sites for constructed wetlands in the plan area. Implement ongoing water monitoring protocols above and below the demonstration site selected by the participating partners to establish baseline water quality levels. Conduct educational programs to provide information on the constructed wetland to citizens within the LSP watershed. Secure appropriate agreements to provide the land for the proposed project and establish agreements among the partners for ongoing maintenance of the wetland as needed. Initiate construction of the wetland, incorporating current technologies and BMPs. Upon completion of the wetland, evaluate the process so the process can be replicated in other parts of the LSP watershed. Continue to monitor water inflow and outflow from the constructed wetland to measure its effectiveness in reducing contaminants.

Education/outreach

In response to a survey sent to farmers who use irrigation in the South Platte basin, 31% of respondents cited salinity as a water quality concern, 19% cited nitrate, 8% cited bacteria/pathogens, and 3% cited selenium as concerns (Bauder and Waskom, 2005). While irrigated farmers are not necessarily representative of all residents of the LSPW, the results indicate a need for education to raise the awareness of water quality issues in the watershed that need to be addressed. It is suggested that an educational program target multiple classes of land users and other stakeholders all over the LSP basin, with programs occurring at least biannually for five years or more.

Additional ongoing educational efforts would also be implemented to offer a variety of delivery methods for residents of all ages to receive updated information on the plan's progress, water quality references, and to communicate about emerging water quality issues in the LSP. Examples of delivery methods to be used include:

- Website
- Watershed tours
- Displays at community events
- Interpretive signs

Selenium and manganese in the South Platte River

The entire length of the South Platte River within the LSPW is impaired (i.e., on the 303(d) list) for Se; segment no. 1 (from Weld/Morgan line to Nebraska) also is impaired for manganese (Mn). The TMDL priorities for the two segments are low and medium. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) remove segment nos. 1 and 1b from the 303(d) list before a TMDL is finalized; and, 2) possibly have the Se and Mn standards for the segments changed by the WQCC to levels that reflect background Se and Mn levels.

Prospect Lake and Horse Creek Reservoir
These water bodies are located near the south edge of Weld County and the LSPW. Both lakes are impaired for pH and ammonia; Prospect Lake also is impaired for dissolved oxygen (D.O.). While Horse Creek Reservoir is not impaired for D.O., the Colorado Water Quality Control Division is required to monitor and evaluate the reservoir for D.O. The TMDL priorities for these water bodies are low and medium. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) remove both lakes from the 303(d) list before a TMDL is finalized; and, 2) prevent Horse Creek Reservoir from being listed as impaired for D.O. Because the inlet drainages for these lakes originate in Adams County, a cooperative effort with watershed stakeholders in that county may be necessary to improve water quality in the lakes.

The following additional potential projects are included in the full plan with explanatory narrative:

- **Salts in the South Platte River and alluvial aquifer**
- **North Sterling, Jackson, and Jumbo Reservoirs**
- **Nutrients in the South Platte River**
- **Nitrate-nitrogen in the South Platte alluvial aquifer**
- **Degraded stream habitats and fish communities**
- **Protection of Gaura neomexicana ssp. *Coloradensis***

The alliances of conservation districts and other partners formed during the creation of this plan will provide the leadership base for implementing educational activities, water monitoring, and BMPs to improve water quality in the Lower South Platte Watershed.

Lower South Platte Watershed Plan -

Table of Contents

Introduction:

The focus of this watershed plan is the Lower South Platte Watershed (LSPW) located in northeastern Colorado. This is one of the major watersheds in Colorado. The purposes of this plan are as follows:

- Provide information about the watershed
- Present information about stakeholders in the watershed
- Identify significant water quality concerns in the watershed
- Provide information about threatened or endangered species and their habitats in the watershed
- Recommend projects for development and implementation by stakeholders in the watershed

This plan is intended to be a living document that is subject to revision in response to new or updated information, as appropriate.

1.0 Watershed Description and Setting

This section illustrates the study area, history, location, topography, climate, geology, vegetation, soils, water resources, hydrology, and land use in the Lower South Platte Watershed (LSPW).

1.1 Watershed Approach to Manage Colorado's Lower South Platte Basin Water Resources

Throughout Colorado, there are a variety of approaches being implemented to safeguard watersheds and to protect or improve water quality in these management areas. Technologies and conservation practices are being used to reduce the introduction of pollutants from municipal or agricultural sources; to minimize the impairment of water resources from naturally-occurring contaminants due to irrigation, percolation to groundwater, and return flows; and limiting other contaminants that can enter rivers, lakes, creeks and other water features from a range of sources and activities.

In 2010, the Colorado Water Quality Control Commission (WQCD) produced its "Integrated Water Quality Monitoring and Assessment Report" on the state's water bodies that do not meet water quality standards for the body's classified use, including the Lower South Platte (LSP). The waters of the Lower South Platte watershed are impacted by various pollutants. Some of these impairments include salinity, nutrients, manganese, *Escherichia coli*, selenium, ammonia, sediments, and pH. The watershed's valuable agricultural industry, including its dominant basin-wide economic impact, as well as the continually increasing demand for water for various uses within and outside the Lower South Platte, necessitate the protection and enhancement of water quality in this watershed. The Lower South Platte Watershed Plan will center on establishing monitoring activities to identify impairment sources, developing educational strategies to increase awareness and knowledge of current and future watershed issues, and recommend strategies to reduce pollution in the plan area's waters.

The goal of the Lower South Platte Watershed Plan is to develop the priorities, partnerships, and resources necessary to improve and protect water quality, land productivity, habitat values, and economic sustainability in the plan area.

1.2 History and Background

"In regard to this section of the country, I do not hesitate in giving the opinion that it is almost wholly unfit for cultivation, and of course, not inhabitable by a people depending upon agriculture for their subsistence." Major Stephen H. Long, 1820, from his journal while on expedition in the area of the Platte River~

Contrary to Major Long's assessment of the land in the vicinity of the Platte River Basin during his travels in and around the LSP Plan area, agricultural production led to the settling of the Lower South Platte Basin and many other regions adjacent to the South Platte River along its course. Agriculture continues to be the driving economic force in the Lower South Platte watershed, with farmers and ranchers in the five counties in the plan area producing over 44% ($2,675,492,000) of Colorado's total value of agricultural products in 2007 (Census of Agriculture, 2007). The availability of good quality water for crop irrigation and livestock production as well as supporting services and domestic use have made this level of agricultural production possible in the watershed.

The 2010 Statewide Water Supply Initiative (SWSI, 2010) estimates a current 379,000 acre-feet per year shortage of irrigation water throughout the South Platte watershed. By 2050, with the loss of irrigated agricultural lands to development and large projected population growth, the South Platte basin in Colorado will be an additional 274,000 acre-feet short of the water necessary for agricultural irrigation.

From 2000 to 2010, the population of the plan area's five counties increased 31.5% (Census Data, 2010). Forecasts for the same region predict a population boom of 123% from 2010 to 2040. Land use changes and the increased demand for domestic water resources will put significant pressure on all available water supplies and will make protecting their quality an ongoing priority for all stakeholders in the watershed.

1.3 Watershed Description and Geographical Information Systems Information

The South Platte River Basin in Colorado has a drainage area of about 19,197 mi^2 (Dennehy, 1991). The South Platte originates in the mountains of Central Colorado in Park County at the Continental Divide and flows northeast across the state to its exit into Nebraska just east of Julesburg, Colorado.

The focus of this plan is the Lower South Platte Watershed from the confluence of the St. Vrain River and the South Platte River in Weld County south of Platteville to where the river leaves the state at the Sedgwick County, Colorado border with Nebraska. The plan watershed (Fig. 1.3) includes a drainage area of approximately 4,276,000 acres (6681 mi^2) in the five counties of Weld, Morgan, Washington, Logan and Sedgwick and all or part of nine different 8-digit Hydrologic Units including:

10190003 — Middle South Platte – Cherry Creek	10190012 – Middle South Platte - Sterling
0190008 – Lone Tree – Owl	10190013 – Beaver
110190009 – Crow	10190014 – Pawnee
10190010 – Kiowa	10190018 – Lower South Platte
10190011 – Bijou	

Fig. 1.3a Lower South Platte Watershed Plan Area

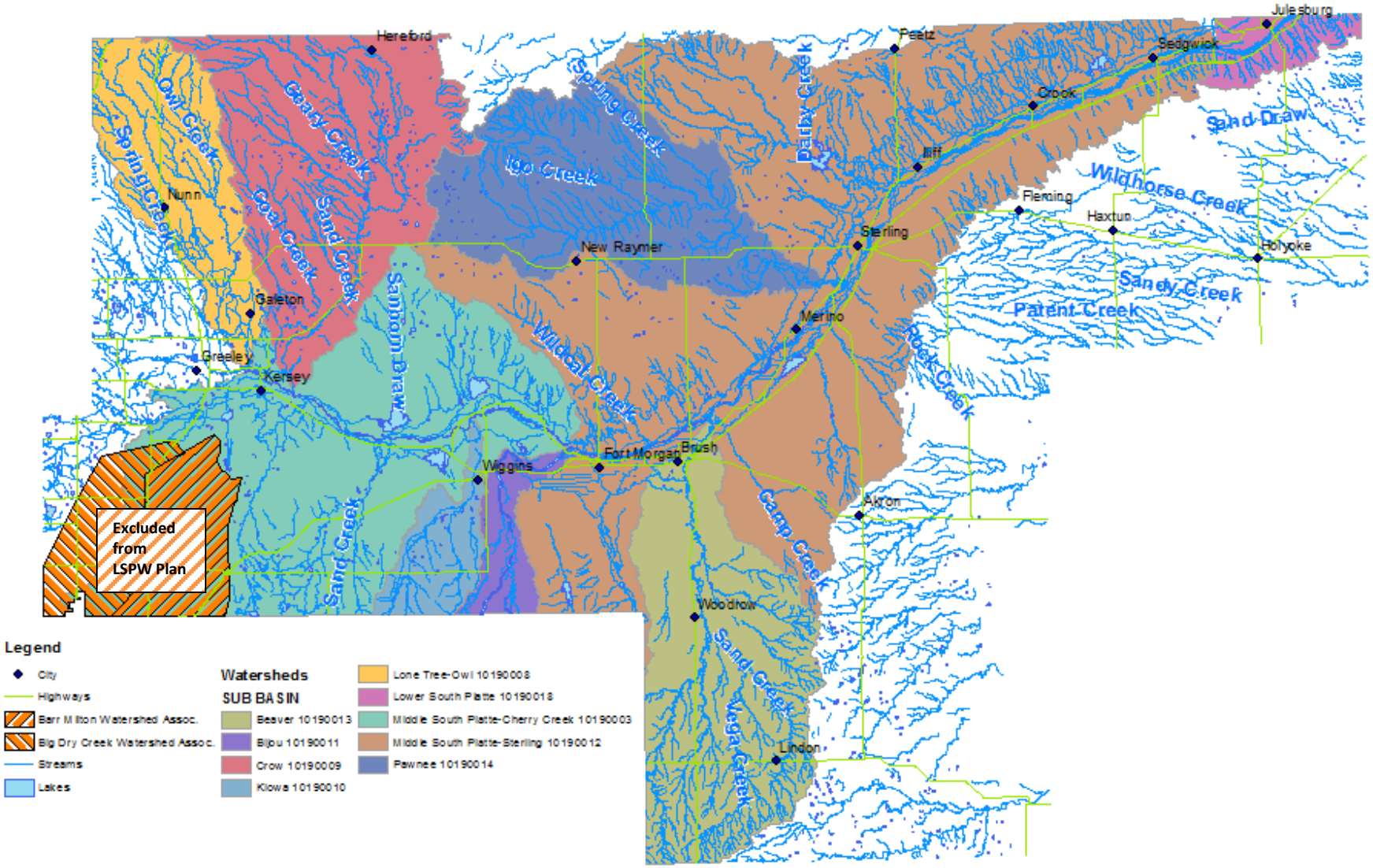
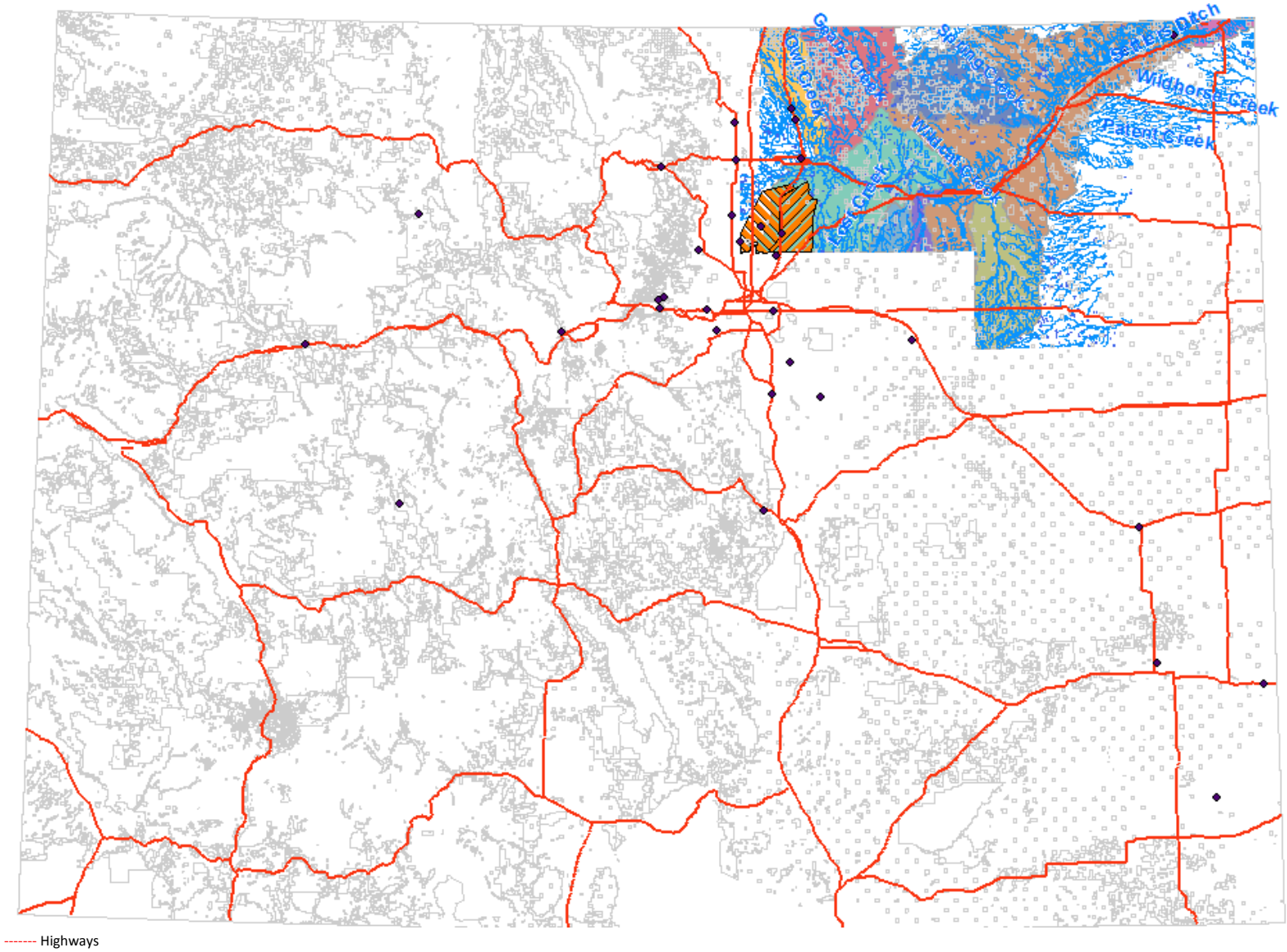


Figure 1.3b Stateview Map of Lower South Platte Watershed Plan Area



1.4 Rationale for defining the watershed boundaries for this plan

The boundaries of the Lower South Platte Watershed were defined after review and discussion by the Core Advisory Committee for several reasons.

- The hydrology of the plan area demonstrates the tributary nature of the sub-watersheds and connectivity of the groundwater resources within the plan's boundaries.
- As reported in other sections of this plan, the agribusiness economy of the region is critical to the overall agricultural economy of Colorado. The interdependence of these vital agricultural interests includes protecting and enhancing the water resources in the basin's five-county region encompassing the plan area.
- The geopolitical county boundaries are indicators of long-established working relationships between municipal, county, regional and state government agencies that will help expedite priority monitoring activities and the implementation of best management practices to deal with water quality issues on a sub-watershed or basin-wide basis.

2.0 Watershed Hydrology- South Platte River

The South Platte River is the dominant waterway of the LSPW. Within the LSPW, the river flows a distance of about 165 miles and drains the lowest portion of the South Platte River drainage basin, one of the major drainage basins in Colorado. Within the LSPW, the river flows northeasterly from its confluence with St. Vrain Creek to Scout Island located north of Kersey, then southeasterly to near Empire Reservoir, then northeasterly to Weldona, then southeasterly to Fort Morgan, then east-northeasterly and northeasterly to where it exits Colorado near Julesburg. At North Platte, Nebraska, the river joins with the North Platte River to form the Platte River.

From the river's confluence with St. Vrain Creek, the South Platte River flows through the Middle South Platte-Cherry Creek hydrologic unit, then the Middle South Platte-Sterling hydrologic unit, and lastly through the Lower South Platte hydrologic unit. Within the LSPW, the drainage areas of these three hydrologic units are 1,400, 2,340, and 107 square miles, respectively.

The river flows in a relatively well-defined, braided channel that is in a broad, shallow valley ranging in width from 1,500 feet to about 21,000 feet and is flanked by rolling plains (FEMA, 1989; Corps, 1977). The riverbed slope is relatively uniform, generally ranging from 4.5 to 10 feet per mile, and averaging 6.5 feet per mile.

From St. Vrain Creek to Fort Morgan, the South Platte River receives drainage water from the following tributaries to the west and north, among others: Big Thompson River, Poudre River, Lone Tree Creek, and Crow Creek. From the south, the river receives drainage water from following tributaries, among others: Box Elder Creek, Kiowa Creek, Bijou Creek, and Badger Creek. At many times during a year, water from Box Elder Creek is retained by the Empire Intake Canal and carried to Empire Reservoir.

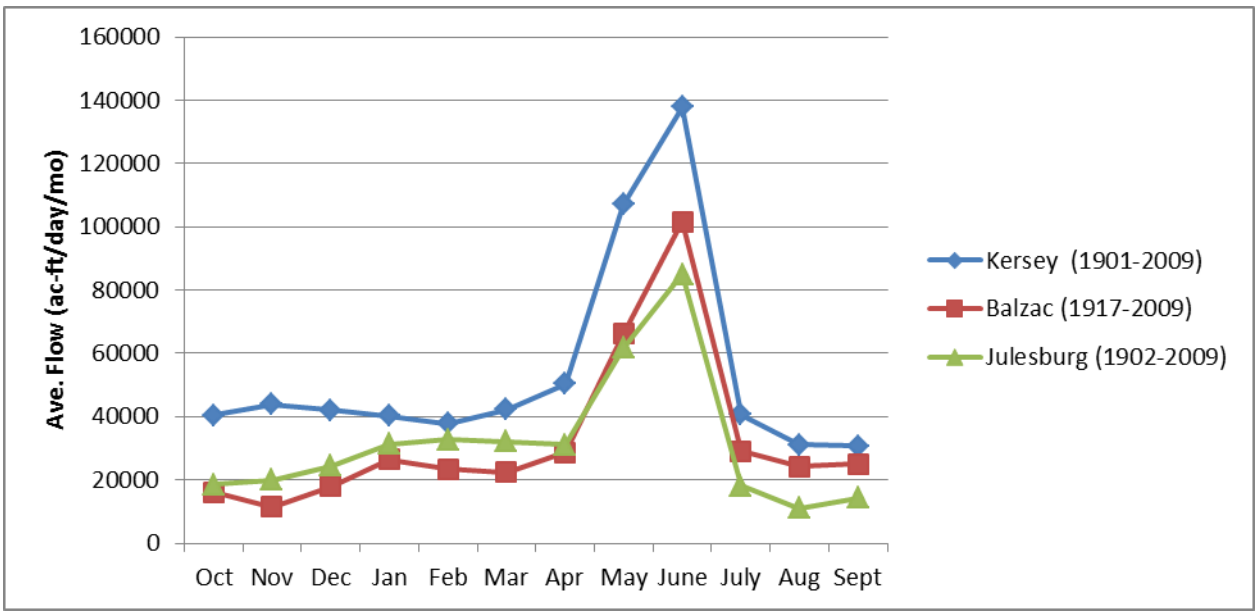
From Fort Morgan to Sterling, the South Platte River receives drainage water from the following tributaries, among others: Beaver Creek from the south, Wildcat Creek from the north, and Pawnee Creek from the west. From Sterling to the state line, the following tributaries enter the river from the north, among others: Lewis Creek, Duck Creek, Cottonwood Creek, and Corral Creek. From Morgan County to the state line, average annual tributary inflow to the river from 1947 to 1961 was 14,500 acre-feet (WRRIC, 1979).

2.1 Monthly Streamflows

The streamflow of the South Platte River varies widely from month to month and year to year in response to the factors presented in Section 1.1.2. Figure 2.1 shows the average daily streamflow for each month during the water year (October through September) at three gauging stations located within the LSPW (DWR, 2011c). The Kersey station is located about 12 miles east of Greeley, the Balzac station is located between Fort Morgan and Sterling. The Julesburg station records how much river water is leaving Colorado.

The lowest stream flow at Julesburg for any month has been 132 acre-feet (in July 1903), and the maximum flow has been 726,219 acre-feet (in June 1983).

Figure 2.1. Average annual daily streamflow of the South Platte River at three gauging station locations.



Floodwaters can result from intense localized rainfall or general rains, either of which may be augmented by snowmelt. Annual peak discharges, however, have been recorded from February through October. The 10-year, 50-year, and 100-year peak discharges at Julesburg are 31,735 acre-feet/day, 84,297 acre-feet/day, and 120,992 acre-feet/day, respectively (Corps, 1977).

2.2 Factors affecting the South Platte River's hydrology

The hydrology of the South Platte River within the LSPW is affected by various factors, including the following occurrences, relationships, activities, and legal agreements:

1. Spring runoff from snowmelt in the Upper South Platte basin located in the mountains
2. Moderate to severe intensity rainfall events that occur within and outside of the LSPW
3. The relationship with the river and its alluvial aquifer
4. Human activities
5. The South Platte River compact between the states of Colorado and Nebraska, dated April 27, 1923
6. The "Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitat Along the Central Platte River, Nebraska", which was signed on July 1, 1997 by the Governors of Nebraska, Wyoming, and Colorado and the U.S. Secretary of the Interior

Some other factors that can affect the river's hydrology are the level of water reuse within the LSPW, transfers of water to outside of the LSPW, and recharge from bedrock aquifers. The South Platte River can receive some recharge water from the three aquifers of the Dawson Group of the Denver Basin geological formation (CWRRI, 1990).

2.2.1 Spring runoff

About 70 percent of the annual streamflow of the full length of the South Platte River occurs during spring runoff from melting winter snowpack (CWRRI, 1990). Much of this runoff is commonly retained by both in-stream and off-stream storage structures located along the full length of the river, but during some years the runoff will exceed the volume of the storage and escape Colorado (CWRRI, 1990). Stored runoff water is control-released back into the river channel during the summer and fall. Excess runoff results in occasional flooding of the river channel within the LSPW.

2.2.2 Moderate to severe intensity rainfall events

Moderate to severe intensity rainfall events are common within the LSPW and within the watershed basins of tributaries of the LSPW (see the "Climate" section for more information on these events). Such rainfall events typically result in significant volumes of water runoff from soils that enter waterways within the LSPW and waterways that are tributary to the LSPW. This runoff can result in flooding of the South Platte River within the LSPW at times from May through September (Corps, 1977). The most frequent flooding occurs in June.

2.2.3 Alluvial aquifer

The sources of the following information about the South Platte alluvial aquifer are Burns (1985), Bjorklund and Brown (1957), CWRRI (2004), CWRRI (1994), CWRRI (1990), CWRRI (1986), Fox (2003), and Robson (1989).

The South Platte River's alluvial aquifer is an important part of the river's water supply, and is the main source of groundwater in the watershed. The alluvium consists of Pleistocene and recent alluvium deposited by the South Platte River and is comprised of clay, sand, and gravel, or lenses of these materials. The thickness of this unconsolidated material ranges from less than a foot at valley edges to 300 feet.

The aquifer is hydrologically connected (tributary) to the river, with the aquifer and river maintaining a hydrologic balance. The alluvial groundwater has a high hydraulic conductivity of 60 to 200 $m\text{-}d^{-1}$; as a result the aquifer has been used for irrigation of crops since the 1920's. The ground water also is used to supply drinking water to individuals and municipalities. The groundwater is recharged by excess surface irrigation water application, by precipitation, and from leakage of canals and reservoirs.

From Kersey to the Colorado/Nebraska state line, the aquifer has 25 million acre-feet of storage capacity; from Kersey to the state line, the aquifer has 8.9 million acre-feet of storage capacity. From Morgan County to the state line, the alluvium's width averages 4.3 miles and the saturated thickness can exceed 100 feet.

2.2.4 Human activities

Human activities that affect the river's flow are listed below. A discussion of each of these activities follows the list.

1. Off- and in-stream storage that captures some spring runoff and released during the summer and fall
2. Water imported to the LSPW from out-of-South Platte Basin sources
3. Irrigation diversions and augmentation activities
4. Discharges from wastewater treatment plants and some other point sources of pollution
5. Export of water to urban areas

2.2.4.1 Off- and in-stream storage facilities

Off-stream storage structures that exist within the LSPW include the following reservoirs:

- Riverside Reservoir
- Empire Reservoir
- Jackson Reservoir
- Bijou No. 2 Reservoir
- Prewitt Reservoir
- North Sterling Reservoir
- Jumbo (Julesburg) Reservoir

These reservoirs capture river and pumped ground water during the fall, winter, and spring and control-release it to the South Platte River or associated irrigation canal systems during the summer and fall. For example, the average annual volume of water released by reservoirs between Morgan County and the state line from 1947 to 1961 was 10,400 acre-feet. Some reservoirs also collect and control-release water that is imported to the LSPW, such as CBT water. In addition, many large off- and on-stream storage facilities exist upstream of the LSPW and affect the river's hydrology by capturing spring runoff and control-releasing back to the South Platte River.

2.2.4.2 Imported water

The LSPW receives a significant volume of water that is used after being imported from non-South Platte mountain drainage basins via trans mountain diversion systems. The major diversion system is the Big Thompson Project (CBT), which is managed by the Northern Colorado Water Conservancy District (NCWCD). The CBT annually delivers 213,000 acre feet of water to northeastern Colorado for agricultural, municipal and industrial uses. CBT water is provided to agricultural producers within the NCWCD for "first use" irrigation. Return flows from furrow irrigations are released to tributaries of the South Platte River for re-use downstream. The heavy majority of "first use" water is used on NCWCD land located west of the LSPW. Within the LSPW, the NCWCD boundary includes the land about five miles in width adjacent to both sides of the South Platte River. A couple of CBT water allotments exist in the LSPW. In addition, the Bijou Irrigation District and Riverside Reservoir receive and manage some CBT water.

Other trans mountain diversion systems that release water to tributaries of the South Platte River include the Moffat Water Tunnel, Straight Creek Tunnel, Laramie Poudre Tunnel, and Harold Roberts Tunnel.

2.2.4.3 Irrigation and augmentation activities

Most arable land along the South Platte River is irrigated. The sources of supplemental water are diversions of river water by ditch companies and water pumped from the alluvial aquifer. Over 1,000 irrigation wells tap the alluvial aquifer within the LSPW. Sixty-three irrigation water diversion structures exist along the river within the LSPW.

Typically, supplemental water is applied to crops by center-pivot or furrow irrigation systems. The water-use efficiency of these systems ranges from 75 to 95 percent and 30 to 90 percent, respectively. Where water is delivered by ditches/canals to crop fields, the delivery efficiencies vary widely, but most range from 60 to 80 percent (CWRRI, 1979). Water in the ditch delivery systems and water applied to crops that is not consumptively used by crops typically percolates through the soil and "return flows" to the river. Return flows are typically available for re-use by downstream irrigators. Most of the water passing out of the state in the river is composed of irrigation return flow (CWRRI, 1979). The Lower South Platte watershed has a high overall water use efficiency as the result of water in the watershed being re-used by agriculture, municipalities, households, and industries.

In 1989, Logan County and Weld County farmers indicated that the alluvial aquifer provided 32 percent of their irrigation water, while Morgan County and Sedgwick County farmers reported that the ground water supplied about 60 percent of their irrigation water (CWRRI, 1994). A Colorado State University Agriculture Experiment Station survey conducted in 1997 revealed similar results (Frasier et al., 1999). These results indicate that the alluvial water provides an effective buffer from low surface water flows in the South Platte River caused by drought and that naturally occur in late summer and early fall.

Under Colorado's water rights law, the alluvial aquifer is considered tributary water and wells that tap this aquifer (non-exempt wells) are subject to the same "first in time, first in right" standard as are surface water rights. Almost all of the surface water right holders in the Lower South Platte watershed are senior to almost all of the ground water well rights (CWRRI, 1986). As the result of a severe drought in Colorado in 2002, which affected the surface water supply in the river during the crop growing season, and as the result of an April 2003 Colorado Supreme Court decision, in 2003 the Colorado Division of Water Resources began the process of shutting down hundreds of alluvial wells in the Lower South Platte watershed, in the interest of protecting senior water rights. As of March 2011, this process has resulted in about 225 wells being shut down within the watershed (some additional wells were shut down in the Badger Creek, Kiowa Creek, and Bijou Creek tributaries to the river) (DWR, 2011b). Wells that were shut down did not have an adequate augmentation plan that provided for protection of downstream senior water rights.

Several augmentation activities exist for the South Platte River within the LSPW. These activities are authorized under augmentation plans that are approved by the Colorado Division of Water Resources. The purpose of the plans is to allow a well(s) with a junior water right to operate without reducing water available to senior water right users. Augmentation can occur in various ways, but often involves the diversion of water during times of high surface water flow, and causing this volume to return to the river when needed during the critical period of need for crop irrigation. By this process, augmentation affects the hydrology of the river over the course of a year.

2.2.4.4 Discharges from wastewater treatment and industrial plants

The South Platte River receives waters throughout the year from wastewater treatment and industrial plants located within the LSPW and upstream of the LSPW. As shown in Section 5.1.1, 20 such dischargers are located near the river within the LSPW. The volume of water from these sources can be of particular significance during the winter when irrigation and snowpack melting is minimal to non-existent.

2.2.4.5 Export of water to urban areas

The majority of Colorado's population resides along the northern Front Range of the state. The population in the Northern Front range is expected to increase by 1.7 percent per year to 2030. As a result of this population increase, including the accompanying industrial growth, a projected increase of 409,700 acre-feet/year of gross water demand is projected (SWSI, 2004). To supply this demand, in part, water rights will continue to be purchased in the LSPW and exported to urban uses located outside of the watershed.

2.2.5 South Platte River compact

The South Platte River compact between the states of Colorado and Nebraska was signed on April 27, 1923 (CRS, 1923). The compact governs Colorado's use of water in the South Platte River, which is an interstate waterway. Important provisions of the compact include:

7. Except as indicated in provision No. 2 below, Colorado has the right to full and uninterrupted use of all the waters in the "lower section" of the South Platte River during the period of October 15 to April 1. The "lower section" is defined as that portion of the river between the west boundary of Washington County and the stateline.

8. Where Nebraska constructs the South Divide Canal with a headgate located southwest of Ovid, Colorado, then that canal will bear an appropriation date of December 17, 1921, and Colorado shall have full use of the river water in the "lower section" plus 35,000 acre-feet, less the amount diverted by the canal.
9. Between April 1 and October 15, Colorado shall not permit diversions from the "lower section" by Colorado appropriators whose decrees are junior to June 14, 1897, on any day when the interstate station shows a mean flow of less than 120 cfs. The interstate station is a stream gauging station upon the South Platte River located at the river bridge near the town of Julesburg, Colorado, or at some other location as specified by the compact. The purpose of the interstate station is to ascertain and record the amount of water flowing in the South Platte River from Colorado into Nebraska.
10. Divides and apportions all waters flowing in Lodgepole Creek, which flows through Nebraska and outlets into the South Platte River at a point near Ovid, Colorado.

During the month of August, South Platte flows leaving Colorado average 153 cfs, which exceeds the compact requirement by only 33 cfs (Smith et al., 1996). The authors noted that in years when water flow is low, compact requirements often restrict the junior water rights in late summer months. This results in limited direct-flow diversion potential for all but the most senior-right water users on the lower end of the basin. As a result, most ditch systems on the lower end with rights junior to the compact have been abandoned.

2.2.6 Three-State/Department of Interior Cooperative Agreement

The "Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitat along the Central Platte River, Nebraska" was signed on July 1, 1997 by the Governors of Nebraska, Wyoming, and Colorado and the U.S. Secretary of the Interior. This agreement obligates Colorado to assist in improving the habitats for four threatened or endangered species that use the central Platte River Basin in Nebraska. The threatened or endangered species are the whooping crane, least tern, pallid sturgeon, and piping plover.

Since the agreement was signed, a Water Action Plan (WAP) has been developed. The first increment of the WAP (from 2007 to 2019) provides for improving flows in the central Platte River by an average of 130,000 to 150,000 acre feet per year using existing projects and retiming return flows to the Platte River system (PRRIP, 1998). Colorado's contribution to the first increment is the Colorado Groundwater Management Project (CGMP), which will provide an estimated yield of 17,000 acre-feet of water per year by retiming water releases to the South Platte River (PRRIP, 2010). The first phase of the CGMP is Tamarack I; the second phase of the project, also known as the expanded Tamarack project, is Tamarack III.

Tamarack I activities are centered in an area within 40 miles downstream from the Tamarack Ranch State Wildlife Area located near Crook, Colorado. Under Tamarack I, which currently is in operation, a maximum of 30,000 acre-feet of water is taken from wells in the South Platte alluvial aquifer, from canals that divert water from the river, and from off-channel reservoirs, and released into off-channel recharge basins. The basins are located at various distances from the river such that percolate water from them enters the South Platte alluvium and enters the South Platte River in February through June. The water diversions will occur primarily during December and January, the months when the greatest target flow excess exists in the river (PRRIP, 2006). Tamarack I is expected to provide an average annual yield to the river of 10,000 acre-feet per year (PRRIP, 2006).

Tamarack III is Colorado's "New Depletion Plan" which must prevent an increase in shortages to targeted South Platte River water flows as the result of new or expanded use of water begun on or after July 1, 1997. New uses that contribute to target flow shortages are subject to mitigation, either with water or with dollars that could be used to produce compensatory flow in the river.

It is projected that the Tamarack III phase will be initiated in 2011 and operational by the end of 2014 (PRRIP, 2010). Activities for this phase will be located along the south side of the South Platte

River in the Tamarack Ranch State Wildlife Area and the Pony Express State Wildlife Area. As an expansion of the Tamarack I phase, Tamarack III will involve additional diversions of water from the river via canals and from the alluvial aquifer, which are deposited in off-channel recharge basins (PRRIP, 2006). The basin locations will be engineered to have the percolate from the basins reach the river in February through June.

The South Platte Water Related Activities Program (SPWRAP) is a Colorado nonprofit corporation established by Colorado water users for the purpose of representing water users' interests and partnering with the State of Colorado to implement the PRRIP in central Nebraska.

3.0 Watershed Hydrology- Tributary Watersheds

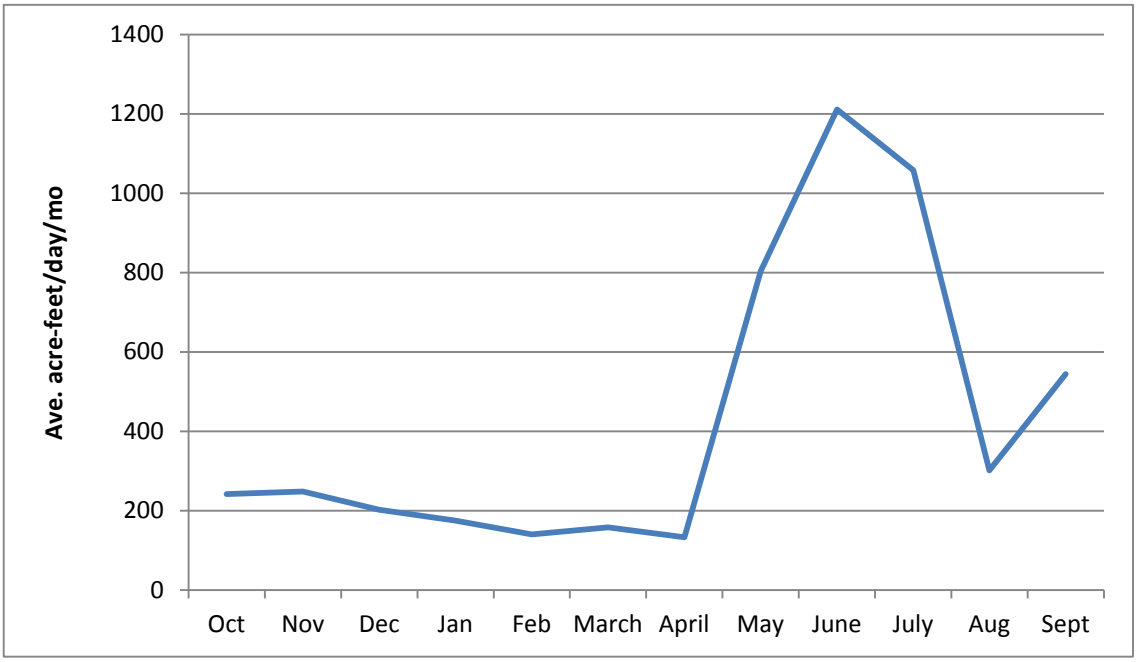
3.1 Lone Tree Creek- Owl Creek Hydrology (Lone Tree-Owl Hydrologic Unit)

Lone Tree Creek is the dominant waterway of the Lone Tree-Owl Hydrologic Unit. The creek originates in the mountains of the Medicine Bow National Forest in Albany County, Wyoming and enters Colorado nearby to the east of Interstate 25. From the state line, the creek is within the LSPW and flows southward about 50 miles to its outlet at the South Platte River. Owl Creek originates in the Simpson Mesa area located just south of the state line and to the east of Lone Tree Creek and U.S. Highway 85. Owl Creek flows southward through part of the Pawnee National Grasslands and outlets into Lone Tree Creek at a junction located about three miles east of Eaton. Tributaries to Owl Creek include Robinson Creek, Little Owl Creek, Eastman Creek, and Cow Creek.

Within the LSPW, Lone Tree Creek and Owl Creek drain an area of 420 square miles. The hydrology of both Lone Tree and Owl Creeks are affected by moderate- to severe-intensity rainfall events, melting snows, and crop irrigation. The source of irrigation water is wells and ditches that carry water from the Poudre and South Platte Rivers. The northern part of the drainages (and south of the state line) is underlain by the High Plains Aquifer.

Research of the Colorado Division of Water Resources website (DWR, 2011c) revealed that the only streamflow data for the hydrologic unit exists from a measuring gauge located near Weld County Road 62.5, which is one mile north of the creek's entry into the South Platte River. The data is for the water years of 1993 through 1995 and 2001 through 2004. Figure 3.1 shows the average daily streamflow for each month during the water year (October through September) at the gauging station.

Figure 3.1. Average annual daily streamflow per month of Lone Tree Creek at a gauging station located near the creek's outlet to the South Platte River.



3.2 Crow Creek Hydrology (Crow Creek Hydrologic Unit)

Crow Creek is the dominant waterway of the Crow Hydrologic Unit. The creek originates in the mountains of the Medicine Bow National Forest in Albany County, Wyoming and enters Colorado northwest of the town of Hereford. From the state line, the creek enters the LSPW and flows southward about 60 miles to its outlet at the South Platte River, located east of Kersey. The creek flows nearby to the west of the towns of Hereford, Grover, and Briggsdale. North of Briggsdale, both Crow Creek and Willow Creek enter Heart Reservoir. South of the reservoir, Crow Creek flows through part of the Pawnee National Grasslands until about one mile southwest of Briggsdale. Most tributaries to Crow Creek enter from the west side and include Little Crow Creek, Sand Creek, Howard Creek, and Sand Creek. The tributaries tending to have notable perennial flows are Coal Creek, Willow Creek, and Little Crow Creek and its tributaries (Hazlet, 1998).

Within the LSPW, Crow Creek drains an area of 699 square miles. The hydrology of Crow Creek is affected by moderate- to severe-intensity rainfall events, melting snows, and crop irrigation on the north and south edges of the watershed. The source of irrigation water in the north is wells. Most wells tap the alluvial aquifer of Crow Creek; many tap the White River Group formation. On the south, irrigation water comes from wells plus ditches that carry water from the South Platte River.

Research of the Colorado Division of Water Resources website (DWR, 2011c) revealed that the only streamflow data for Crow Creek exists from a measuring gauge located about two miles southeast of Cornish. The data is for the water years of 1951 through 1997 and zero water flow was recorded.

3.3 Pawnee Creek Hydrology (Pawnee Hydrologic Unit)

Pawnee Creek is the dominant waterway of the Pawnee Hydrologic Unit. The creek begins at the confluence of the North and South Pawnee Creeks, which originate south of Pawnee Buttes and east of the Chalk Bluffs. The confluence of the north and south creeks is located about three miles north

of the town of Stoneham, and near State Highway 71. The Pawnee Creek mainstem flows east and southeastward about miles to its outlet at the South Platte River, located north of Atwood. The waterway with the most perennial water flows is South Pawnee Creek (Hazlett, 1998). The Pawnee sub-watershed drains an area of 652 square miles in the LSPW.

The alluvium of the Pawnee Creek valley is about one mile wide and 33 feet thick about five miles upstream from the South Platte River.

The hydrology of Pawnee Creek is affected by moderate- to severe-intensity summer rainfall events, with runoff being directed by the terrain to drainages. About 70 percent of the watershed's precipitation is received between April and August. Documented floods of the creek since 1844 have occurred in 1883, 1894, 1914, 1921, 1935, 1965, and 1997 (CWCB, 1987; Doesken, 1998).

Research of the Colorado Division of Water Resources website (DWR, 2011c) did not reveal streamflow data for Pawnee Creek.

3.4 Kiowa Creek Hydrology (Kiowa Hydrologic Unit)

Kiowa Creek is the dominant waterway of the Kiowa Hydrologic Unit. The creek begins in the Black Forest of El Paso County, Colorado at an elevation of 7,650 feet. Total length of the creek is about 100 miles, however, only the northernmost 24 miles of the creek exists within the LSPW. This reach extends from the Morgan County- Adams County line to the South Platte River. The creek flows about one-half mile to the west of Wiggins on its way to the South Platte River. Tributaries of Kiowa Creek within the LSPW include Rock Creek, Goose Creek, and Jack Rabbit Creek.

The creek has a channel slope ranging from 0.2 percent to 0.6 percent, and drains a total area of 709 square miles (Gingery Associates, 1977). Within the LSPW, Kiowa Creek drains an area of about 148 square miles. Within the LSPW, the creek's channel is poorly defined; it becomes more distinctly channeled about three miles south of Wiggins.

The alluvium of the creek consists of beds of sand, gravel, and clay and is about one to three miles wide. The average thickness of the alluvium is 85 feet, and the average depth to water is 25 feet.

The hydrology of Kiowa Creek is affected by moderate- to severe-intensity summer rainfall events, with runoff being directed by the terrain to drainages. In addition, Kiowa Creek can receive some recharge water from the three aquifers of the Dawson Group of the Denver Basin geological formation (CWRRI, 1990), and from the Laramie-Fox Hills aquifer.

Research of the Colorado Division of Water Resources website (DWR, 2011c) did not reveal streamflow data for the creek.

3.5 Bijou Creek Hydrology (Bijou Hydrologic Unit)

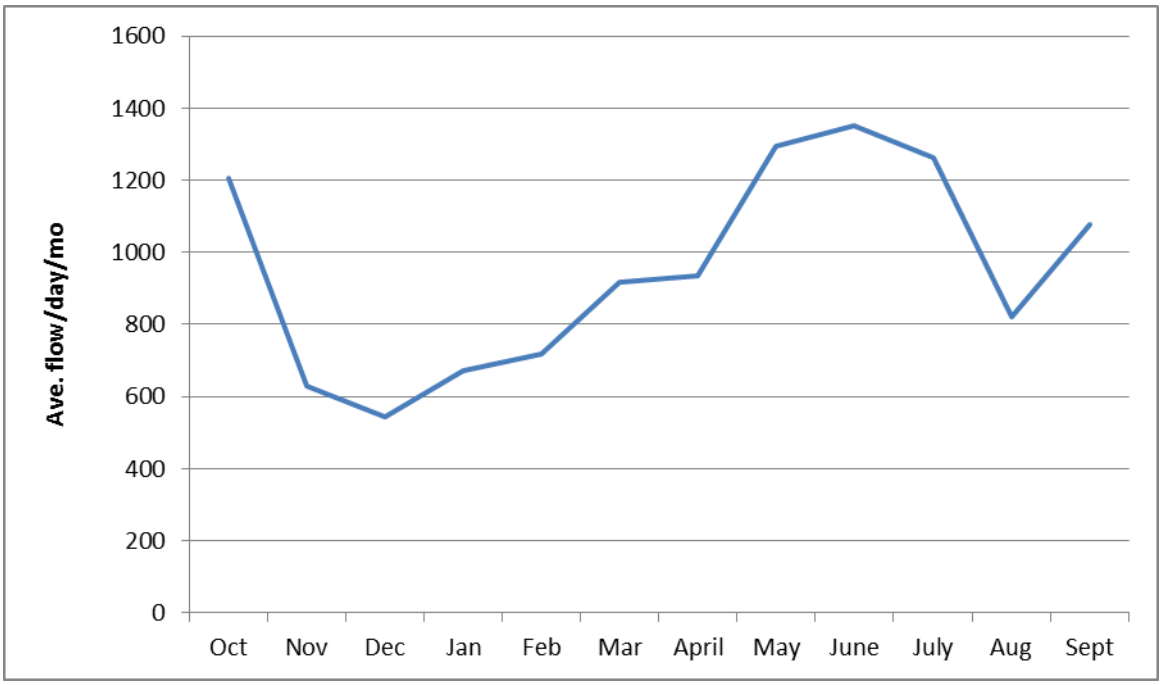
Bijou Creek is the dominant waterway of the Bijou Hydrologic Unit. The creek begins in the Black Forest of El Paso County, Colorado at an elevation of above 7,000 feet. Total length of the creek is about 100 miles, however, only the northernmost 30 miles of the creek exists within the LSPW. This reach extends from the Morgan County- Adams County line to the South Platte River. The creek flows about two miles to the east of Wiggins on its way to the South Platte River. Tributaries of Bijou Creek within the LSPW include Muddy Creek, Potty Brown Creek, and Antelope Creek.

Within the LSPW, Bijou Creek drains an area of 115 square miles. Within the LSPW, the creek's channel is characteristically a fairly wide, sandy wash with minimal to poorly defined banks. The alluvial fill of the creek consists of beds of sand, gravel, and clay that is five to 10 miles wide. This aquifer merges with that of Kiowa Creek about eight miles from the South Platte River. The alluvium is about 100 feet thick at the Adams/Morgan County line, and 240 feet thick near Wiggins. Depth to water ranges from 20 feet to 80 feet.

The hydrology of Bijou Creek is affected by moderate- to severe-intensity summer rainfall events, and by pumping of the creek's alluvial aquifer by wells that supply irrigation water to center pivots. In addition, Bijou Creek can receive some recharge water from the three aquifers of the Dawson Group of the Denver Basin geological formation, and from the Laramie-Fox Hills aquifer (CWRRI, 1990).

Research of the Colorado Division of Water Resources website (DWR, 2011c) revealed Bijou Creek streamflow data for the water years of 1950 through 1956 and from 1977 through 1987. Only the latter data is provided in this LSPW Plan. The measuring gauge for this data was located just northeast of State Highway 144, which is about one-quarter mile north of the South Platte River. Figure 3.5 shows the average daily streamflow for each month during the water year (October through September) at the gauging station.

Figure 3.5. Average annual daily streamflow per month of Bijou Creek at a gauging station located near the creek's outlet to the South Platte River (1977 through 1987).



3.6 Beaver Creek Hydrology (Beaver Hydrologic Unit)

Beaver Creek is the dominant waterway of the Beaver Hydrologic Unit. The creek begins in the northeast corner of Elbert County, Colorado, at an elevation of about 5,600 feet. The northernmost 57 miles of the creek exist within the LSPW. This reach extends from the Washington-Lincoln County line to the South Platte River. The creek flows just east of Brush and enters the South Platte River northwest of the town of Hillrose. Tributaries of Beaver Creek within the LSPW include Rock Creek, Antelope Creek, Sand Creek, Plum Brush Creek, Muddy Creek, and Wetzel Creek.

Beaver Creek drains a total area of 1,135 square miles; within the LSPW, the creek drains an area of 800 square miles. Within the LSPW, the creek's channel is meandering in form. The hydrology of Kiowa Creek is affected by moderate- to severe-intensity summer rainfall events, and by pumping of the creek's alluvial aquifer by wells that supply water to center pivot- and furrow-irrigated fields. A number of irrigation wells in the drainage were drilled though the alluvium to the underlying Pierre shale.

The alluvial aquifer of the creek consists of beds of gravel, sand, and clay. Within Morgan County, the alluvium ranges in depth from minimal to 55 feet at the south end, to 120 feet at the north end. The width of the aquifer is three to five miles.

Research of the Colorado Division of Water Resources website (DWR, 2011c) did not reveal streamflow data for the creek. Notable floods occurred on Beaver Creek in 1935, 1955, and 1965.

4.0 Watershed Inventories and Characteristics

4.1 Elevations and climate

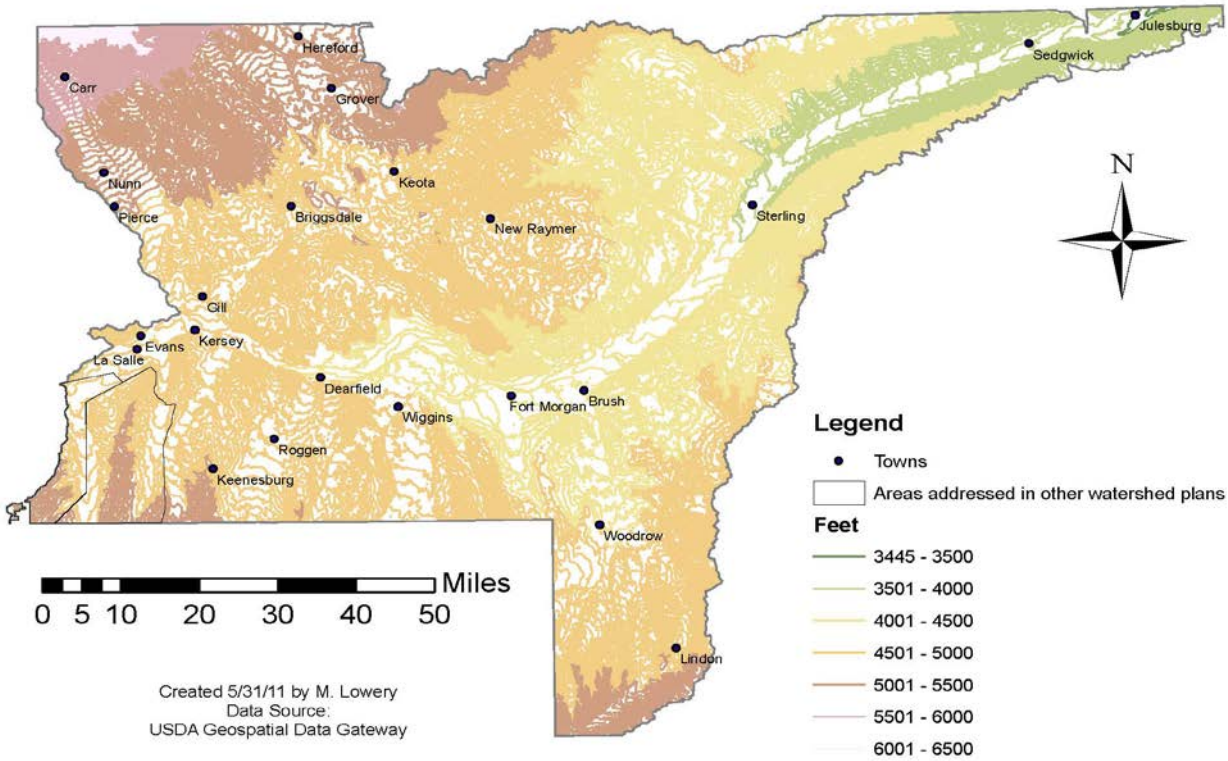
The elevation of the LSPW ranges from 3,435 feet to 6,300. The elevation of the South Platte River is 4,740 feet at its junction with St. Vrain Creek and 3,435 at the Colorado/Nebraska state line located northeast of Julesburg. The high end elevations of the major tributaries to the South Platte River range from 4,900 feet for Beaver Creek, and 6,300 feet for Owl Creek (Simpson Mesa). The Chalk Bluffs in the Pawnee and Crow Creek watersheds are at about 5,500 feet elevation. The Peetz table located north of Sterling sits at 4,100 feet, and the Jones Flat located northeast of Brush and east of the South Platte River sits behind the dune sands at a height of 4,300 feet.

The LSPW has a semi-arid, continental climate. The average precipitation ranges from 11 inches (Greeley) to 16.3 inches (Julesburg). About 75 percent of precipitation falls as rain during the growing season of April through September. The rain often falls as severe localized thunderstorms that arrive from the southwest or southeast, resulting in high runoff and reduced soil infiltration. The thunderstorms can produce hail. Droughty years and periods occur. Average snowfall is about 40 inches; much of this snow drifts with high winds and/or is sublimated to the atmosphere.

Wide variations in daily temperature (often 32 degrees difference between the daily high and low) and seasonal temperature occur. During the summer, the average temperature is 70 degrees, with an average daily maximum of 87 degrees. In winter, the average daily temperature is about 28 degrees, with an average daily minimum of about 15 degrees.

Wind commonly blows across the area at an average speed of about 7 to 10 miles per hour and gust to over 30 miles per hour in advance of storm fronts, providing a strong soil erosive force. The winds and low relative humidities during summer days result in an annual evaporation of 50 to 70 inches from the surface of open water.

Figure 4.1 Elevations of the LSPW.



4.2 Geology

The LSPW is located in the geomorphic sections of the Great Plains province known as the High Plains and the Colorado Piedmont formations (Hazlett, 1998). The escarpments found along the northern edge of the watershed are the northern border of the Colorado Piedmont. The High Plains formation is located in the northeastern one-fourth of the watershed and represents an area in which the Ogallala formation has been exposed to minimal erosion, and has been covered by sand dunes and windblown silt deposits, called loess.

The watershed contains thick layers of rock that formed from sediments in oceans for a half billion years (Trimble, 1980). These rock layers include the Dakota and Fox Hills Sandstones within the Denver Basin aquifer system, located west of the Morgan/Weld County line in the Middle South Platte-Cherry Creek watershed. Above these rock layers are three major sediment/rock layers that were laid down by streams and wind during the Tertiary geologic age, as the Rocky Mountains were being uplifted about 70 million years ago: the Dawson Arkose and White River Groups, and the Ogallala formation. The uppermost and most extensive of these is the Ogallala formation. The thickness of these layers ranges from a few feet to several hundred feet, depending upon the shape of topographic surfaces on which they were deposited.

The Ogallala formation is comprised of primarily sandstone, but also has silt, clay, gravel that are cemented by calcite and silica. The tops of the Pawnee Buttes are capped by the Ogallala formation. The escarpments that exist along some of the northern edges of the LSPW are rolling to steep and consist of rock outcroppings of siltstone that have a cap of sandstone (e.g., the Ogallala formation). Deposits of weathered material from siltstones, sandstones, and some shale are directly below the escarpments. The Chalk Bluffs in the Crow and Pawnee Watersheds are comprised of limestone and sandstone.

About 10 million years ago, as the apparent result of regional uplift of the entire western part of the North American continent, streams were forced to cut down into and excavate the deep sediments

that had been deposited over the previous 60 million years, forming the Colorado Piedmont and the LSPW. The South Platte River and its tributaries were the erosive streams that carved through the sediments, and they will continue their erosive action.

4.3 Soils

The soils information provided in the subsections below are based on the soil surveys for Weld, Morgan, Logan, Sedgwick, and Washington Counties published by the USDA-Natural Resources Conservation Service.

4.3.1 Soils- South Platte River Valley

The bottomlands of the South Platte River have level to nearly level, poorly drained to well-drained loam and sandy loam soils. Between St. Vrain Creek and about Kersey, the river is flanked by terraces with level to nearly level clay loam and sandy loam soils. On the uplands exist loam and sandy loam soils on nearly level to moderately sloping land.

From Kersey to Empire Reservoir, the river is flanked by youthful dune sands. From Empire Reservoir to Sterling, the low and high terraces have well-drained loamy and sandy soils. The uplands on the north side of the river have sandy and deep loam and sand soils. Intermixed are shallow to moderately deep gravels and loams on breaks and on shale and sandstone. The terraces/uplands on the south side of the river have dune sands that range from feather-edge to as 100 feet thick.

From Sterling to the state line, the first uplands have nearly level to strongly sloping loams, sands, sandy loams, and clay loams. The higher uplands have a variety of loamy and sandy soils on nearly level to moderately sloping land. Some gravelly soils also exist. The Peetz table land has nearly to moderately sloping land with sandy loam to clay loam soils.

The south side of the river (to Sedgwick) is dominated by dune sands that are as much as 100 feet thick, with nearly level to moderately sloping sandy loam to clay loams on upper table lands.

The Land Capability Classes of the soils along the South Platte River are shown in Figures 4.3.1-4.3.7. The north side of the river has some Class 1 soils and significant acreages of Class 2 and 3 soils, when irrigated. Some Class 4 and 6 irrigated soils also exist, when irrigated. On the west, east, and south sides of the river between St. Vrain Creek and Fort Morgan, some Class 1 soils and significant acreages of Class 2 and 3 soils exist when irrigated. The south side of the river between Fort Morgan and the state line is dominated by Class 4 to 7 soils, whether irrigated or non-irrigated.

The South Platte River valley's soils are highly to very highly erodible from wind. The dune sand soils on the north part of the watershed are very highly susceptible to wind erosion. Some strips of soils along the river are not susceptible to wind erosion.

Figure 4.3.1.1 Soils-Lower South Platte Land Capability.

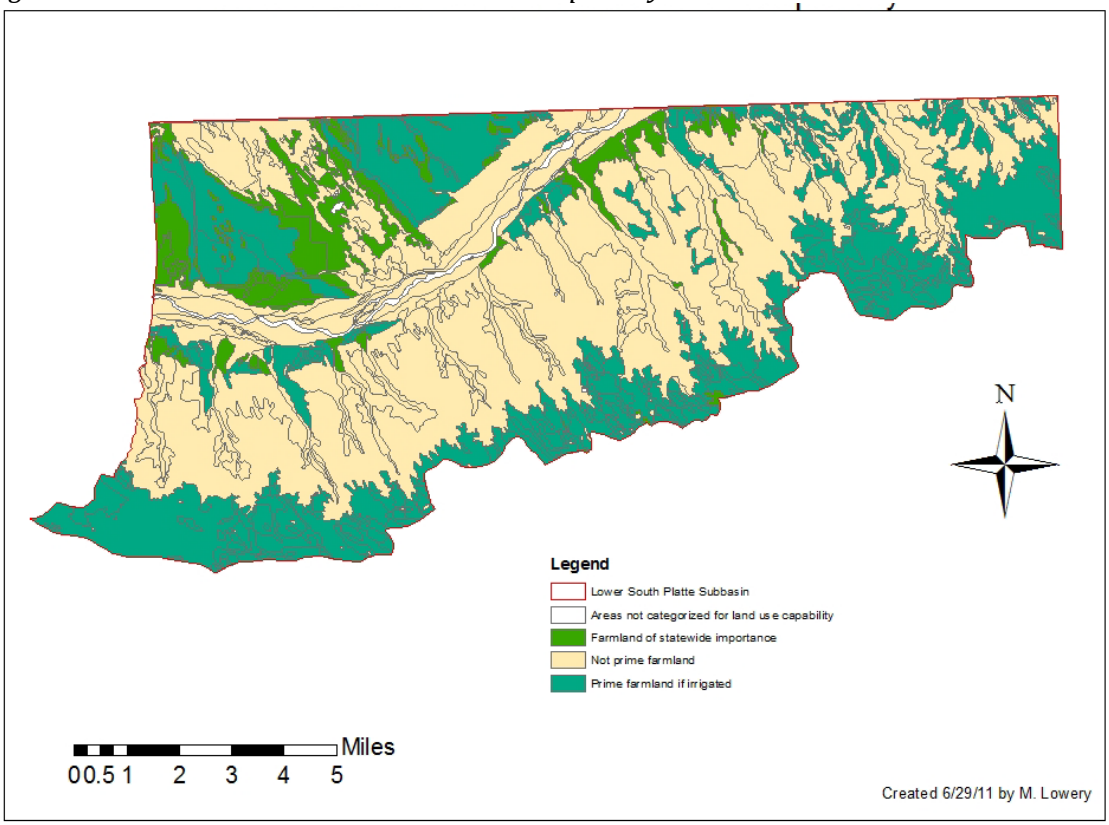


Figure 4.3.1.2 Soils-Middle South Platte-Cherry Creek Sub-basin Land Capability.

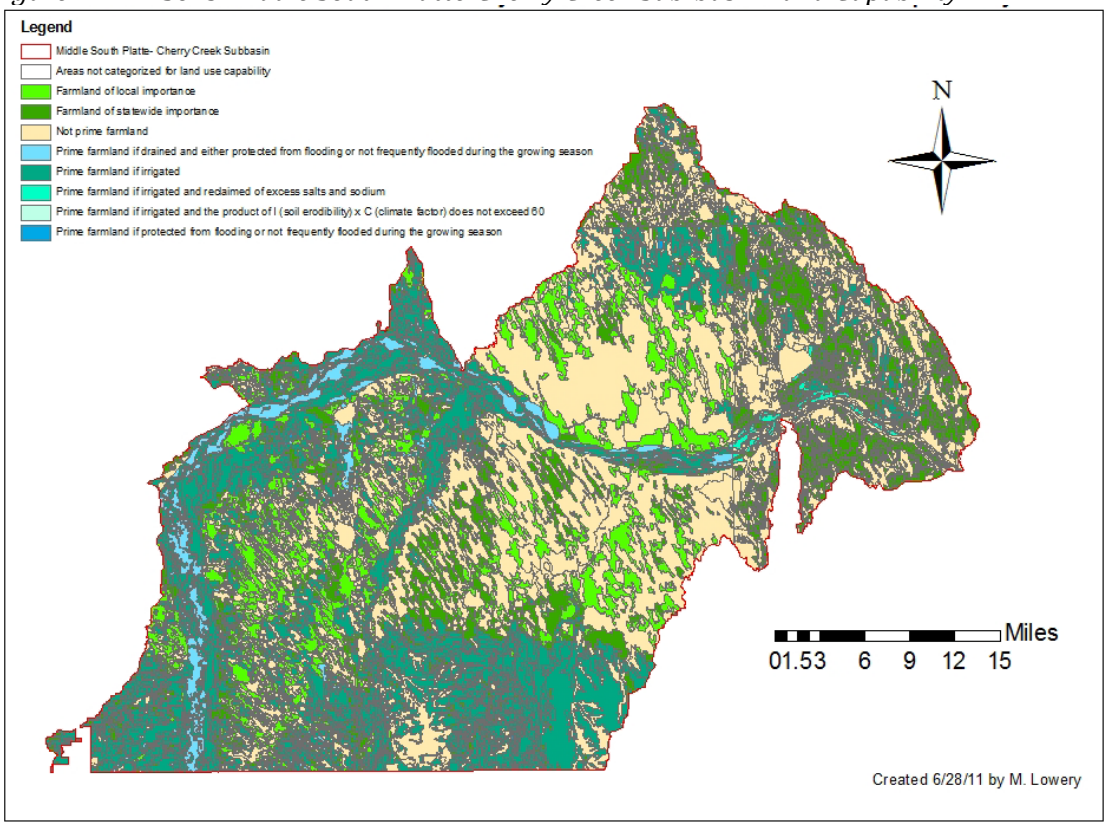
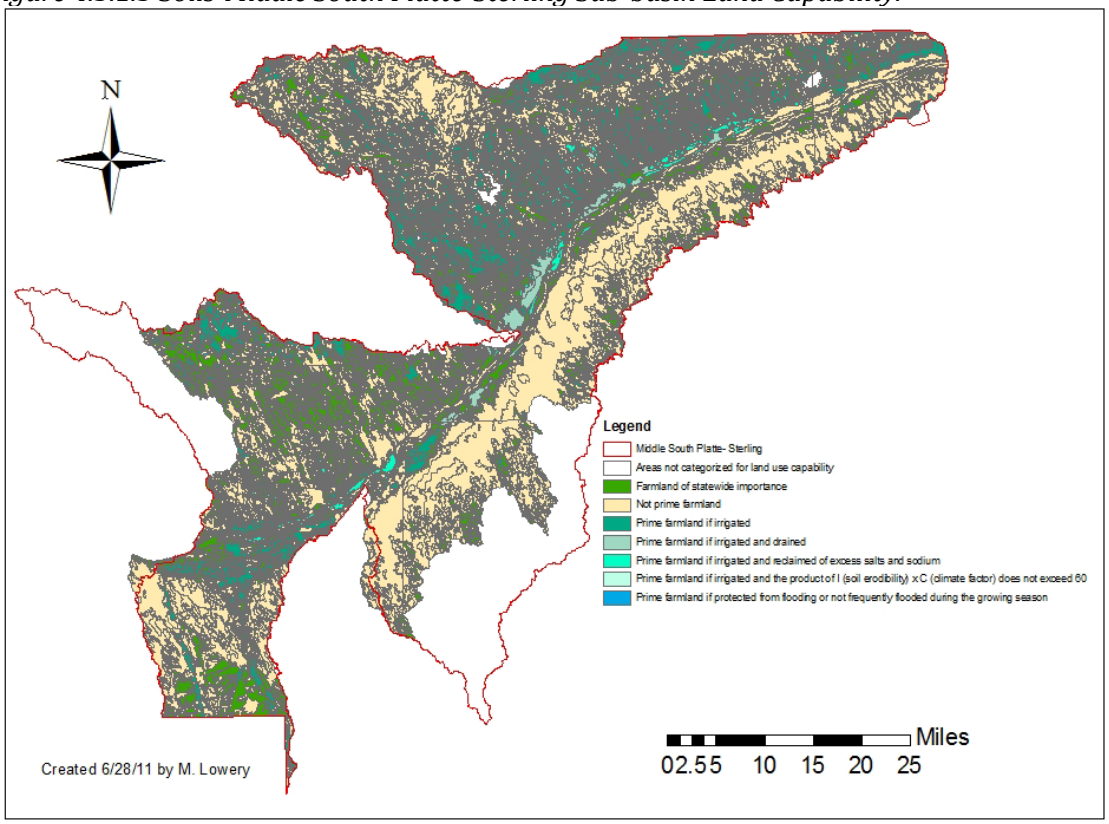


Figure 4.3.1.3 Soils-Middle South Platte-Sterling Sub-basin Land Capability.

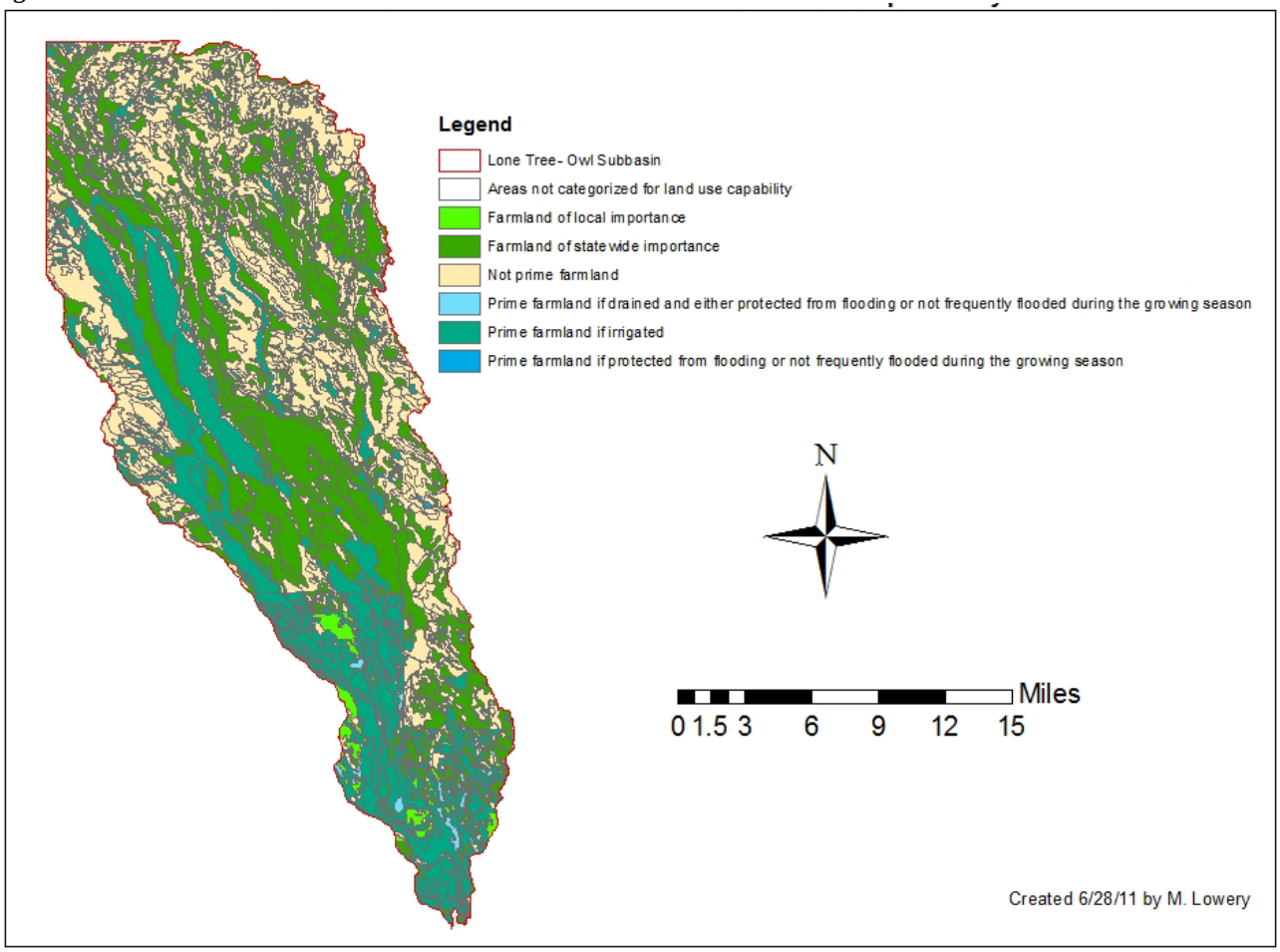


4.3.2 Soils- Lone Tree-Owl watershed

Soils in the Lone Tree-Owl watershed vary significantly from north to south (Figure 4.3.2). The escarpment and ridges area to the north have well-drained loamy and gravelly soils mixed with rock outcrops. The alluvial fans along the creeks have deep, well-drained loams, clay loams, and sandy loams that are level to nearly level and are prime farmlands if irrigated. On the uplands and terraces away from the fans, soils are on nearly level to rolling terrain and have deep, well-drained loamy textures.

The Land Capability Classes of the soils are shown in Figure 4.3.2. The best ratings are with the alluvial fan soils, which are commonly irrigated. Most soils in this watershed are not irrigated or are on high ridges and, as a consequence, have high capability rankings of Class 4 and above. These soils have significant limitations for use as cropland or require very careful farming management to protect the soils. All but a few acres of the soils are highly erodible from wind (Figure 4.3.2).

Figure 4.3.2 Soils-Lone Tree-Owl watershed.



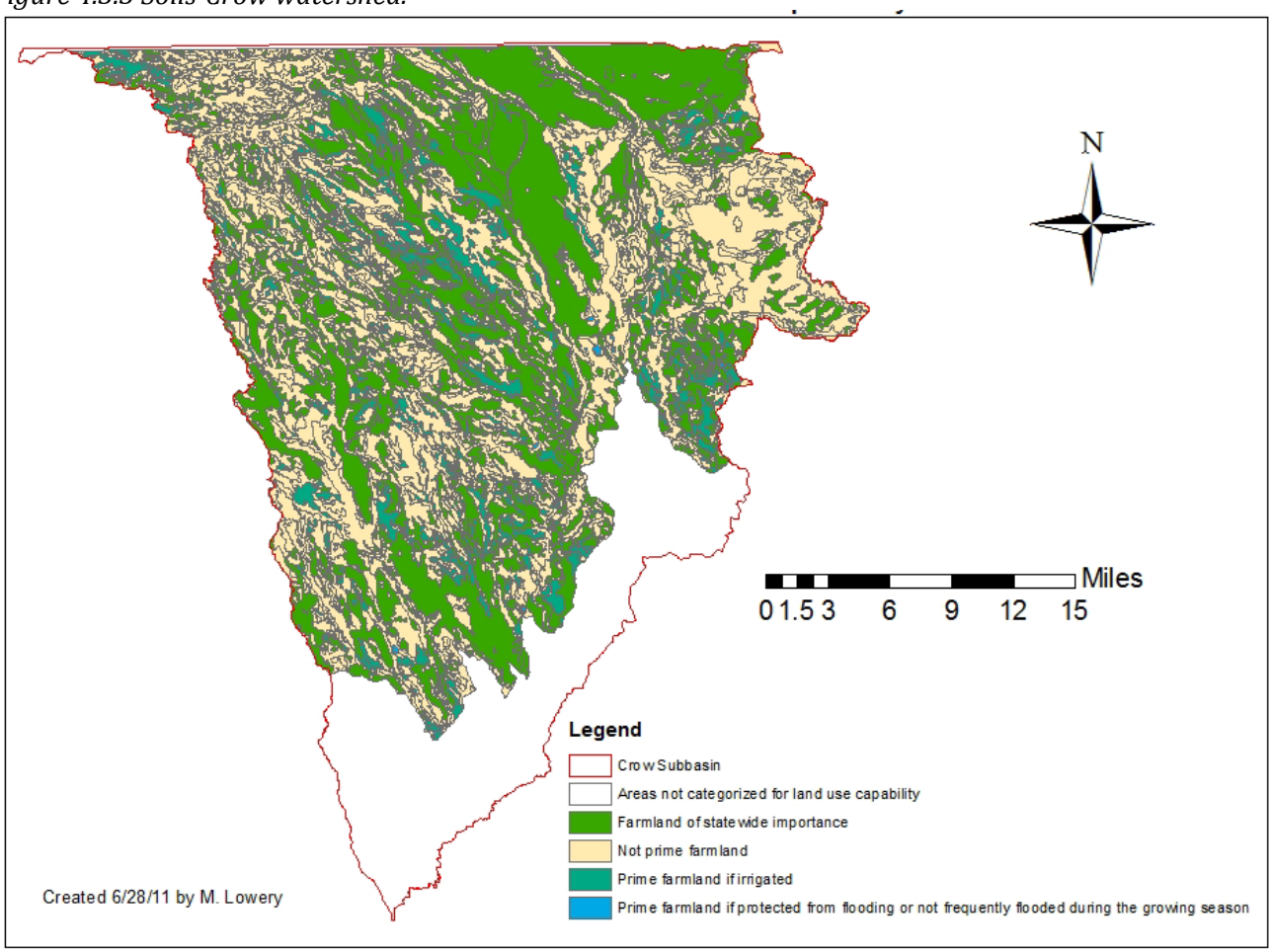
4.3.3 Soils- Crow watershed

Soils in the Crow watershed are primarily loamy on terraces and alluvial fans, and on level to rolling to hilly slopes. The northwestern part of the watershed has sandstone and gravel breaks, with an intermixture of shallow to moderately deep loamy and sandy soils. Shallow to moderately deep loamy and gravelly soils are present near the Chalk Bluffs along the northeastern part of the watershed. A mosaic of sandy soils exist throughout the watershed.

The Land Capability Classes of the soils are shown in Figure 4.3.3. The loamy soils around and south of Hereford and Grover have Class ratings of 3, which means that they have severe limitations that reduce the choice of crops that can be grown, or that careful farming management is needed to protect the soils. Outside of this area, the soils primarily have a Capability Class of 4. Areas of Class 6 and 7 soils also are present, which are typically suitable only for perennial vegetation.

All of the soils are highly erodible from wind (Figure 4.3.3).

Figure 4.3.3 Soils-Crow watershed.



4.3.4 Soils- Pawnee watershed

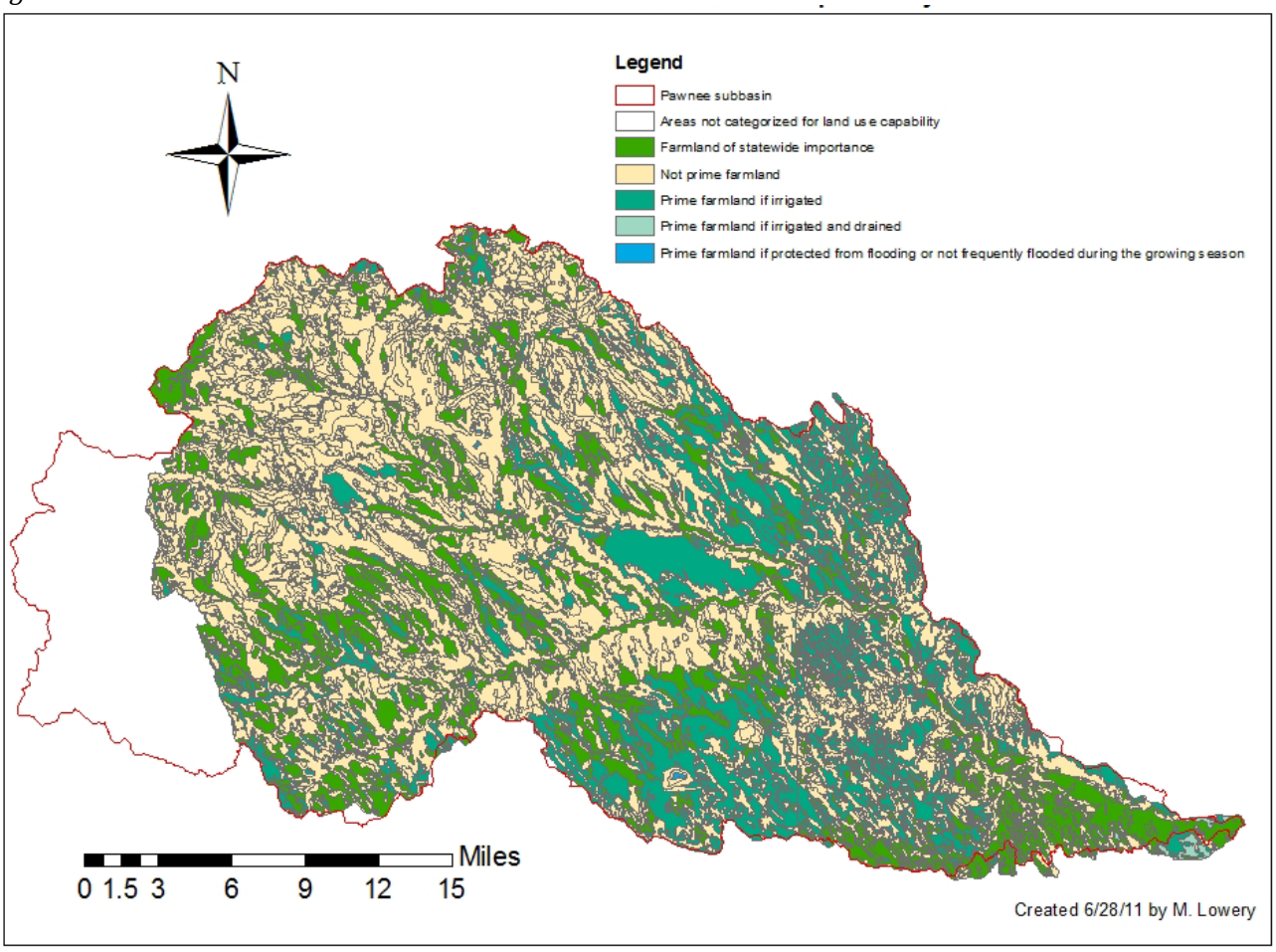
Soils in the Pawnee watershed vary significantly from northwest to southeast (Figure 4.3.4). The Chalk Bluffs and ridges area to the west and northwest have rock outcrop and shallow to deep loamy and gravelly soils on steep slopes. The alluvial fans along along the forks and mainstem of Pawnee Creek have shallow to deep loams, with some areas of sands. On the uplands and terraces away from these fans, soils are on nearly level to rolling plains, hills, and ridges and have deep, well-drained loamy textures.

Some drainages, playas, and riparian areas have an accumulation of salts on or near the surface (Hazlett, 1998). Salt-affected soils exist on bottomlands near the outlet of Pawnee Creek into the South Platte River.

The Land Capability Classes of the soils are shown in Figure 4.3.4. A significant acreage of good Class 2 soils (whether irrigated or non-irrigated) exist around the confluence of North and South Pawnee Creeks and southeast from the confluence towards the South Platte River. Below the escarpments, soils have Capability Classes of 3 or 4, which have severe to very severe limitations for cropping, unless properly managed. Some areas of Class 6 soils exist, such as where sandy soils exist.

All but a few acres of the soils are highly erodible from wind (Figure 4.3.4).

Figure 4.3.4 Soils-Pawnee watershed.



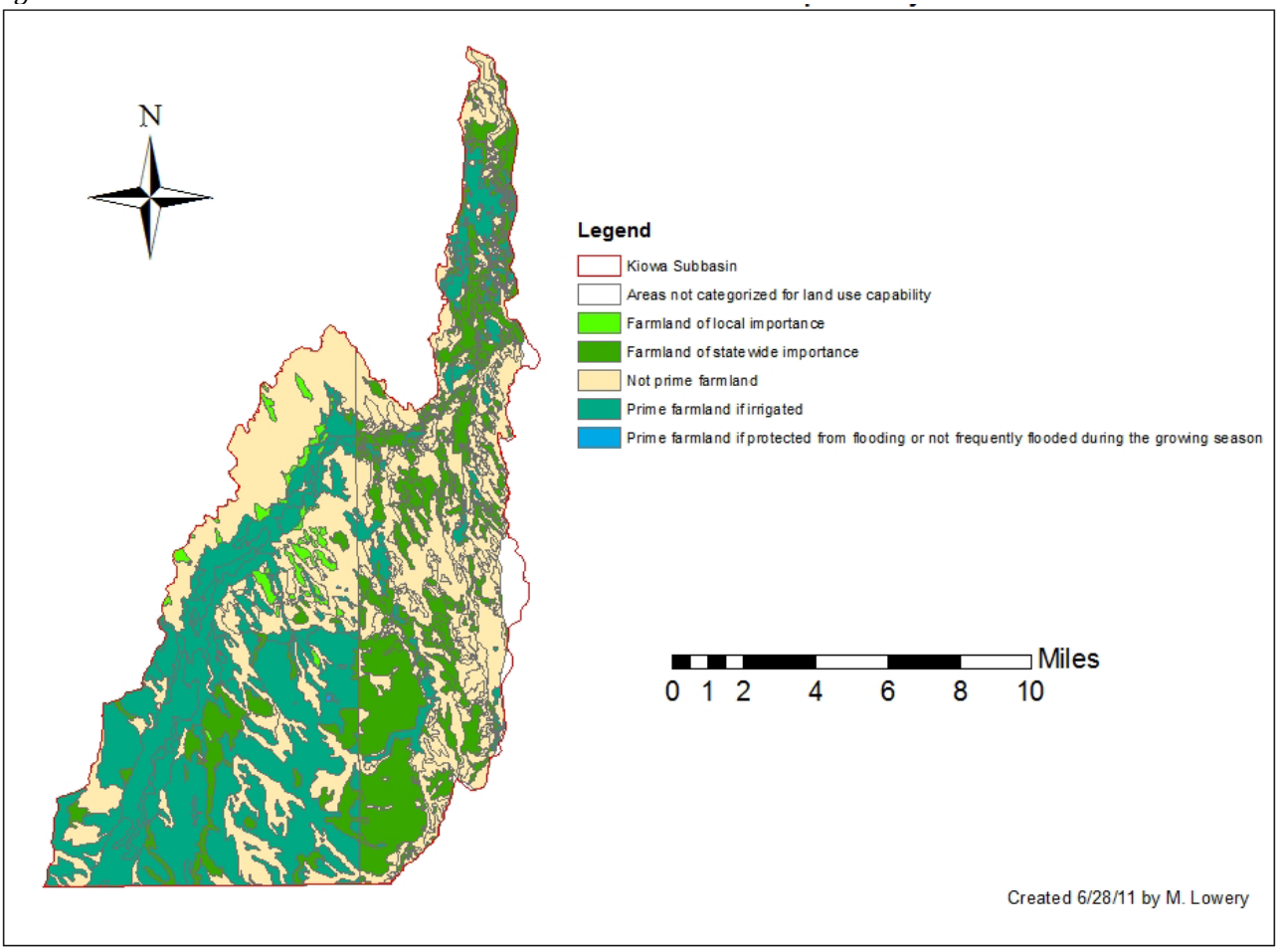
4.3.5 Soils- Kiowa watershed

Soils in the Kiowa watershed are predominantly calcareous loams, clay loams to sandy loams, and sands. From the Weld-Adams County line, the Kiowa Creek bed has deep, level to nearly level loams and clay loams. From about five miles southwest of Wiggins, the creekbed soils and surrounding terraces and uplands have deep sands. South of the sandy soils are calcareous loams and good silt loams on nearly level to moderately sloping land.

The Land Capability Classes of the soils are shown in Figure 4.3.5. A significant acreage of good Class 2 soils exist for irrigation, and are irrigated. The sandy soils have a Capability Class of 4, with some being Class 6, which are not suitable for cropping use.

All but a few acres of the soils are highly erodible from wind (Figure 4.3.5). The sandy soils are highly susceptible to wind erosion.

Figure 4.3.5 Soils-Kiowa watershed.



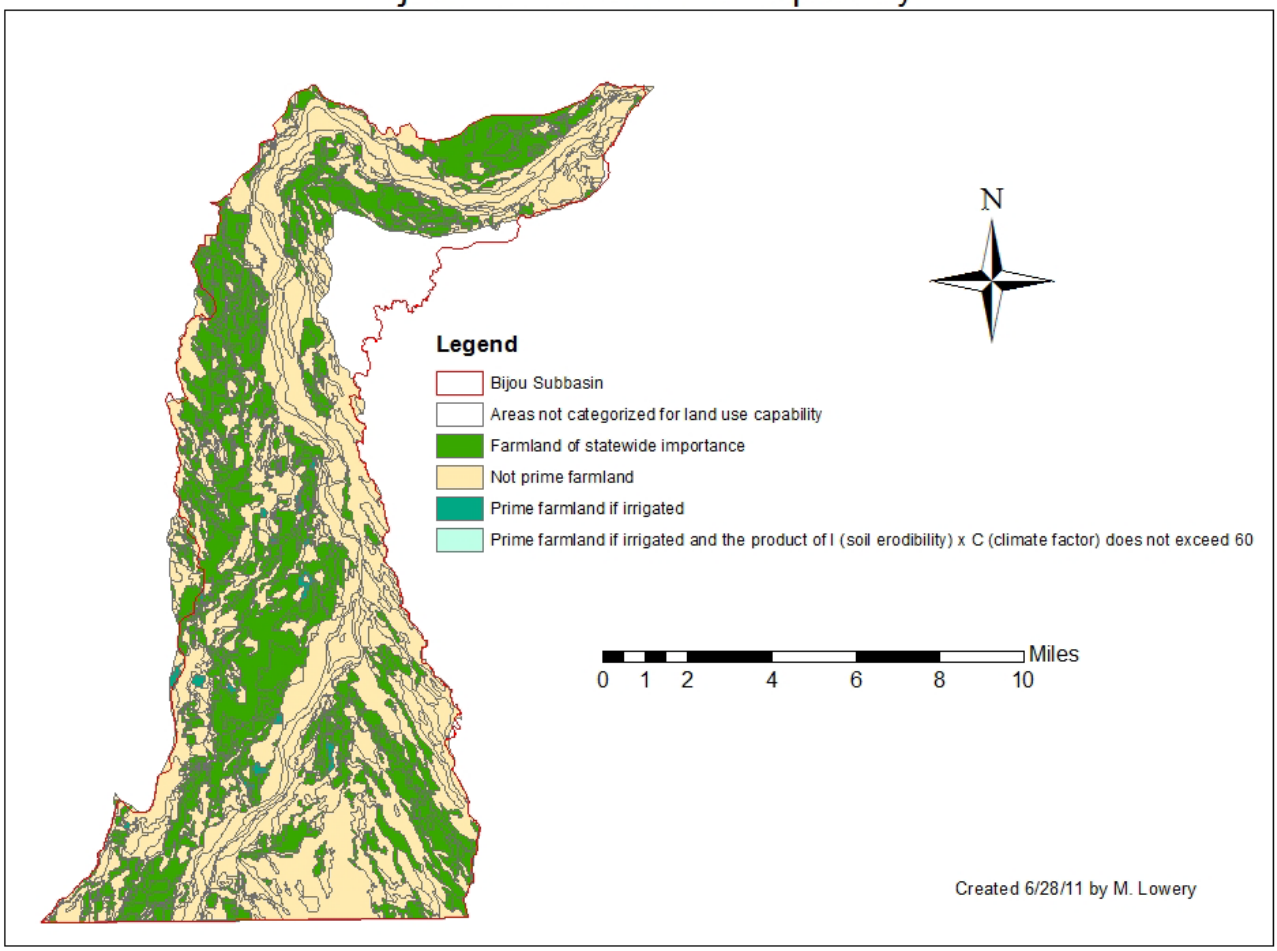
4.3.6 Soils- Bijou watershed

Soils in the Bijou watershed are predominantly sandy soils on terraces, uplands, and the creek bottom.

The Land Capability Classes of these sandy soils are shown in Figure 4.3.6. When irrigated, most of the acreage is Class 2 or 3; some Class 4 locations exist. When not irrigated, the watershed's soils are a mixture of Class 3, 4, and 6.

The watershed's soils are highly to very highly erodible from wind (Figure 4.3.6).

Figure 4.3.6 Soils-Bijou watershed.



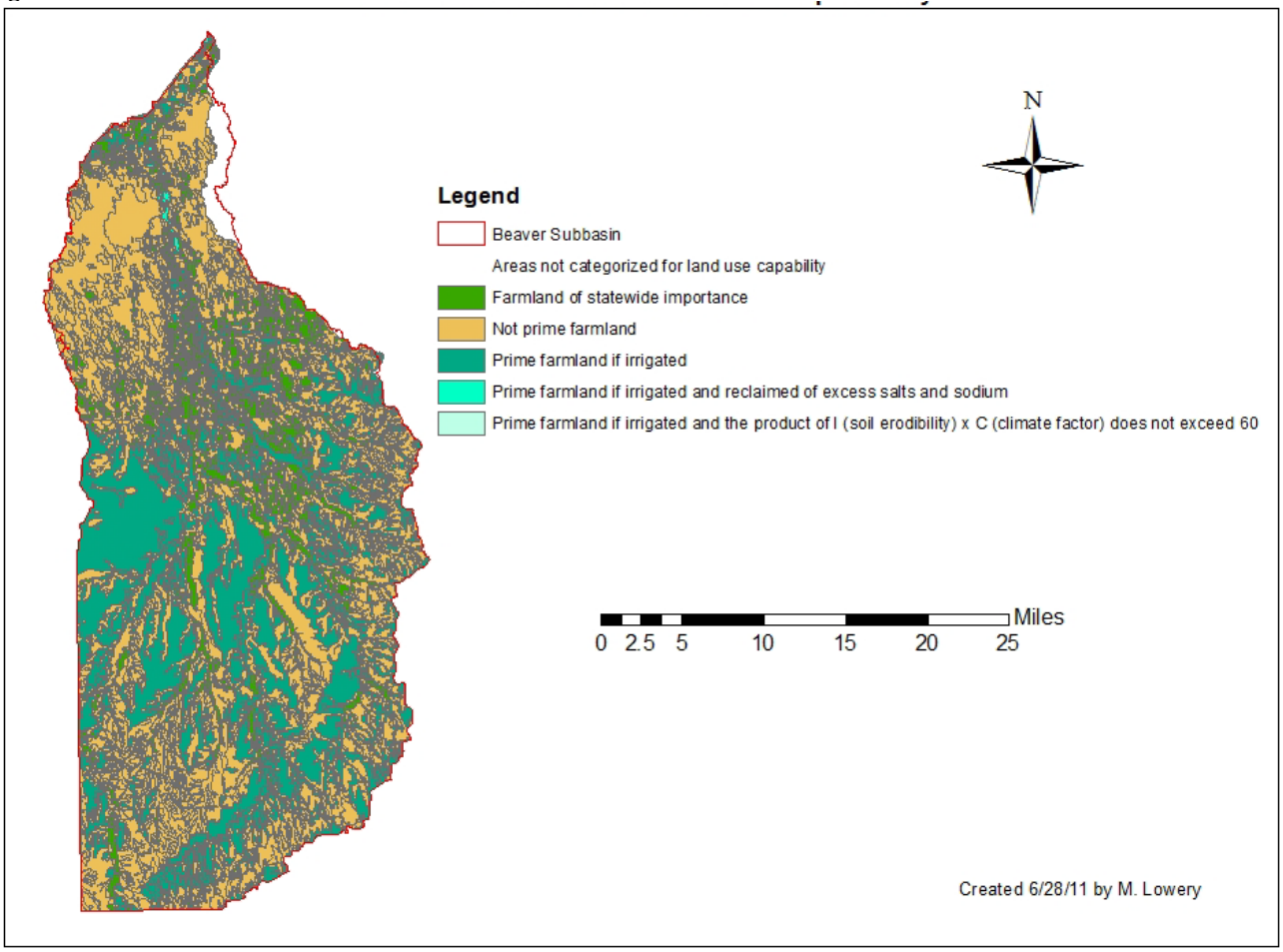
4.3.7 Soils- Beaver watershed

Soils in the Beaver watershed vary from south to north. From the Washington-Lincoln County line, the bottoms and low terraces of Beaver Creek and its main tributaries have loam to clay loam soils. In Morgan County, the Beaver Creek bottomland has clay soils. In Washington County, the nearly level to hilly uplands have silt loam to loam soils. From near the Morgan-Washington County line to the South Platte River, the upland areas have sandy soils.

The Land Capability Classes of the soils are shown in Figure 4.3.7. When irrigated, a significant acreage of soils is Class 2, having moderate limitations for soil protection when farmed. A significant acreage of Class 6 soils also exist, which are generally unsuitable to farming. When not irrigated, the watershed's soils are a mixture of Class 3, 4, and 6. The Class 3 soils are in the middle of the watershed.

The watershed's soils are highly to very highly erodible from wind (Figure 4.3.7). The sandy soils on the north part of the watershed are very highly susceptible to wind erosion.

Figure 4.3.7 Soils-Beaver watershed.



4.4 Threatened and endangered species

Some threatened and endangered plant and wildlife species exist within the LSPW, under the criteria of the federal Endangered Species Act. With regard to plants, one listed species occurs and it is located in the Lone Tree-Owl hydrologic unit. The species is *Gaura neomexicana* Woot. ssp. *coloradensis* (Rybd.) P.H. Raven & Gregory and collections of it have been made along Lone Tree Creek, just south of the Colorado-Wyoming state line (NRCS, 2011). The plant's common name is Colorado butterfly plant and it is listed as "threatened" by the U.S. Fish and Wildlife Service. Its global rank is G3T2 and its Colorado protection status in S1, which means that the plant is critically imperiled globally and statewide because of rarity (five or fewer occurrences in the world/state). The state status is as of February 7, 1991.

The Colorado butterfly plant is an obligate wetlands plant, and is found within a short distance from Lone Tree Creek. Threats to this plant include overgrazing by livestock, mowing its habitat for hay before seed is released, herbicides, and competition from weeds, and loss of habitat to urban expansion (CPC, 2011).

With regard to wildlife, Table 4.4 lists the threatened or endangered wildlife species that may occur or have been found to occur within the LSPW. The information in the table is from rapid watershed assessments of the 8-digit watersheds that exist within the LSPW prepared by the USDA- Natural Resources Conservation Service.

Table 4.4 Threatened or endangered wildlife species within the LSPW.

T= threatened; E = endangered

		8-Digit Watersheds								
Common Name	**State Status**	**MSP-Cherry Creek**	**MSP-Sterling**	**Lower South Platte**	**Kiowa**	**Bijou**	**Beaver**	**Lone Tree-Owl**	**Crow**	**Pawnee**
Mammals										
Preble's meadow jumping mouse	T	Occurs			Occurs			Occurs	May occur	
River otter	T	Occurs								
Birds										
Bald eagle	SC		Occurs	Occurs		May occur	May occur			
Burrowing owl	T	Occurs	Occurs		Occurs	Occurs	Occurs	Occurs	Occurs	Occurs
Least tern	E		May occur							May occur
Piping plover	T		May occur						May occur	May occur
Plains Sharp-tailed grouse	**E**		Occurs	Occurs					Occurs	Occurs
Fish										
Brassy minnow	T	Occurs	Occurs		May occur	May occur	May occur	Occurs	May occur	Occurs
Common shiner	T		Occurs	Occurs					May occur	May occur
Plains minnow	E		Occurs	Occurs			May occur			May occur
Suckermouth minnow	E		Occurs	Occurs	May occur	May occur	May occur			May occur

Typical habitat for the Preble's meadow jumping mouse is comprised of well-developed plains riparian vegetation with adjacent, relatively undisturbed grassland communities and a nearby water source. This mammal is under a federal conservation plan.

With regard to threatened or endangered bird habitats, burrowing owls can be found in grasslands, usually in or near prairie dog towns. The least tern's preferred nesting habitat is on sandy or pebbly beaches, well above the water line, around lakes and reservoirs or on sandbars in river channels. Nesting habitat for the piping plover is on sandy lakeshore beaches, sandbars within riverbeds, or sandy wetland pastures. The plains sharp-tailed grouse uses rolling hills with scrub oak thickets and grassy glades.

The burrowing owl and plains sharp-tailed grouse are under state species conservation plans. The least tern and piping plover are under federal species recovery plans. The piping plover also is under a state recovery plan.

With regard to threatened or endangered fish habitats, the brassy minnow can tolerate a variety of conditions, but is restricted in abundance and distribution by unknown factors such as fluctuating plains streams. The common shiner requires streams of moderate gradient with cool, clear water, gravel bottoms and shaded by brush or trees. The plains minnow prefers main channels with some current and sandy bottoms. The suckermouth minnow looks for riffle areas of warm prairie streams of all sizes with low to moderate currents and year-round flows. These four minnows will be under a South Platte Native Fish Conservation Plan that is soon to be finalized by the Colorado Division of Parks and Wildlife.

4.5 Critical riparian habitats

The Colorado Natural Heritage Program (CNHP) has identified some extremely rare to very rare (within Colorado and globally) natural plant communities within the LSPW (Kittel, G. et al, 1998). The CNHP found the plains cottonwood/wooly sedge (*Populus deltoids* ssp. *monilifera/Carex lanuginosa*) plant association at three locations located along the South Platte River within Logan, Washington, and Weld Counties. The CNHP categorized this community as extremely rare, with some uncertainty involved.

The CNHP found the plains cottonwood/western snowberry (*Populus deltoids* ssp. *monilifera/Symphoricarpos occidentalis*) plant association at twelve locations along the South Platte River within Logan, Morgan, and Sedgwick Counties. This community is ranked as very rare globally in Colorado.

The CNHP found the plains cottonwood-(peach-leaved willow/prairie slough grass (*Populus deltoids* ssp. *monilifera-(Salix amygdaloides)/Spartina pectinata*) plant association at eleven locations along the South Platte River within Logan, Morgan, and Sedgwick Counties, and one location along Dave's Draw in the Pawnee National Grasslands in Weld County. This community is ranked as extremely rare globally in Colorado.

4.6 Important farmland areas

Under Title 7 CFR Volume 6, Part 657, it is the USDA-Natural Resources Conservation Service's (NRCS's) policy to make and keep an inventory of the prime farmland and unique farmland of the United States. The objective of the inventory is to identify the extent and location of important rural lands needed to produce food, feed, fiber, forage, and oilseed crops.

To this end, the NRCS has identified and mapped important farmlands that exist within the hydrologic watersheds that occur in the LSPW. The NRCS categorizes important farmland into the following categories: prime farmland, farmland of statewide importance, unique farmland, and farmland of local importance. These categories are defined below.

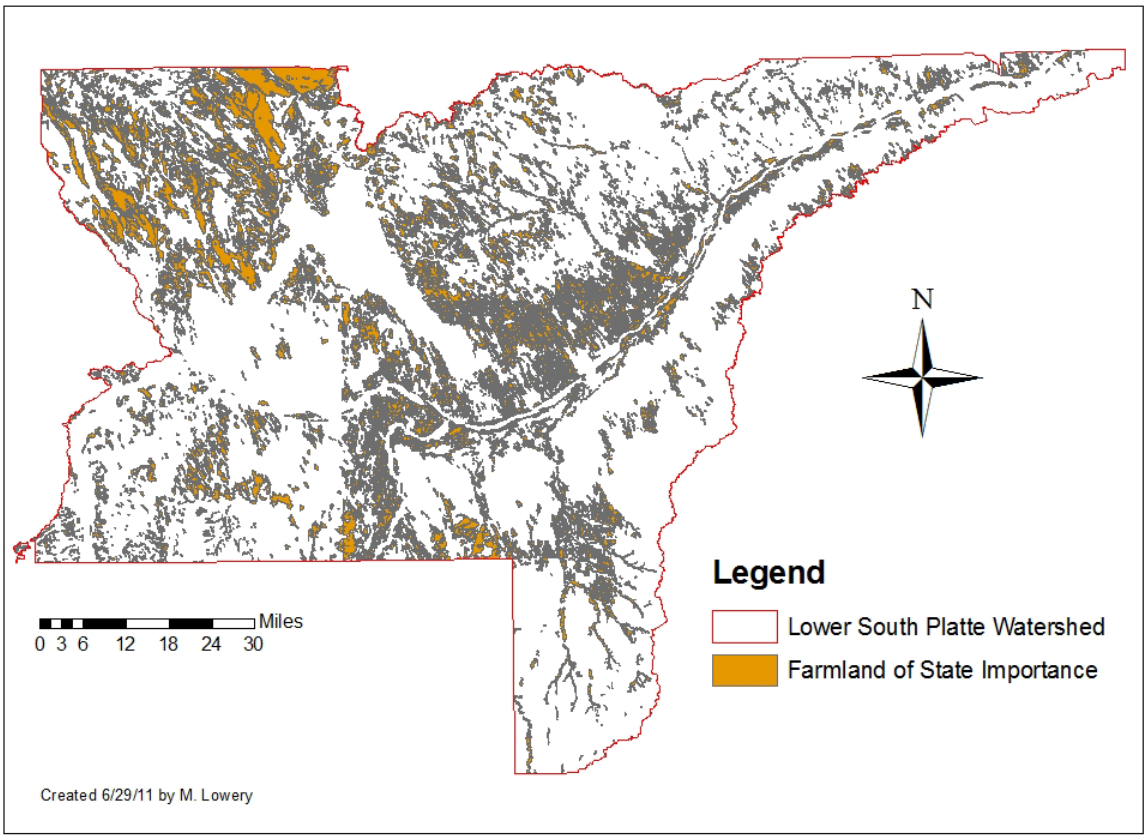
Prime Farmland is land which has the best combination of physical and chemical characteristics for the production of crops. It has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops when treated and managed, including water management, according to current farming methods. Prime farmland must have been used for the production of irrigated crops at some time during the two update cycles prior to the NRCS's current mapping date. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Farmland of Statewide Importance is land other than Prime Farmland which has a good combination of physical and chemical characteristics for the production of crops. It must have been used for the production of irrigated crops at some time during the two update cycles prior to the NRCS's current mapping date. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Unique Farmland is land which does not meet the criteria for Prime Farmland or Farmland of Statewide Importance, that has been used for the production of specific high economic value crops at some time during the two upgrade cycles prior to the NRCS's current mapping date. It has the special combination of soil quality, location, growing season, and moisture supply needed to produce sustained high quality and/or high yields of a specific crop when treated and managed according to current farming methods. Examples of such crops may include oranges, olives, avocados, rice, grapes, and cut flowers. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Farmland of Local Importance is either currently producing crops, has the capability of production, or is used for the production of confined livestock. Farmland of Local Importance is land other than Prime Farmland, Farmland of Statewide Importance, or Unique Farmland. This farmland may be important to the local economy due to its productivity or value. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Figure 4.6 shows the locations of important farmlands in the LSPW.



4.7 Ditches and canals

Because of the low average annual precipitation received in the watershed, supplemental water is needed to apply to many high cash crops, such as sugar beets and corn, for the purpose of obtaining optimal crop growth and yields. As a result, the early settlers of the LSPW looked toward surface water flows in the South Platte River and its tributaries as sources of the needed supplemental water. In upstream tributaries to the west of the South Platte River, diversions of surface water began in the early 1860s. Canals/ditches were dug to carry diverted streamflows to farmlands via a system of laterals. Within the LSPW, water from the South Platte River began to be diverted to newly constructed canals/ditch/lateral systems in the late 1860s and additional systems were constructed from Greeley to the stateline during the 1870's and 1890's.

Today, these surface water diversion systems continue to play a significant and essential role in providing for the high crop productivity along the waterways of the LSPW. However, the number of irrigated acres supplied by these systems has decreased, and continues to decrease, as a result of urban growth and purchase of the water rights to these systems for non-agricultural use.

According to the Structures (Diversions) Data Search records of the Colorado Division of Water Resources, the number of ditches that are actively diverting water from the South Platte River from diversion structures located within the LSPW are as follows:

- 8 between St. Vrain Creek and Greeley
- 29 between Greeley and Balzac (Morgan-Washington County line)
- 26 from Balzac to the state line.

In addition to the South Platte River, numerous other diversions are made from tributaries to the river within the LSPW. For example, three active ditch systems divert water from Lone Tree Creek, four systems divert water from Owl Creek, one system diverts water from Crow Creek, two systems divert water from Bijou Creek, 23 systems divert water from Kiowa Creek, two systems divert water from Beaver Creek, and eight systems divert water from Pawnee Creek.

4.8 Rivers, creeks, lakes, springs, and reservoirs

A discussion of the rivers and creeks within the LSPW is provided in section 3 (Hydrology) of this LSPW plan.

A number of reservoirs exist within the LSPW for the purposes of storing water during times of high river or creek flows and releasing the water during the growing season for crop irrigation. A selection of these reservoirs is provided in Table 4.8, along with the watershed within which each reservoir is found.

Numerous lakes and springs exist within the LSPW.

Table 4.8. Major reservoirs within the LSPW and their watershed location.

Reservoir	Watershed Location
Bijou No. 8 Reservoir	Middle So. Platte- Sterling
Empire Reservoir	Middle So. Platte-Cherry Creek
Heart Reservoir	Crow
Horse Creek Reservoir	Middle So. Platte- Cherry Creek
Jackson Reservoir	Middle So. Platte- Sterling
Jumbo (Julesburg) Reservoir	Middle So. Platte-Sterling
Lower Latham Reservoir	Middle So. Platte- Cherry Creek
Owl Creek Reservoir	Lone Tree-Owl
Prospect Reservoir	Middle So. Platte- Cherry Creek
Prewitt Reservoir	Middle So. Platte- Sterling
Riverside Reservoir	Middle So. Platte- Cherry Creek
Romener Reservoir	Middle So. Platte- Sterling
Sterling Reservoir	Middle So. Platte- Sterling

4.9 Wetlands

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (FWS, 1979). The soils commonly are often or frequently inundated or saturated with water. Table 4.9 lists and describes the wetland types existing in the South Platte River valley (SPWFAC, 2002). Riparian areas exist along Lone Tree, Beaver, and Crow Creeks and may also harbor wetland areas.

According to the South Platte Wetland Focus Area Committee (SPWFAC), many of the wetlands originally present in the lower South Platte River basin have been lost and/or degraded due to land conversion and as a result of numerous land and water management practices (SPWFAC. 2002). The SPWFAC is a working group of public and private partners (including Colorado Open Lands) organized to facilitate the development of wetland conservation projects. Approximately $750,000 in projects have been implemented, in cooperation with private landowners, by Ducks Unlimited, CDOPW, and the USFWS. These projects have helped develop augmentation plans, improve and restore wetland habitat and maintain and repair existing ditch structures.

Table 4.9. Wetland areas that exist in the South Platte River Valley.

Wetlands Types	Description
Submerged aquatic	• Small permanent ponds, both natural and artificial • Semi-permanent to permanent flooding • Dominated by submerged vegetation
Emergent marsh	• Cattail-dominated marsh • Seasonal or semi-permanent flooding • Dominated by perennial emergent vegetation (cattail or bulrush) • Occurs predominantly in poorly drained areas
Wet meadow	• Surface water usually absent but with seasonally high water table • Dominated by grasses, sedges, and rushes
Riverine wetlands	11. Riparian woodlandsOccurs along the South Platte River channels and associated flowing water wetlands • Includes irrigation canals and ditch systems
Warm water seeps, springs, sloughs	• Important subset of Riverine wetlands • Return-flow streams that do not normally freeze • Includes seep ditches and toe drains below reservoirs
Lakes and reservoirs	• Mostly irrigation reservoirs with highly fluctuating water levels • Large, deep water bodies with wave-formed shorelines • Usually lack emergent vegetation
Playas	• Temporary (ephemeral) lakes in pastures or farmground • Usually circular depressions in areas with no external drainage • Seasonally, or less often, flooded • Located on clay soils away from stream channels in shortgrass prairie (or cultivated fields)
Artificial wetlands	• Constructed wetlands • Moist-soil units are managed to provide shallow water habitat dominated by annual seed producing plants • Temporary flooding usually occurs in spring and autumn

4.10 Oil and gas wells

The LSPW lies within the Denver-Julesburg geologic structural basin. Most of the oil and gas wells in the basin tap Cretaceous sandstones. The major oil and gas field within the watershed is the Wattenberg Field, which exists in Weld County. The rough boundaries of this field are: on the north, State Highway 14; on the south, the town of Hudson; on the east, Briggsdale, Roggen, and Hudson; and on the west, the west boundaries of the Lone Tree-Owl and Middle South Platte-Cherry Creek watersheds.

The Wattenberg Field was discovered in 1970 and in terms of proven reserves, is the 13th largest crude oil field and the 10th largest natural gas field in the United States (USEA, 2009). A high density of permitted oil and gas wells are in place within this field in the LSPW.

Another significant oil/gas producing area is located within the Crow, Lone Tree-Owl, and Pawnee watersheds. This area is bounded on the east by State Highway 71, on the south by State Highway 14, and on the west by the west boundary of the Lone Tree-Owl watershed. Concentrations of permitted wells exist around the towns of Hereford, Grover, and Keota; for example, more than 100 permitted wells are in place within a 12 mile radius of Grover and Hereford. Exploratory work has been conducted on the Pawnee National Grasslands to discern the viability of drilling additional oil/gas wells tapping the Niobrara shale formation, located more than 6,000 feet below the surface (Denver Post, 2011).

A small number of permitted wells are in place west of Peetz and north of Sedgwick.

Colorado Oil and Gas Commission require that new wells be constructed in a manner that protects surface and ground waters. Examples of requirements are liners in water pits when drilling wells, obtaining and following a stormwater permit, buffer zones from surface waters and best management practices that must be used within the zones, and reclamation of well pads.

4.11 Source Water Protection areas

The 1996 federal Safe Drinking Water Act Amendments directed that each state develop a Source Water Assessment and Protection (SWAP) program. The first phase of the program is assessments of all public water supplies in Colorado, including their susceptibility to potential contamination from discrete and dispersed contaminant sources. The second phase of the program is development of plans to protect the water supplies from potential contamination sources.

The Colorado Department of Public Health and Environment- Water Quality Control Division (WQCD) completed source water assessments of all public water supplies in Colorado in 2004. Table 4.11 shows the number of public water supplies that were assessed in the LSPW, by county, and the contamination susceptibility ratings for each of the supplies. Information specific to cities/towns is included. For all of the water supplies, the source of water was ground water wells. The assessment reports by county are available at the following web site: http://www.cdphe.state.co.us/wq/sw/swapreports/swapreports.html

Concerning Phase II of the SWAP program, protection plans are being developed for Brush and Morgan County Quality Water District, and for Julesburg, Ovid, and Sedgwick. The Morgan County Quality Water District's plan is focusing on three areas: Hay Gulch (near Morgan/Weld County line), San Arroyo Creek, and Beaver Creek.

Table 4.11 Public Water Supply Assessments in the Lower South Platte Watershed - 2004

County/City/Town	Public Water Supplies Assessed	Contamination Susceptibility Ratings of Source Water Wells
Logan	18	ML (15); M (13); MH(16); H (15)
• Crook		MH (2)
• Iliff		ML (1)
• Merino		MH (1)
• Peetz		ML (1)
• Sterling		MH (2); H (10)
Morgan	8	ML (8); M (8); MH (7); H (3)
• Brush		M (7); MH (3)
• Ft. Morgan		MH (1)
• Hillrose		MH (2)
• Morgan County WD		ML (8); H (1)
Sedgwick	5	ML (1); M (2); MH (3)
• Julesburg		MH (1)
• Ovid		M (2)
• Sedgwick		ML (1)
Washington	2	MH (1); M (1)
Weld	13	ML (8); M (4); MH (5); H (2)
• Briggsdale		ML (1); M (1)
• Grover		ML (2)
• Hudson		H (2)
• Keenesburg		ML (2)
• Nunn		ML (2)
• Pierce		MH (2)
• Raymer		ML (1)

ML = moderately low; M = moderate; MH = moderately high; H = high contamination susceptibility

4.12 Major Land Uses

4.12.1 Agriculture

The major land uses in the LSPW are agriculture, wildlife habitat, cities/towns, and commercial/industrial and education.

The watershed is dominated by agricultural land uses, including irrigated and dryland farming, livestock feeding and grazing, milk production, agricultural production support businesses (including elevators), and agricultural product processing.

Irrigation is accomplished primarily by furrow and center pivot irrigation. Furrow irrigations occur along or near waterways. Some of the best furrow-irrigated areas are on terraces on the north side of the South Platte River. The major irrigated area within the LSPW is in the Middle South Platte-Cherry Creek watershed and in the southern Lone Tree-Owl watershed (Figure 4.12.1). Other

irrigated land exists along the South Platte River and major tributaries. Major irrigated crops are alfalfa and other forage crops, corn, corn silage, irrigated wheat, sugar beets, barley, beans, and assorted vegetables.

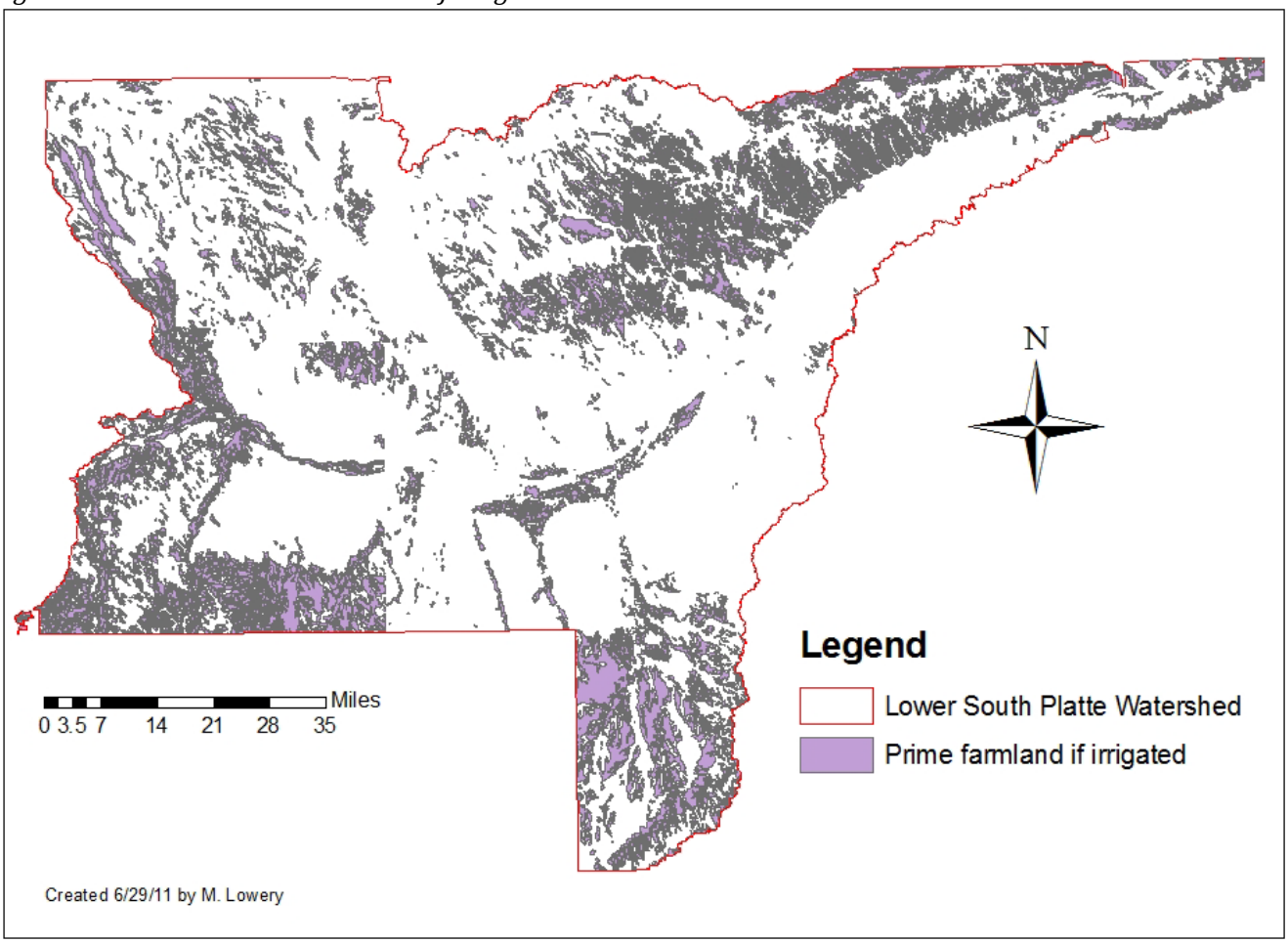
Dryland farming acreage is interspersed throughout the LSPW. This land is farmed using a range of conventional tillage to conservation tillage, and alternate year fallow to continuous cropping. Major dryland crops are winter wheat, millet, and sunflowers.

A significant acreage of grassland exists within the watershed, especially on and near escarpments, dune sands, and dissected terrain. These areas are used for cattle grazing.

Livestock feeding facilities include numerous small- to medium-sized lots that feed poultry, cattle, swine, and sheep. In addition, 74 large feeding operations (concentrated animal feeding operations) exist within the LSPW. The majority of these facilities feed cattle (47); 21 are dairy farms.

The major agricultural product processing facilities are a sugar beet processing plant operating in Fort Morgan (Western Sugar Cooperative), a cheese making facility in Fort Morgan (Leprino Foods), a packing house in Fort Morgan that processes about 4,000 head of cattle per day (Cargill Meat Solutions), and a milk processing plant in Fort Morgan that processes two million gallons per day (Dairy Farmer of America, Inc.).

Figure 4.12.1 LSPW Prime Farmland if Irrigated.



4.12.2 Cities/Towns

A number of cities/towns are established in the watershed, including Wiggins, Fort Morgan, Brush, Sterling, Ovid, Sedgwick, and Julesburg that lie along the South Platte River.

The cities/towns, especially Fort Morgan, Brush and Sterling, are home to a variety of commercial/ industrial businesses and higher education facilities. Examples of these are the Sterling Correctional Facility (850 employees), Northeastern Junior College, Colorado Community College, Xcel Energy power plant, and Burlington Northern Railroad.

4.12.3 Wildlife

The mix of riparian, wetland and grassland habitat types within the watershed provide numerous wildlife habitats which support large populations of deer, small mammals, birds, fish and reptiles. The Lower South Platte and associated reservoirs, ditches and impoundments provide critical loafing, feeding and roosting habitat for migrating waterfowl in the spring and fall. Additionally, wintering populations of bald eagles make use of the major plains reservoirs. The riparian vegetation, found predominantly along the South Platte, provides vital cover for populations of turkeys and quail, white-tailed deer and non-game bird species such as shorebirds and song birds.

Twenty-six State Wildlife Areas (SWAs) are located within the LSPW along the South Platte River, comprising a total of 24,035 acres. Eight SWAs are located in Logan County, eight in Morgan County (including Jackson Lake), three in Sedgwick County (including Jumbo/Julesburg Reservoir), two in Washington County (including Prewitt Reservoir), and five in Weld County. In addition to wildlife habitat, the SWAs provide access to the public for, depending on the SWA, hunting, hiking, boating, wildlife viewing, fishing, and camping.

Most land within the watershed is privately owned. With permission of a private landowner, the public can view, hunt or fish wildlife that exists on the owner's land.

4.12.4 Pawnee National Grasslands

The Pawnee National Grasslands (PNG) are federal lands that occur in a mosaic pattern in two areas located to the west and east of the town of Grover and comprise 193,060 acres. The grasslands are managed by the Arapahoe and Roosevelt National Forest offices in Fort Collins and Greeley. The PNG is located in the Lone Tree-Owl, Crow Creek, and Pawnee watersheds.

The PNG is characteristic of the shortgrass prairie (steppe) type vegetation dominated by blue grama and buffalo grass. The Forest Service's PNG website indicates that the PNG is an internationally known birding area. Among other species, the Colorado State Bird, the lark bunting is very common on the grasslands in spring and summer. The PG also has many unique high plains bird species such as the mountain plover, burrowing owl, and many birds of prey.

Activities available to the public on the PNG include dispersed camping, RV camping at the Crow Valley Recreation and Campground located near Briggsdale, hiking, off-highway vehicle riding, target shooting, outdoor learning, picnicking, and scenic driving.

4.12.5 Central Plains Experimental Research Station

The Central Plains Experimental Research Station is a USDA-Agricultural Research Service research facility located north of Nunn in Weld County, and is in the Lone Tree-Owl watershed. The station has 15,500 acres of land at an elevation of from 5,250 feet to 5,550 feet. Research began in 1939 and focuses on improved grazing management practices on the fragile shortgrass prairie (steppe).

4.12.6 State Trust Lands

Several thousand acres of state trust lands exist throughout the LSPW. These lands were given to Colorado by the federal government in 1876 and are often located in sections 16 and 36 of each township of 36 sections of land. State trust lands are managed by the Colorado State Land Board

and are leased for grazing, farming, mineral/oil/gas production, recreational activities, and other uses.

4.13 Demographics

4.13.1 Population

The Lower South Platte Watershed experienced significant population growth over the last decade (Table 4.13.1a), experiencing an overall increase of 76,063 people from 2000 through 2010. This increase, when combined with the population increase of 132,468 in the remaining counties (Park, Jefferson, Denver, and Adams) containing the main channel of the South Platte River, shows more than a 12.2% gain in population during that ten-year span (Colorado Demography Office). Population decreases in Sedgwick and Washington Counties were offset during the 2000-2010 timeframe by a 40.5% increase in Weld County, the second fastest growing county in the state during that period. The Lower South Platte Watershed's 32.2% population growth was almost twice as fast as the state's 16.9% rate during the same time span.

Table 4.13.1a. Lower South Platte Watershed Population Changes – 2000 to 2010

County	2000	2010	% Change
Logan	20,504	22,779	11.09
Morgan	27,171	28,212	3.83
Sedgwick	2747	2384	-13.21
Washington	4926	4824	-2.07
Weld	180,936	254,148	40.46
TOTAL	**236,284**	**312,347**	**32.19**

Source : 2010 U.S. Census, Colorado Demography Office

Thirty-year projections (Table 4.13.1b) made by the Office of the State Demographer show annual population growth in the Lower South Platte Watershed Plan area to exceed 4% per year, with Weld County alone expected to realize a gain of 384,417 people (136.9%) and an additional 22,835 individuals (80.9%) living in Morgan County from 2010 to 2040. Total growth of 123% in the LSP is expected to far outpace Colorado as a whole, with state growth projected to be approximately 58% during the next three decades.

Table 4.13.1b. Projected Lower South Platte Watershed Population Changes – 2010 to 2040

County	2010	2040	% Change
Logan	22,779	35,548	56.06
Morgan	28,212	51,047	80.94
Sedgwick	2384	2990	25.42
Washington	4824	4987	3.38
Weld	254,148	602,192	136.95
TOTAL	**312,347**	**696,764**	**123.07**

Source: 2010 U.S. Census, Colorado Demography Office

4.13.2 Economy and Workforce

Historically, population growth and economic development in the Lower South Platte Watershed have been driven by agriculture and industries that add value to agricultural production from the area. According to the 2007 Census of Agriculture, the total value of crops produced in the counties of the LSP was $534.9 million while the value of livestock production was more than $2.15 billion. This level of production placed three of the LSP's counties in the top five counties in total value of

agricultural production in Colorado (#1 – Weld = $1.54 billion; #3 – Morgan = $494 million; and #4 - Logan = $442 million) and a fourth county was in the top ten (#9 – Washington = $130 million).

Agricultural production has a significant impact on the workforce in the Lower South Platte Basin of Colorado. According to the Colorado Center for Business and Economic Forecasting, Inc. (Kendall, 2007). In 2000 there were 121,039 jobs in the LSP area, with one in every 5.7 jobs being agricultural-related, with agricultural job percentages ranging from 14.5% in Weld County and 17.0% in Logan County to 33.6%, 40.8% and 44.1% in Morgan, Sedgwick and Washington Counties respectively.

Forecasts for job growth in the area by 2030 reflect the large predicted population expansion in the LSP, with a projected 238,616 jobs available, a 98% increase from 2000 levels. As might be expected with land use changes related to population growth, total agricultural jobs in the plan area are expected to increase to 26,386 from the 21,479 available thirty years earlier. However, this represents a substantial percentage decrease from 17.7% of all jobs being from the agriculture sector in 2000 to 11.1% in 2030.

Hunting and fishing are an important part of Colorado's tourism economy and this is true within the the Lower South Platte basin as well. According to a report from BBC Consulting (2008) for the Colorado Division of Wildlife, estimated direct expenditures for fishing and hunting in the five counties in the plan area during 2007 totaled $36.1 million, while the total economic impact of these activities within the plan counties was more than $61.8 million. An estimated 583 jobs were directly attributed to this revenue.

The greatest percentage of job growth in the LSP in the future is expected in providing regional and national services and supporting tourism in the area. In 2000, 14,666 jobs in the Lower South Platte Watershed were regional and national service jobs and tourism accounted for 3445 jobs. In 2030, it is forecast there will be 92.6% more jobs in regional/national services and 94.5% of additional jobs in tourism.

From 1999 to 2008, median household income in the LSP's counties increased by a higher percentage than Colorado's 21.2% in four of the five counties in the area (Table 4.13.2).

Table 4.13.2. Changes in Median Household Incomes in the Lower South Platte – 1999 to 2008

	1999	2008	% Change
Colorado	$47,203	$57,184	21.2
Logan	$32,724	$42,163	28.8
Morgan	$34,568	$43,246	25.1
Sedgwick	$28,278	$35,350	25.0
Washington	$32,431	$38,982	20.2
Weld	$42,321	$55,845	32.0

Source: U.S. Census Bureau

Population increases, job growth and the potential for household incomes to increase in counties with relatively lower costs of living will have significant impact on land use, demand for water, and other factors affecting water quality in the basin.

5.0 Point source and nonpoint sources of pollution

5.1 Point sources

Point source water pollution is contamination that directly enters state waters through a discrete, discernible source such as a pipe, ditch, tunnel, channel, or conduit, and includes application of certain wastewaters to land. A point source does not include irrigation return flow (CWQCA, 2010). Point source water pollution is regulated by the Colorado Water Quality Control Act (CWQCA,

2010) and its implementing regulations, the Colorado Discharge Permit System Regulations (CDPS Regulations, 2010). Section 25-8-501 of the CWQCA specifies that, "No person shall discharge any pollutant into any state water from a point source without first having obtained a permit from the [Colorado Department of Public Health and Environment- Water Quality Control Division for such a discharge…"

Point sources of water pollution in the LSPW include land to which biosolids and wastewaters are applied, discharges from wastewater treatment plants and industrial plants, from Concentrated Animal Feeding Operations (CAFOs), and for certain stormwater discharges.

Table 5.1 Weld County

Facility Name	Permit No.	Receiving Waters
Evans	CO-0020508	South Platte River
Evans – Hill-N-Park	CO-0047287	Unnamed ditch tributary to South Platte River
Platteville	CO-0040355	South Platte River
Gilcrest	CO-0041653	South Platte River
Pierce	COX-631000	Infiltration beds
Weld Co.School Dist. RE-3J	COG-589000	Lowline Canal Ditch
Hemingway Lodge at Eagles Nest	COX-621050	Soil absorption field
Galeton	CO-0043320	Willow Creek, tributary to Lone Tree Ck. & So. Platte
Boulder Valley Poultry	COG-600000	South Platte River
Swift Beef-Lone Tree	CO-0027707	Lone Tree Creek

5.1.1 Wastewater treatment plants and industrial facilities.

Water discharge permits that have been issued to wastewater treatment plants and industrial facilities located within the LSPW are shown in Table 5.1. The waters that receive discharges also are identified in the table. Permits also have been issued for on-site biosolids processing and for applications of treatment plant products to land. The latter activity receives ground water protection permits. These permits are not listed in Table 5.1. Other point source dischargers exist upstream from the boundaries of the LSPW and in the watersheds located in the LSPW, except the Pawnee Watershed. Discharges from these additional sources likely have an effect on the water quality within the LSPW.

Water discharge permits either have limits on the concentration of pollutants that can enter receiving waters, or restrictions within which the discharger must operate. Limits on the concentration of pollutants are designed to protect the standards and use classifications set for the receiving waters.

Table 5.1 Discharge permits and receiving waters for wastewater treatment plants and industries located in the LSPW.

Facility Name	Permit No.	Receiving Waters
Logan County		
• Crook	COG-589015	Unnamed drainage ditch
• Crook	COG-603116	Settler's Ditch
• Sterling WWTP	CO-0026247	S. Platte tributary
• Sterling Ethanol	CO-0047066	S. Platte tributary
Morgan County		
• Brush WWTF	COG-073592	S. Platte River
• Fort Morgan Beef Plant	CO-0044270	S. Platte River
• Fort Morgan Cheese Facility	CO-0043958	S. Platte River
• Fort Morgan WWTF	CO-0044849	S. Platte River
• Fort Morgan Factory	CO-0041351	S. Platte tributary
• Hillrose	COG-589030	Beaver Creek tributary
• Morgan Heights Water & San	COG-588040	S. Platte River
• Snyder San. District	COG-588016	S. Platte tributary
Sedgwick County		
• Julesburg	CO-0021113	S. Platte River
• Ovid	COG-588106	S. Platte- unnamed tributary
Washington County		
• Woodlin School Dist.	CO-0047970	Vega Creek
Weld County		
• Cheyenne Plains Amine Plant	COG-600617	Lone Tree Creek
• Evans WWTF	CO-0020508	S. Platte River
• Hudson	COG-589013	Beebe Seep Canal
• Hudson	COG-589104	Box Elder Creek
• Keenesburg POTW	CO-0041254	Sloan Reservoir

• Kersey	CO-0021954	S. Platte tributary- unnamed ditch
• LaSalle	COG-588058	S. Platte River
• Schulte Investments, Inc.	COG-605002	S. Platte River
• USAF F.E. Warren AFB	CO-0034789	Pawnee watershed

5.1.2 CAFOs

A Concentrated Animal Feeding Operation (CAFO) is an animal feeding operation that confines 1,000 cattle or an equivalent number of other livestock. Equivalent numbers of some other livestock are: sheep, 10,000; mature dairy cattle, 700; swine weighing 55 pounds or more, 2,500; turkeys, 55,000; and, laying hens with a dry manure system, 82,000. Feedlots, dairies, and swine and poultry barns that hold above the threshold number of livestock are CAFOs.

An animal feeding operation is a facility or lot where the following conditions are met:

- Animals have been or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12 month period; and,
- Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

CAFOs are defined as point sources of pollution in the Colorado Water Quality Control Act (CWQCA, 2010). As such they must either hold a discharge permit in accordance with section 61.17 of Regulation No. 61 (CDPS, 2010), or register with the Colorado Department of Public Health and Environment- Environmental Agriculture Program (EAP), in accordance with section 81.5 of Regulation No. 81 (CWQCC, 2009). Any CAFO must have a permit prior to discharging pollutants to waters of the U.S. The South Platte River is a waterway that is waters of the U.S.

Seventy-five CAFOs are located in the portions of the five counties that are within the LSPW, according to a facility spreadsheet received from the EAP on February 4, 2011. The number of CAFOs in each county that are either registered or hold coverage under general permit COA-931000 are shown in Table 5.1.2.

Table 5.1.2 Number of either permitted or registered CAFOs located in the portions of the five counties that are within the LSPW.

CAFO Type	Logan Co.	Morgan Co.	Sedgwick Co.	Washington Co.	Weld Co.
Permitted	10	15	1	0	9
Registered	8	6	1	0	25
Total = 75					

Both permitted and registered CAFOs have surface water protection requirements. For example, they can only discharge pollutants to lakes or waterways as the result of receiving in excess of a 25-year, 24-hour storm, and manure and wastewater has to be applied at an agronomic rate. CAFOs

also have groundwater protection requirements in section 81.8 of Regulation No. 81. For example, a wastewater pond cannot seep more than 1 x 10^{-6} cm/sec.

5.1.3 Biosolids

Biosolids, previously known as sewage sludge, are the treated residual product from domestic wastewater treatment plants. Biosolids contain a number of organic and inorganic pollutants, many of which have undergone extensive studies by the U.S. Environmental Protection Agency for possible long-term effects from land application of biosolids. This risk assessment resulted in the establishment of concentration limits for a number of the pollutants (EPA, 2010). The National Academy of Sciences has reviewed current practices, public health concerns, and regulatory standards, and has concluded that the use of biosolids on crops presents a negligible risk to the consumer, crop production, and the environment (EPA, 2009).

The beneficial use of biosolids is regulated as a point source under the "Biosolids Regulation" (Regulation No. 64, 5 CCR 1002-64) of the Colorado Water Quality Control Commission (CWQCC, 2010). The purposes of the regulation are to protect public health and prevent the discharge of pollutants into state waters as the result of land application of biosolids. The Biosolids Regulation requires that a Notice of Authorization (NOA, or discharge permit, be issued by the Colorado Department of Public Health and Environment's Water Quality Control Division (WQCD) prior to biosolids being beneficially used. Beneficial use means the use of the nutrients and/or organic matter in biosolids as a soil conditioner (reclamation of disturbed land) or fertilizer for the promotion of plant growth. Plant nutrients in biosolids include nitrogen, phosphorus, potassium, calcium, copper, iron, magnesium, manganese, sulfur, and zinc (EPA, 2010).

Biosolids must be beneficially used in accordance with a Biosolids Management Plan (BP). A BP describes, among other things, how biosolids will be land applied in accordance with Federal, State, and local regulations. Regulations address, among other elements, heavy metals loading limits, the quality of biosolids that must be used, agronomic rate, minimum soil and ground water depths, and application restrictions, such as to slopes and to nearby state waters. In addition, the Biosolids Regulation specifies that biosolids cannot be applied where it is likely that threatened/endangered species or their critical habitats will be adversely affected.

NOAs have been issued for application of biosolids to 281 locations in the portions of the five counties that are within the LSPW, according to a spreadsheet received from the WQCD on January 25, 2011. The number of permitted application sites per county are shown in Table 5.1.3. NOAs for biosolids composting sites are not included in the table. The WQCD data do not show whether an NOA is for application to crops or to disturbed land, nor does the data show whether biosolids have been applied to a site.

Table 5.1.3 Number of Notices of Authorizations issued for land application of biosolids in the portions of the five counties that are within the LSPW.

Logan Co.	Morgan Co.	Sedgwick Co.	Washington Co.	Weld Co.
15	38	2	4	222

5.1.4 Stormwater discharges

Stormwater runoff can carry pollutants into surface waters and impact water quality in the Lower South Platte Watershed. Such runoff results from precipitation and snowmelt flowing over land and impervious surfaces and not infiltrating into the soil. This runoff water can accumulate pollutants such as debris, chemicals, and sediment.

Stormwater runoff from certain municipal and industrial sources are considered point sources of pollution and require a stormwater discharge permit issued by the Colorado Department of Public Health and Environment- Water Quality Control Division (CDPS regulations, 2010) [see section 61.3(2) of the Colorado Discharge Permit System Regulations of the Colorado Water Quality Control Commission (Regulation No. 61, 5 CCR 1008-61)]. A stormwater discharge permit requires certain practices to be used for the purpose of reducing contamination of stormwater runoff and eliminating illicit discharges.

Certain industrial sites require a permit for stormwater runoff from the sites. Examples of such areas include industrial plant yards, material handling sites, refuse sites, shipping and receiving areas, manufacturing buildings, tank farms, recycling facilities (including salvage and junk yards), airports, power plants, and sand and gravel pits. For these sites, the Water Quality Control Division issues certifications of coverage under one of the following three discharge permits: "Stormwater Discharges Associated with Light Industry" (COR-010000), "Stormwater Discharges Associated with Heavy Industry" (COR-020000), or "Sand and Gravel Mining and Processing" (COR-340000).

Stormwater discharges from municipal separate storm sewer systems (MS4s) require a MS4 discharge permit. A MS4 is used to collect or convey stormwater (including storm drains, pipes, and ditches), and from which stormwater is discharged into surface water. A MS4 is owned by a state, city, town, village, or other public entity.

Table 5.1.4 shows the number of certifications of coverage under a stormwater permit that have been issued to industrial sites located in the portions of the five counties that are within the LSPW, according to data retrieved from the CDPHE-WQCD on February 23, 2011 (Industrial Certs, 2011). No MS4 permit has been issued to a municipality located in the LSPW (MS4, 2008).

In Logan County, coverage under the light or heavy industrial permits has been issued to facilities in Sterling. Coverage under the sand and gravel permit has been issued for eight locations in Sterling, two locations near Peetz, and three locations in unincorporated Logan County.

In Morgan County, coverage under the light or heavy industrial permits has been issued to four facilities in Brush and seven facilities in Fort Morgan. Coverage under the sand and gravel permit has been issued for one location in Fort Morgan, and five sites in unincorporated Morgan County.

In Weld County, coverage under the light or heavy industrial permits has been issued to one facility in Gilcrest, two facilities in Hudson, one facility in LaSalle, two facilities in Keenesburg, and one facility in Roggen. Coverage under the sand and gravel permit has been issued for three locations each in Carr and Keenesburg, and one location in each of the following towns: Keota, Galeton, Hereford, Kersey, New Raymer, and Pierce. Coverage under the recycling permit has been issued to two sites in Hudson.

Table 5.1.4 Number of certifications of coverage under stormwater permits issued to industrial sites located in the portions of the five counties that are within the LSPW.

Industrial Permit	Logan Co.	Morgan Co.	Sedgwick Co.	Washington Co.	Weld Co.
Light Industry	6	8	---	---	4
Heavy Industry	1	3	---	---	3
Sand & Gravel	13	6	---	---	9

Recycling	0	0	0	0	2

Stormwater runoff from certain small construction sites also are considered point sources of pollution and requires a stormwater discharge permit. Small construction activity includes clearing, grading, and excavating that result in land disturbance of equal to or greater than one acre and less than five acres. Construction activities associated with oil and gas exploration, production, processing or treatment operations or transmission facilities are included in this permit coverage requirement. Under the "Stormwater Construction Activities" permit (COR-030000), activities must be in accordance with a Stormwater Management Plan that identifies best management practices that will reduce or eliminate any possible water quality impacts.

5.2 Nonpoint sources of pollution

Nonpoint sources of water pollution can occur from many diffuse sources such as atmospheric deposition and land runoff from precipitation (rain or melting snow). As runoff moves, it picks up both natural pollutants and pollutants from human activities and transports them into water bodies. Since point sources of pollution are generally controlled under discharge permits, nonpoint sources of pollution can be a significant source of pollution of water bodies. Polluted runoff can cause damage to wildlife and their habitat, drinking water supplies, water quality (e.g., sedimentation and excessive algae and weed growth), and recreational opportunities.

According to the U.S. Environmental Protection Agency, nonpoint source pollution can include:

- Excess fertilizers (including manure) and pesticides from agricultural and residential lands
- Oil, grease, and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks
- Salt from irrigation practices
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems
- Atmospheric deposition and hydromodification

All of the above bulleted items, except forest lands, can be sources of nonpoint source pollution of water bodies in the LSPW. An additional potential source of nonpoint pollution is excessive seepage and runoff from furrow and flood irrigation systems. Excessive seepage through the soil can carry fertilizers and pesticides and can dissolve elements in the native geology, and be carried through shallow ground water tables to surface water bodies.

6.0 Watershed Partnerships

The Colorado State Conservation Board (CSCB) initiated this plan and the process to develop it. A wide array of participants were involved from throughout the planning area to provide input on water quality issues impacting all segments of the watershed planning area including agricultural crop and livestock production, domestic use, natural resource management, land use changes, mining and energy development, ground water uses, and water management entities.

As a project to be coordinated and led collaboratively by community stakeholders, a variety of citizen representatives from industry, landowners, municipalities, government, business, recreation, and agriculture reviewed the planning area and the perceived factors affecting water quality in the Lower South Platte Watershed. Additional individuals, organizations and businesses

with an interest in maintaining or improving water quality were encouraged throughout the input process to become involved in implementing the plan.

Due to a number of powerful influences, including the decrease in available water for agricultural production through water transfers and permanent irrigation well shutdowns, meeting South Platte River Compact compliance and the water and flow requirements of the Platte River Recovery Implementation Plan, as well as increased demand for domestic water use in the entire river basin, stakeholder public input for this watershed plan was overwhelmingly concerned with water quantity rather than water quality in the Lower South Platte Basin. Individuals, agencies and organizations that recognize the importance of identifying water quality problems and applying appropriate practices and educational programs to reduce or eliminate the quality problems were particularly valued in developing the plan.

Supervision of plan development was provided by the Colorado State Conservation Board. The process was communicated to and discussed with citizens in the plan area through stakeholder meetings, a dedicated website, webcast, conservation organization meetings, electronic communication, direct mailings, and watershed forums and meetings.

6.1 Watershed Partners

There are a number of entities interested in water quality problems in the Lower South Platte Watershed. These private, local, county, state, and federal organizations work to identify, provide education about, as well as develop and implement practices to deal with water quality concerns in the basin. A partial list of the partners working to identify, quantify and mitigate these concerns includes:

- USDA-Natural Resources Conservation Service
- Northeast Colorado Health Department
- Agricultural Chemicals and Groundwater Protection Program
- Colorado State University Extension
- Colorado Corn Growers Association
- Colorado Corn Administrative Committee
- Colorado Division of Parks and Wildlife
- United States Geological Survey
- Colorado Department of Public Health and Environment
- North Front Range Water Quality Planning Association
- Morgan County Quality Water
- Conservation Districts in the LSP
- Lower South Platte Water Conservancy District
- Northern Colorado Water Conservancy District
- South Platte Roundtable
- Central Colorado Water Conservancy District
- Counties in the LSP
- United States Forest Service
- Colorado Livestock Association

6.2 Categories of Stakeholders

Stakeholders include water conservancy districts, conservation organizations, local, county, state, regional, and federal governments, agricultural producers and organizations, business owners, landowners, elected and appointed decision-makers, water experts, water suppliers, recreational

consumers, wastewater managers, and the general public. Stakeholders providing input to the plan process are recorded in Appendix B.

6.3 Public Information, Education and Outreach Activities

Making the Lower South Platte Watershed Plan a broad-based effort, with input from throughout the planning area, was a priority of the Core Committee that provided advice and direction throughout development of the plan. A variety of methods were incorporated by the plan coordinator and the Core Committee to educate the public about the planning process, the importance of protecting and enhancing water quality, and advertising public meetings to gather input from the watershed's stakeholders. These methods included news releases, informational brochures, static displays, public input meetings, focus group meetings, dedicated website, public meeting webcast, and presentations to stakeholder groups in the basin and interested groups in tributary areas surrounding the LSP.
Outreach activities for the Lower South Platte Watershed plan are listed below.

- July 8, 2009
  - Stakeholders Input Meeting, Fort Morgan.
- August 17, 2009
  - Focus Group Input Meeting, Municipalities Meeting, Northeast Colorado Health Department, Akron.
- August 2009
  - LSP Website (www.lspwp.com) launched. Sponsored and maintained by West Greeley Conservation District.
  - Display on planning process, Haxtun Conservation District Annual Meeting, Haxtun.
  - Display and presentation, Republican River Watershed Association Meeting, Burlington
- September 16, 2009
  - Stakeholders Input Meeting, Sterling.
  - Simultaneous webcast of Sterling Stakeholders Input Meeting, Brian Allmer Radio Network.
- September 2009
  - Display and presentation on planning process, Lower South Platte Watershed Association Meeting, Sterling.
  - Display and presentation on planning process, Upper South Platte Watershed Association Meeting, Agate.
- October 14, 2009
  - Focus Group Input Meeting, South Platte Focus Area Committee, Brush.
- October 21-22, 2009
  - Display on LSP Plan process, 20th Annual South Platte Forum, Longmont.
- November 16-18, 2009
  - Display on LSP Plan process, Colorado Association of Conservation Districts Annual Meeting, Breckenridge.
- December 10, 2009
  - Presentation and Focus Group Input Meeting, North Front Range Water Quality Planning Association, Longmont.
- January 4, 2010
  - Plan Input Meeting, Weld County Commissioners and Appointed Officials, Greeley.
- January 27, 2010

- Stakeholders Input Meeting, Colorado Farm Show, Greeley.

- February 5, 2010
  - Focus Group Input, Northeast Colorado County Commissioners and Appointed Officials, Sterling.

- June 2010
  - Water Quality Input Survey sent to more than 9000 landowners in the West Greeley Conservation District newsletter for additional prioritization of water quality issues provided by stakeholders during the planning process.

6.4 Watershed Organization Structure

CSCB coordinated the planning process and facilitated the development of the plan with the advice and commitment of a dedicated Core Committee consisting of the following organizations and agencies:

12. Audubon Colorado
13. Central Colorado Water Conservancy Dist.
14. Colorado Cattlemen's Assn.
15. Colorado Corn
16. Colorado Dept. of Agriculture
17. Colorado Division of Wildlife
18. Colorado Livestock Association
19. Colorado State University
20. Colorado State University Extension
21. Lower South Platte Watershed Assn.
22. Lower So. Platte Water Conservancy Dist.
23. Natural Resources Conservation Service
24. No. Front Range Water Quality Planning Assn.
25. Northeast Colorado Health Dept.
26. Northern Colorado Water Conservancy Dist.
27. Sedgwick County Conservation Dist.
28. West Greeley Conservation Dist.

These entities bring their own concerns and strong involvement in LSP water issues as well as committed partnerships with other groups that will focus expertise on the water quality priorities identified in the plan.

As a plan initiated and completed on the principle of citizen-based leadership and action to drive projects in the watershed, agencies, groups and coalitions of groups will provide leadership for priority projects recognized as important to protecting or improving water quality, as well as educating citizens in sub-watersheds or throughout the LSP about current or emerging water quality issues, depending on their management focus.

CSCB and other Core Committee member organizations of the planning process will facilitate regular reviews of the Lower South Platte Watershed Plan within the plan area every two years. Accomplishments in working towards or meeting plan priorities will be assessed and reported,

while newly identified water quality problems can be added to the plan through the Adaptive Watershed Management Strategy in Section 14.

6.5 Integration of this Plan with Other Watershed Plans and Programs in the Watershed

Development of the Lower South Platte Watershed plan was accomplished with the input and commitment of various organizations, groups and an array of local, state and federal agencies. These units brought knowledge of and involvement in other watershed plans and practices being implemented to deal with water quality problems around the basin. Where appropriate, the practices and programs incorporated to improve water quality in the LSP will balance or enhance the established efforts in the watershed. Monitoring will supplement the efforts of the USGS and Agricultural Chemicals and Groundwater Protection Program, while education outreach will add to what is currently being accomplished by conservation districts, NRCS, Colorado State University Extension, and water conservancy districts.

7.0 Watershed Vision

Vision for the Lower South Platte Watershed

Through the dynamic application of innovative practices, citizen-based water monitoring, and the delivery of broad-based water quality education by committed organizations, agencies and individuals, the quality of water in the watershed will be enhanced and protected for the benefit and enjoyment of future generations.

7.1 Watershed Goals and Objectives

Defined goals and objectives have been outlined that will provide direction in addressing the water quality concerns in the Lower South Platte Watershed. These benchmarks will help move the basin's stakeholders forward in fulfilling the vision of the LSP Watershed Plan. (Table 7.1)

Table 7.1 Lower South Platte Watershed Management Goals and Objectives

Goals	Develop awareness and knowledge among citizens throughout the watershed about current and emerging water quality issues.
	Increase the data available from throughout the watershed to guide and support decisions about projects and practices implemented to improve water quality and monitor their effectiveness.
	Improve water quality by implementing best management practices and innovative processes.
Objectives	Educate citizens through coordinated information campaigns.
	Conduct watershed tours focused on methods of water quality enhancement.
	Disseminate information about programs and plan progress through the LSP website.
	Use static and manned displays at community events to make citizens aware of water quality problems and processes to improve watershed resources.
	Initiate coordinated monitoring of water sources in LSP by schools and citizen groups.
	Share collected data from monitoring activities through the Colorado Data Sharing Network.
	Communicate collated data with decision makers in the LSP and the entire South Platte Basin.
	Implement BMPs in source locations to provide the best opportunity for improving water quality.
	Facilitate financial and programmatic incentives through the Conservation organizations for landowners implementing BMPs.

8.0 Impaired Waters and Other Water Quality Concerns

8.1 Water Segments and Use Classifications

Regulation No. 38 (5 CCR 1002-38) of the Colorado Water Quality Control Commission holds the classification and numeric standards for the South Platte River Basin. Two sub-basins pertain to water bodies located within the LSPW: Middle South Platte River and Lower South Platte River. Table 8.1 shows the stream segment descriptions and associated use classifications for water bodies in each sub-basin.

Figure 8.1 Impaired Segments within the LSPW.

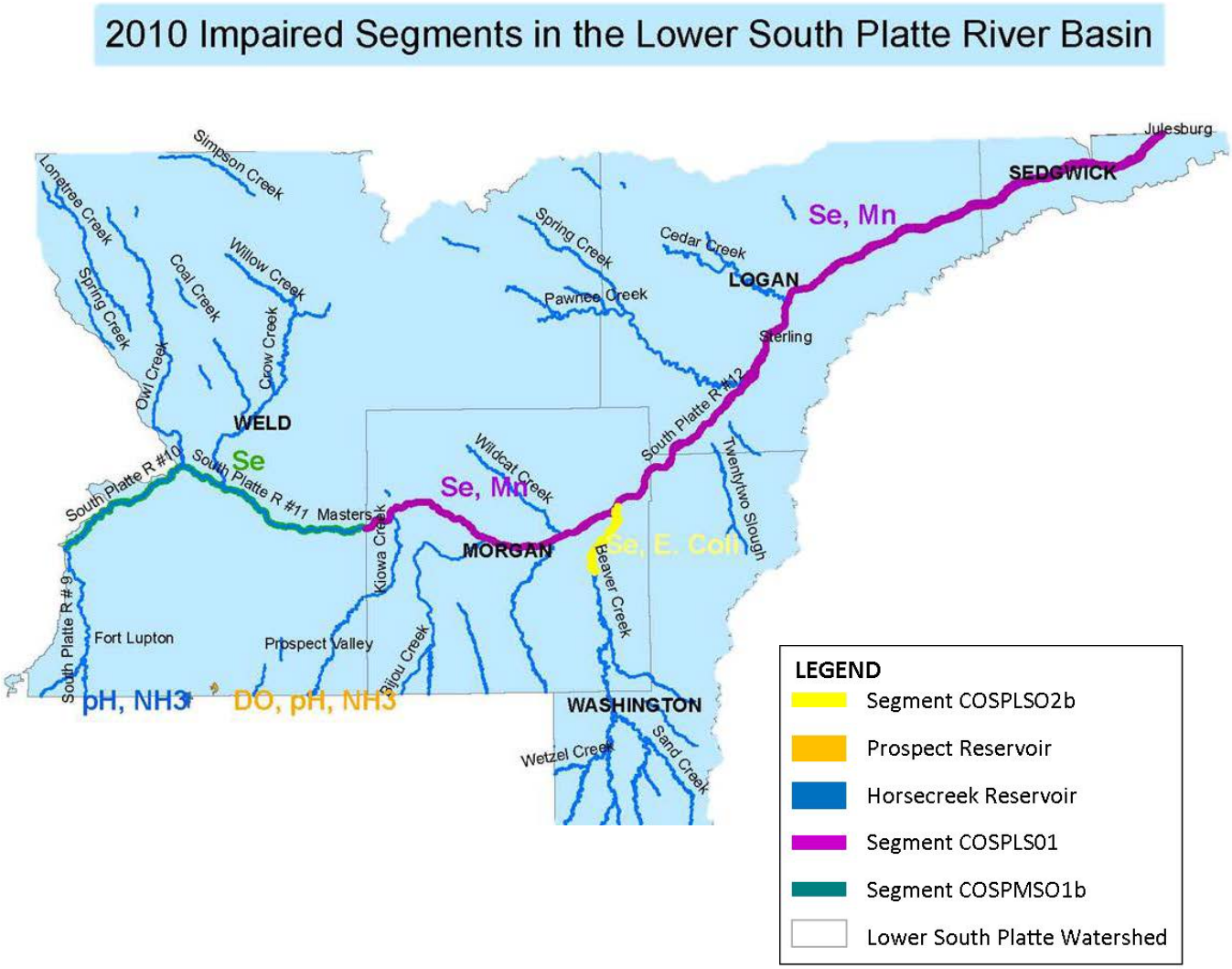


Table 8.1 Stream segment descriptions and associated use classifications for the LSPW.

Stream Segment No.	Stream Segment Description	Use Classifications
Middle So. Platte sub-basin		
1b	Mainstem of the South Platte River from a point immediately below the confluence with St. Vrain Creek to the Weld/Morgan County line	Aquatic Life Warm 2 Recreation E Water Supply Agriculture
5a	Mainstem of Lone Tree Creek from the source to the confluence with the South Platte River	Aquatic Life Warm 2 Recreation N Agriculture
5c	Mainstems of Crow Creek and Box Elder Creek from their sources to their confluence with South Platte River	Aquatic Life Warm 2 Recreation N Agriculture
7	All lakes and reservoirs tributary to the South Platte River from a point immediately below the confluence to the Weld/Morgan County line	Aquatic Life Warm 2 Recreation E Water Supply Agriculture
Lower S. Platte sub-basin		
1	Mainstem of the South Platte River from the Weld/Morgan line to the Colorado/Nebraska border	Aquatic Life Warm 2 Recreation E Water Supply Agriculture
2a	All tributaries to the South Platte River, including all wetlands, from the Weld/Morgan County line to the Colorado/Nebraska border, except for the listings in Segment 2b	Aquatic Warm Life 2 Recreation N Agriculture
2b	All tributaries to the South Platte River, including all wetlands, north of the South Platte River…, and the mainstems of Beaver Creek, Bijou Creek, and Kiowa Creek from their sources to the confluence with the South Platte River, except for the portion of Beaver Creek from its source to the Fort Morgan Canal	Aquatic Life Warm 2 Recreation E Agriculture
3	Jackson Reservoir, Prewitt Reservoir, North Sterling Reservoir, Jumbo (Julesburg) Reservoir, Riverside Reservoir, and Vancil Reservoir	Aquatic Life Warm 1 Recreation E Agriculture
4	All lakes and reservoirs tributary to the South Platte River from the Weld/Morgan County line to the Colorado/Nebraska border, except those listed in Segments 3 and 5	Aquatic Life Warm 2 Recreation U Water Supply Agriculture
5	All lakes and reservoirs tributary to the South Platte River north of the South Platte River…, and the mainstem of Beaver Creek [from its source to the Fort Morgan Canal]	Aquatic Life Warm 2 Recreation E Water Supply Agriculture

The **Class 1 Warm Water Aquatic Life** use classification refers to waters that (1) currently are capable of sustaining a wide variety of warm water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. Waters are considered capable of sustaining such biota where physical habitat, water flows or levels, and water quality conditions result in no substantial impairment of the abundance and diversity of species.

The **Class 2 Warm Water Aquatic Life** use classification refers to waters that are not capable of sustaining a wide variety of warm water organisms, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.

The above table shows three classes of **recreation use**: Classes E, N, and U. Class E waters have the highest water quality standards because they are used for primary contact recreation. Class N waters are "not primary contact use" waters, as they are not suitable or intended to become suitable for primary contact recreation uses. Class U waters are "undetermined use" waters for which, under Regulation No. 31 of the Water Quality Control Commission, are to be protected at the same quality level as Class E (primary contact) waters.

Water Supply waters are waters that are suitable or intended to become suitable for potable water supplies.

The **Agriculture** use classification refers to waters suitable or intended to become suitable for irrigation of crops and which are not harmful to livestock.

8.2 Impaired water segments[(303(d)-listed]

Section 303(d) of the federal Clean Water Act requires states to produce a list of water bodies that do not meet the water quality standards for the water's classified uses. In Colorado, this "303(d)" list is produced biennially as Regulation No. 93 of the Water Quality Control Commission (WQCC). The current Regulation No. 93 was adopted by the WQCC in 2010.

Table 8.2 shows the impaired water bodies that exist within the LSPW, according to Regulation No. 93, together with the specific impaired water body, where applicable. Also shown is information about the impairment, including parameters and the Total Maximum Daily Load priority ranking.

For the two impaired lakes/reservoirs, parameter values are provided for both the epilimnion and metalimnion layers/profiles of the waters. Starting in the spring, lakes/reservoirs become thermal stratified into three layers, governed by water temperature and, thereby, water density. The top layer is the epilimnion, which is the warm layer that is well mixed due to wind action over the water. The second layer is the metalimnion or thermocline region, which rapidly changes temperature with depth. Water quality standards exist for both profiles.

Water bodies that are identified as impaired must be prioritized (as high, medium, or low) by the WQCC for identifying the cause(s) of the impairment and establishing TMDLs of pollutants that both point and nonpoint sources of pollution can release into the impaired waters. A TMDL is for the purpose of having a water body meeting its intended use(s) and must be written within 13 years of an impairment being identified on a 303(d) list (per EPA and Colorado guidance). As part of a TMDL being developed, the Colorado Department of Public Health and Environment- Water Quality Control Division (and other entities, where possible) expand the level of sampling intensity (number of sampling locations and increased frequency of sampling) for the purpose of assisting in identifying point and nonpoint sources of pollution that are causing the impairment(s).

Table 8.2 Impaired water bodies in the LSPW as shown in the Colorado 303(d) list of 2010.

Impaired Segment No. and Specific Water Body	Parameter Causing Impairment	Use Impaired	Concentration Standard	Parameter Concentration	Sampling Period	No. of Samples	No. of Sampling Locations	TMDL Priority	Year First Listed on 303(d) List
Middle So. Platte									
1b- all So. Platte	Selenium	Aquatic Life (chronic)	4.6 ug/l (dissolved)	6.9 ug/l	Oct 2003 – June 2009	78	6	L	2010
7- Horse Creek Reservoir	pH Ammonia	Aquatic Life Aquatic Life (chronic)	9.0 0.19-1.68 mg/l 0.38-0.70 mg/l	Epilim- 9.15 Hypolim- 9.12 Epilim- 0.30-2.47 Hypolim- 0.60-1.01	Jan 2004 – Dec 2008	30 20 23 21	56 profiles	L	2008
7- Prospect Lake	Dissolved oxygen pH Ammonia	Aquatic Life Aquatic Life Aquatic Life (chronic)	5.0 mg/l (min) 9.0 0.19-0.63 mg/l	Below standard in both layers Epilim- 9.36 Hypolim- 9.34 Epilim- 0.60-0.70 Hypolim- NH3 ok	Jan 2004 – Aug 2008	???? 42 15 14 13	48 profiles	M	2010
Lower So. Platte									
1- all S. Platte	Selenium Manganese	Aquatic Life (chronic) Water Supply (chronic)	4.6 ug/l (dissolved) 50 ug/l	12.4 ug/l 83.2 ug/l (adj. for 400 mg/l CaCO3)	Oct 2003 – June 2008	124 124	6	M	2010
2b- Beaver Cr between Ft. Morgan Canal and So. Platte	Selenium *E. coli*	Aquatic Life (chronic) Recreation E	4.6 ug/l (dissolved) 126/100 ml	7.0 ug/l 426/100 ml	Dec 1997 – August 2003	28 13	1	H	2004

8.3 Potentially Impaired Waters

8.3.1 Segments Required to be Monitored and Evaluated

Regulation No. 93 of the WQCC identifies, in addition to impaired waters, waters that must be monitored and evaluated because evidence exists to suspect water quality problems, but does not justify placing the waters on the 303(d) list for certain parameters. Additional data needs to be collected to determine whether a 303(d) listing is justified.

Table 8.3.1 shows the water bodies that Regulation No. 93 requires must be monitored and evaluated for the parameter(s) or use(s) identified.

Table 8.3.1 Water bodies that must be monitored and evaluated according to Regulation No. 93.

Impaired Segment No. and Specific Water Body	Parameter(s) or Use to be Monitored/Evaluated
Middle So. Platte	
7- Horse Cr. Reservoir	Dissolved oxygen (D.O.)
Lower So. Platte	
1- all of So. Platte River in segment	Aquatic Life Use
3- North Sterling Reservoir	Dissolved oxygen
3- North Sterling, Jackson, and Jumbo Reservoirs	Selenium pH

8.3.2 Eutrophic reservoirs

Section 314(a)(2) of the Clean Water Act requires states to report the status of lake quality. Colorado monitored 50 lakes and reservoirs from 2007 to 2009, and evaluated them for trophic status. Trophic status is a measure of the level of biological productivity (especially of algae) and nutrient status. Commonly used indicators of nutrient status and productivity include the amount of algae as measured by chlorophyll-*a*, water transparency as measured by the observable depth of a Secchi disc, and in-lake epilimnetic total phosphorus concentration.

According to Art (1993), eutrophication is the process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These nutrients typically promote excessive algae growth. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other biota, such as fish.

According to WQCD (2010) in its 305(b) report, trophic status is an index of water quality only to the extent that trophic condition limits the desired use of a lake (e.g., recreation). Generally, the effects of lake eutrophication are considered to be negative, especially if the eutrophication is accelerated by human activities.

Trophic states can be categorized as follows:

- Oligotrophic: lakes with few available nutrients and a low level of biological productivity; often supports cold water fish.
- Mesotrophic: lakes with moderate nutrient levels and biological productivity between oligotrophic and eutrophic; usually supports warmwater fish.
- Eutrophic: lakes with high nutrient levels and high level of productivity; typically supports exclusively warmwater fish.
- Hypereutrophic: lakes in an advanced eutrophic state.

In WQCD (2010), the Trophic State Index (TSI) equations developed by Carlson (1977) were used to estimate trophic status. Data for the epilimnion (upper most thermal layer) collected during the summer was used to calculate the mean chlorophyll-*a* concentration for each lake.

Of the 50 lakes sampled from 2007 to 2009, four were located within the LSPW. The trophic status of these lakes is presented in Table 8.3.2. The three reservoirs with eutrophic or hypertrophic status are potentially impaired as the result of nitrogen and phosphorus loading. The Water Quality Control Division will next sample lakes in the South Platte basin in 2013.

Table 8.3.2 Trophic status of four lakes in the LSPW.

Lake	Chorophyll *a* (ug/l)	Cholorophyll TSI[1]	Est. Trophic Status
Jackson Reservoir	26.67	63	Eutrophic
Jumbo Reservoir	3.66	43	Mesotrophic
N. Sterling Reservoir[2]	77.80	73	Hypertrophic
Prewitt Reservoir	14.50	57	Eutrophic

[1] TSI = Trophic State Index

[2] North Sterling Reservoir must be monitored for D.O. under Regulation No. 93

8.3.3 Nutrients in South Platte River

Nitrogen (N) and phosphorus (P) are two nutrients that are required by aquatic life, but in oversupply, are the primary causes of eutrophication and resulting algal blooms. P is the nutrient in short supply in most fresh waters, and even a modest increase in P can set off a whole chain of undesirable events in a stream. As a result of these concerns, the U.S. EPA developed the National Strategy for the Development of Regional Nutrient Criteria in June 1998. Under the strategy, the EPA expects states to set numeric levels for nutrients that will protect aquatic life, recreational, and other water uses. In 2007, the EPA wrote a memorandum encouraging all states to accelerate their efforts and give priority to adopting numeric nutrient standards.

The Colorado Department of Public Health and Environment- Water Quality Control Division have been working with stakeholders since about 2001 to develop nutrient standards for Colorado waters and point source dischargers. It is anticipated that a rulemaking hearing before the Colorado Water Quality Control Commission regarding the standards will take place in 2012. While the rulemaking hearing could be delayed, it is clear that nutrient standards for waters will be set in the near future. Therefore, this watershed plan considers whether nutrient levels in the South Platte River are a potential concern. As shown in Table 8.3.3, a concern does exist that the nutrient levels in the river will exceed state limits. Compared to the interim standard proposed by the Water Quality Control Division (as of April 2011), ambient N and P concentrations often exceeded the limits during recent years between Kersey and Julesburg. Dennehy et al. (1998) found that total N and total P concentrations decreased in a downstream direction from Kersey to Julesburg.

Table 8.3.3 Nutrient concentrations in the South Platte River at four sampling stations.

USGS Station	Year	Total N (mg/l)[1]	Total P (mg/l)[1]
(Potential limit)[2]		(2.0 mg/)l	(0.16 mg/l)
Kersey	2009-2010	2.2 – 12.0	0.49 – 1.16
	2005-2006	3.5 – 9.2	1.23 – 3.73
	2000	6.3 – 9.5	0.16 – 0.82
Weldona	2001-2003	4.3 -7.3	0.13 – 0.72
	1995-1996	4.9 -7.4	0.23 – 0.68
Cooper Bridge, near Balzac	1993	2.8 – 5.7	0.21 – 0.54
	1994	3.3 – 7.3	0.17 – 0.73
	1995	1.6 - 6.3	0.15 – 1.20
Julesburg	1990 -1991	1.2 – 5.8	0.01 – 0.70

[1] Unfiltered samples
[2] Proposed interim standards for warm water rivers, per Colorado Water Quality Control Division's draft revision of Regulation No. 31 ("The Basic Standards and Methodologies for Surface Water")

8.4 Excessive nitrate in South Platte alluvial aquifer

As discussed in the "Hydrology" section of this plan, the South Platte alluvial aquifer is an important part of the river's water supply, as it is hydrologically connected (tributary) to the river. The aquifer and river maintain a hydrologic balance.

The quality of the aquifer has been monitored since 1992 by the Colorado Groundwater Protection Program (CGPP) housed at the Colorado Department of Agriculture. Nitrate-nitrogen and pesticides have been the major focus of sampling. The goal of the CGPP is to reduce negative impacts to ground water and the environment by improving the management of agricultural chemicals and to assure that ground water remains safe for domestic and livestock consumption by preventing contamination.

According to Hall (1998), the majority of the alluvial aquifer within the LSPW has a medium sensitivity with regard to the ease with which pesticides can enter the aquifer from the overlying ground surface. Some areas of high sensitivity and low sensitivity also are present. The sensitivity ratings are based on the physical characteristics of the overlying ground and the potential recharge of the water table from precipitation and irrigation.

According to Ceplecha et al. (2004) and Rupert (2003), the majority of the alluvial aquifer within the LSPW has a medium or high vulnerability to nitrate contamination from surface activities above the water table.

Results from the 2008 sampling of the alluvial aquifer by the CGPP are provided in a Colorado Department of Public Health and Environment- Water Quality Control Division report (WQCD, 2010). In Weld County, ground water samples were taken from monitoring, irrigation, and domestic wells. With regard to nitrate-nitrogen, the ground water between Gilcrest and the Poudre River predominantly has concentrations of 20 to 40 ppm. These concentrations exceed the maximum contaminant level (MCL) for nitrate-nitrogen of 10 ppm set by the EPA under the Safe Drinking Water Act. The concentrations are comparable to previously sampled values.

Twenty monitoring wells tap the alluvial aquifer from the Weld/Morgan County line to the state line (Lower South Platte network). In 2008, the median nitrate-nitrogen concentration was 5.0, which represented a decrease from the median value of 9.3 in 2001. Five wells exceeded the MCL of 10 ppm; three of these wells are located north of Wiggins (median nitrate-nitrogen of 20.4 ppm).

8.5 Excessive salts in South Platte River and alluvial aquifer

As noted elsewhere in this Plan, irrigated agriculture is a major land use within the LSPW, in particular along the South Platte River. Irrigators draw water from both the alluvial aquifer and diversions from the river. The concentration of salts in these waters must be limited in order to protect the health of crops and the soils in which they grow. Regulation No. 93 does not have salinity standards for the South Platte watershed. Section 31.12 of Regulation No. 31 states that:

> *The Commission recognizes that excessive salinity and suspended solids levels can be detrimental to the water use classifications. The Commission has established salinity standards for the Colorado River Basin…, but has not established or assigned other standards for salinity or suspended solids control practices to be developed through… coordination with agricultural agencies, and further studies of existing water quality.*

For ground water, the Colorado Water Quality Control Commission's Regulation No. 41 ("The Basic Standards for Ground Water", 5 CCR 1002-41) specifies that ground water used for agricultural purposes have a Total Dissolvable Solid (TDS) concentration of less than 10,000 mg/l. A TDS of 10,000 mg/l equates to a specific conductance level of 12.5 dS/m.

The USGS found that salinity increased in both the river and alluvial aquifer downstream from LaSalle to Julesburg (Dennehy et al, 1998) during the period of 1992 to 1995. The specific conductance of the surface water increased over this flow distance from about 1.0 dS/m to over 2.0 dS/m; in the aquifer, the specific conductance increased from 1.7 dS/m to 3.0 dS/m. According to Colorado State University Fact Sheet no. 0.506, irrigation water that is of "permissible" quality to use has a conductivity range of 0.76 to 2.00 dS/m, and leaching of the salts is needed if this water is used. Irrigation water with a conductivity range of 2.01 to 3.00 dS/m is of "doubtful" quality for use on crops and soils. Based on these criteria, South Platte River surface water can be used with some proper management. However, use of the aquifer water will require special management to prevent damage to crops and soil.

Using data for water years 1991 to 2004, Haby (2011) also found that the salt concentration in the river increased in a downstream direction along the river. In addition, the data revealed that the largest contributors of salts to the river were the following three major tributaries to the river: St. Vrain Creek, Cache la Poudre River, and Big Thompson River. The source of salts in these tributaries is thought to be the Pierre Shale that the rivers flow through prior to emptying into the South Platte River. The author found a downward trend of salt loading from the Saint Vrain River and Big Thompson River, and evidence that loading from the Cache la Poudre River is decreasing.

As the South Platte River flows through the irrigated cropland area from Kersey to Julesburg, Haby (2011) found the salt load decreased slightly, which suggests that soils in the area are actually accumulating salts instead of contributing additional salts to the river. However, irrigation with saline water does result in the delivery of salts to the alluvial aquifer and, hence to the river, as the result of concentration of the salts through evaporation and percolation of the irrigation water (carrying salts) through the soil (containing salts) to ground water. Dennehy et al. (1998) noted that other research has shown that dissolved salts can take as long as 25 years to migrate from beneath crop fields to the river, via the alluvium. As a result, improvements in water quality via this transport path will depend on management of the nonpoint source, irrigation practices.

Evidence that the irrigated soils along the South Platte River are accumulating salts is provided by the investigations of Lord (1997), which revealed increased soil salinity problems in the basin. In Logan County, some fields can no longer grow dry beans, a crop very sensitive to salts, and some fields have had to be abandoned. Haby (2011) noted that the USDA- Natural Resources Conservation Service estimates that up to 25 percent of the irrigated land along the river is affected by salinity.

8.6 Degraded stream habitats and fish communities

The National Water Quality Assessment program focused on the South Platte River basin from 1992 to 1995 (Dennehy et al., 1998). Within the LSPW, the five sites listed below were assessed for stream habitat and fish community health. Additional locations may exist within the LSPW that have degraded stream habitat and/or fish communities.

- Confluence of St. Vrain Creek and South Platte River
- Confluence of Lone Tree Creek and South Platte River
- Mouth of Lone Tree Creek
- Confluence of Beaver Creek and South Platte River
- South Platte River at Colorado/Nebraska state line

Regarding stream habitat quality, the physical characteristics of stream channels (natural compared to modified) and of streambanks (vegetation cover, bank erosion) were assessed. The sites at the mouth of Lone Tree Creek and the confluence of Beaver Creek and the South Platte River were highly degraded.

Regarding fish community health, degraded communities are characterized by a large percentage of contaminant-tolerant species and a correlation with stream habitat degradation and high concentrations of chemicals in water, sediment, and fish. The sites at the confluences of the South Platte River and St. Vrain Creek, Lone Tree Creek, and Beaver Creek were highly degraded. The site at the South Platte River at the Colorado/Nebraska state line was moderately degraded.

The Colorado Division of Wildlife is anticipating the completion in mid-2011 of a South Platte Native Fish Conservation Plan that will focus on recovery of the threatened and endangered native fish populations in the river.

9.0 Contaminants, Sources, Data Gaps

This section discusses the contaminants of concern that exist in the waters of the LSPW. Except for Beaver Creek, the contaminants existing in the South Platte River and its alluvial aquifer were identified previously in Section 8. Also discussed in this section are the possible sources of the contaminants and data gaps that exist for identifying contaminant sources.

9.1 Ammonia

Ammonia is a 303(d)-listed contaminant for Horse Creek Reservoir and Prospect Reservoir. High ammonia levels impair the use of these water bodies for aquatic life use. The source(s) of this contaminant is not known. Wastewater treatment plants can be a source of ammonia. Monitoring of the inflow to the reservoirs and of upstream reaches is needed to identify the source(s).

9.2 Dissolved oxygen

Dissolved oxygen (D.O.) is a 303(d)-listed contaminant for Prospect Lake. High D.O. levels impair the lake for aquatic life use. The cause of this contamination is likely the loading of excess nitrogen and phosphorus into the lake. Monitoring of the lake strata, of inflow to the lake, and of upstream reaches is needed to confirm the cause of the high D.O.

9.3 Escherichia coli fecal bacteria

The fecal bacteria, *Escherichia coli*, is a 303(d)-listed contaminant for the ten-mile section of Beaver Creek located south of the Fort Morgan Canal [*E. coli* was not a focus of the Beaver Creek Watershed Plan]. High *E*. Coli levels impair the ten-mile section of the creek for recreation use. The potential sources of this bacteria is likely either runoff from adjacent agricultural land and/or from improperly operating septic systems in the area. *E. coli* in runoff may come from manure or livestock wastewater applied to crop fields, or from runoff from animal feeding operations (AFOs). AFOs exist in the lower reach of Beaver Creek.

The 303(d) listing is based on one sampling location and 13 samples. No sampling locations exist above the Fort Morgan Canal. Additional sampling points need to be established both below and above the Fort Morgan Canal and the points sampled intensively for the purpose of identifying the source(s) of the *E. coli* contamination.

9.4 Manganese

Manganese (Mn) is a 303(d)-listed contaminant of both the middle South Platte and lower South Platte segments. High Mn levels impair these water segments for domestic water supply use. The source of this metal is likely nonpoint source delivery from the underlying geology of the basin.

According to Howe and Malcolm (2004), manganese is a naturally occurring element that is a component of more than 100 minerals, including carbonates, sulfides, oxides, silicates, phosphates, and borates. Pierre Shale, which underlies the LSPW, is a marine sedimentary layer that contains Mn. It is released into soils by the weathering of these minerals. Mn can migrate as particulate matter (suspended sediments) to water, and it can be leached from soil as soluble Mn [such as by irrigation water leachate). Water-soluble Mn is directly proportional to soil pH. Surface freshwater data suggests that higher Mn concentrations occur during high stream flows, and lower concentrations occur downstream of lakes.

More monitoring is needed to identify the source(s) of the Mn contamination, including whether the significant source is surface runoff or irrigation return flows.

9.5 Nitrate-nitrogen in the alluvial aquifer

High levels of nitrate-nitrogen, above the MCL for drinking water, exist in certain locations of the alluvial aquifer of the South Platte River. It is suspected that the cause of these levels is nonpoint source agricultural irrigation and fertilization activities on the ground surface. Dennehy et al. (1998) noted that previous research has shown that the location of high nitrate-N in the aquifer were correlated with soil texture of cropland and to the locations of combined organic (e.g., manure) and inorganic nitrogen fertilizer applications. Since the age of the top of the ground water is from five to 30 years (WQCD, 2010), the causative activity(ies) may have occurred five to 30 years ago.

While the high nitrate-N alluvial water does at some time move into the river, as much as 90 percent of the nitrate-N can be removed from the surface water over short distances by microbial activity in the riverbed sediments.

9.6 pH

High pH in Horse Creek Reservoir is a 303(d)-listed contaminant. High pH levels impair the reservoir for aquatic life use. The use of dissolved carbonates by aquatic plants in a reservoir for photosynthesis releases hydroxyl ions, causing an increase in pH. As a result, Horse Creek Reservoir may have excessive growth of aquatic plants, fed by excessive nutrients. Monitoring of

the reservoir strata, aquatic plant growth, inflow to the reservoir, and of upstream reaches is needed to confirm the cause of this contaminant.

9.7 Salinity

High salinity levels exist in both the South Platte River and its alluvial aquifer. High salt levels in water degrade crop lands and domestic water supplies. As discussed in Section 8.5, significant causes of these levels are tributary inflows and irrigation return flows. Other sources of salts can include urban areas, wastewater treatment plants, highway deicers, and oil/gas well drilling.

9.8 Selenium

Selenium (Se)) is a 303(d)-listed contaminant of both the middle South Platte and lower South Platte segments, and of the the ten-mile section of Beaver Creek located south of the Fort Morgan Canal. High Se levels impair waters for aquatic life use. The source of this metal is likely nonpoint source delivery from the underlying Pierre Shale of the basin.

According to McNeal and Balistrieri (1989), selenium in the environment is derived mainly from rock weathering. In the northern Great Plains, the parent material for selenium-rich soils is the sedimentary Pierre Shale from the Cretaceous Age. Pierre Shale underlies the LSPW, but some of this shale is exposed to the environment in some eroded areas of Morgan and Logan Counties on the north side of the South Platte River (Bjorklund and Brown, 1957). Distribution processes for selenium include volcanic activity, combustion of fossil fuels, soil leaching, and ground water transport, among others. In most oxygen-rich environments the dominant forms of selenium are selenite and selenate. The latter is highly mobile and easily leached from the soil. Although natural water tends to have low concentrations of selenium, relatively high concentrations can occur if the water is alkaline or if it leaches and drains seleniferous rocks and soils.

Agricultural activities can act to mobilize selenium. Juracek and Ziegler (1998) assessed the effect of irrigation return flows on selenium concentrations in the Republican River Basin in Kansas and found increased selenium concentrations in reservoir sediment. The reservoir was located downstream from a large irrigated area with return flows and exposed Pierre Shale, and it acted as a sink for selenium deposition within the Basin. Wright (1999) found that where irrigation occurs on Cretaceous shales, oxidation-reduction processes are important for the mobilization of selenium in the environment, and nitrate can contribute to the oxidation and mobilization of Se (and uranium). The author concluded that proper management of N fertilizer might help to control the oxidation and mobilization of Se and other trace constituents into the environment.

More monitoring is needed to identify the source(s) of the Se contamination, including whether the significant source is surface runoff or irrigation return flows. Also, for Beaver Creek, additional monitoring is needed to discern whether the source of the Se is from within the impaired segment or above the Fort Morgan Canal.

9.9 Nutrients (N and P)

Elevated levels of total N and total P appear to exist in the South Platte River. Potential sources of these nutrients include the river's alluvial aquifer, soils, wastewater treatment plants, water treatment, runoff from fertilized lawns and croplands, failing septic systems, runoff from confined animal lots, and disturbed land areas. More monitoring is needed to identify the source(s) of the high nutrient levels.

10.0 Existing Watershed Management Activities

10.1 Agricultural activities

The main agricultural activities that may result in many of the contaminants shown in Section 5 entering waters in the LSPW as nonpoint sources are nitrogen/phosphorus fertilization, irrigation, and confined livestock feeding. Crops are typically fertilized with nitrogen for the purpose of obtaining maximum economic yields. In addition, irrigated crops are fertilized with phosphorus for the same purpose. Manure often is applied to irrigated crop fields, depending on their location relative to feedlots. Manure contains both nitrogen and phosphorus nutrients, as well as a level of salts.

Furrow irrigation can cause excessive soil infiltration and field runoff, resulting in return flows to the South Platte River and its tributaries possibly harboring nitrogen, phosphorus, selenium, manganese, salts, and *E. coli*. Sheet and rill erosion from dryland cropland also can carry these pollutants.

Confined animal feeding facilities (e.g., feedlots) may be sources of nitrogen, phosphorus, and *E. coli* in uncontrolled runoff. They also can be sources of nitrogen in ground water where captured runoff is stored in ponds that seep excessively, especially in areas with shallow ground water.

Several Best Management Practices (BMPs) are available to land managers for use in minimizing nonpoint source pollution of waters in the LSPW via the pathways described above. Colorado State University Extension (CSUE), the USDA- Natural Resources Conservation Service (NRCS), Conservation Districts, irrigation districts, agricultural organizations, and others have published documents describing the BMPs. For example, Colorado State University's "Colorado High Plains Irrigation Practices Guide" has specific BMPs for improving irrigation efficiency and runoff control. The BMPs have been brought to land managers via numerous educational programs (such as field days and seminars) over the past several years. In addition, state regulations specify how confined animal feeding facilities must manage their manure and wastewater.

CSUE conducted a survey in 1997 and 2001 of land managers in the South Platte basin for the purpose of discovering the level of use of BMPs on irrigated lands. Following are selected highlights from the 2001 survey (Bauder and Waskom, 2005):

- At least 51% of respondents have implemented an irrigation system upgrade. Many of the upgrades are intended to increase the irrigation uniformity and/or efficiency of a particular system. Thirty-six percent of respondents use a center pivot irrigation system, 45% use a ditch/check dam system, 45% use a gated pipe system, and 51% use a ditch/siphon tube system.
- At least 52% of respondents use an irrigation scheduling method. More precise scheduling methods, such as monitoring soil moisture and evapotranspiration, had lower use than less precise methods such as crop appearance and the producer's experience.
- At least 64% or respondents use a nutrient management method.
- At least 43% of respondents use a method to determine manure application rates.
- At least 46% of respondents apply nitrogen fertilizer in the spring.
- At least 21% of respondents keep records of the amount of irrigation water applied.
- 21% of respondents had concerns about salinity in their county; 18% had concerns about erosion/sediment; 26% had concerns about nitrate; 5% had concerns about selenium; 11% had concerns about manure runoff; and, 22% had concerns about urban runoff.

In the five years following the 2001 survey, some respondents made changes on their farms. The responses suggested that producers are more likely to make changes to manage water, which is

their most important input. The types of changes that producers made, and the percentage of producers who made the changes, are provided below:

- 36% made a change(s) in their water system
- 14% made a change(s) in their water management system
- 20% made a change in their crop management system
- 13% made a change in their tillage system
- 9% made a change in their fertilizer management

Smith et al. (1996) related that improved irrigation strategies have been adopted on a continual basis in recent times throughout the South Platte basin. The adopted measures include both structural improvements in conveyance structures and irrigation systems, use of information management techniques, improved crop management, and changes in crops being grown.

The Colorado Division of Water Resources ((Wolfe, 2007) has observed the following changes (among others) by farmers in the South Platte basin in response to well regulation and water supply changes:

- Increased use of the South Platte aquifer for retiming of water depletions from well pumping
- Increased use of surface water rights in sprinkler irrigation systems
- Increased use of surface water supplies, especially early in the year due to cost of pumping wells
- Increased use of reservoirs for irrigation
- Increased installation of sprinkler systems (but reduces return flows)
- Change in cropping patterns (more winter wheat, alfalfa, etc.)

10.1.1 Beaver Creek watershed plan

Since 2005, a watershed plan has been in effect for the South Platte valley area located between Bijou Canal (between Wiggins and Fort Morgan) and Prewitt Reservoir (MCD, 2005). In Morgan County, the project area is bounded on the west by the Bijou Canal, on the south by the Fort Morgan Canal, and on the southeast by the Lower Platte and Beaver ditches. In Washington County, the project area is bounded on the southeast by the Lower Platte and Beaver ditches, on the north by Prewitt Reservoir, and on the east by the South Platte ditch.

The project area is 82,900 acres in area and has 300 farms having an average size of 240 acres. Irrigated cropland constitutes 59,600 acres; 60 percent of this acreage was targeted for land treatment projects.

The major problems identified in the watershed by stakeholders were the following:

- Water quality and quantity
- Crop nutrient management
- Irrigation ditch erosion
- Augmentation ponds
- Irrigation erosion
- Saline irrigation water
- Flooding
- Agricultural waste management
- Wildlife habitat
- Wind erosion

The purposes of the land treatment projects on irrigated farms were the following:

1. Improve water application effectiveness and reduce water quality and quantity impacts to surface and ground water. The targeted impacts were excessive loading of nitrates, nutrients, sediment, and salts.
2. Protect the soil resource base from excessive irrigation-induced erosion and sedimentation, and improve soil health through carbon sequestration.
3. Create and improve wetland and wildlife habitat.

According to the NRCS- Morgan County office April 2011, 58 land treatment contracts were awarded under the watershed plan. The projects are 70 percent completed; all projects are expected to be completed in 2011. Most contracts were for projects on farms located on the south side of the South Platte River; some were on farms located along Beaver Creek and south of the Fort Morgan Canal. About 30 contracts involved placing sprinkler pivots on land that had been furrow irrigated. Other projects included installing the following:

- Low pressure nozzles on about six pivots
- Two or three drip irrigation systems
- Some underground pipe for on-farm water transfer
- Some concrete ditches to replace on-farm dirt ditch delivery systems
- Some windbreaks.

10.2 Point source activities

The wastewater treatment plans at Brush and the water treatment plant in Sterling are in the process of being upgraded for the purpose of enhancing removal of selected constituents. Sterling anticipates that the upgrade in the plant will decrease salts loading to the South Platte River.

The Cargill Fort Morgan beef plant is in the process of engineering a $6 million upgrade to its treatment plant to enhance removal of total inorganic nitrogen.

In 2010, the town of Hudson completed construction of a new wastewater treatment plant located northwest of the town. Currently, Hudson is using both this new plant and the upgraded plant located in the town.

In 2006, the town of Kersey began operating its new wastewater treatment plant.

11.0 Stressors on water quality

Dennehy et al. (1998) indicated that water quality in the South Platte River basin is a product of its environmental setting and hydrologic conditions. Environmental conditions that affect the water quality include natural factors such as physiography, climate, geology, and soils. Human factors are water use, population, land use, and water management practices.

Stressors on water quality within the LSPW focus on the continued high demands on the water. Dennehy et al. (1998) highlighted the following water supply-related issues:

- Allocating water between urban and agricultural demands
- Managing growth without deterioration of water quality
- Restoring degraded riparian habitat and fisheries in the plains
- Developing future water supplies without affecting the environment
- Protecting existing drinking water supplies

The Colorado Water Conservation Board estimates that a 22 percent gap will exist in 2030 in the South Platte Basin in meeting demands for municipal and industrial water needs unless certain projects are accomplished to satisfy the shortfall (SWSI, 2004). For the Lower Platte area (Morgan,

Washington, Logan, and Sedgwick counties), a shortfall of 8,000 acre-feet/year is projected. A decline in water quantity can result in concentration of contaminants in waterways.

A continued decline in irrigated acreage is projected to continue, with 100,000 to 200,000 acres being dewatered by 2030, primarily as a result of diversion to municipal/industrial uses. Less irrigated land will reduce irrigation return flows to waterways.

Water rights laws will remain a highly significant factor in how water is managed and used in the LSPW, and can trump implementation of projects such as water storage and some best management practices intended to improve water quality (such as irrigation water conservation measures). Irrigation return flows remain as a very important part of the LSPW's hydrology and to downstream water rights holders and water habitats.

As a result of water stressors in the South Platte Basin, the South Platte Basin Roundtable has adopted the following priorities to address the issues (https://cwcb.state.co.us/water-management/basin-roundtables/Pages/SouthPlatteBasinRoundtable.aspx):

- Address potential impacts of agricultural transfers and find alternatives to permanent agricultural dry-up.
- Address agricultural supply shortages for both surface and ground water users.
- Identify opportunities to optimize existing and future water supply infrastructure.
- Successfully implement endangered species program to protect existing and future in-basin uses.
- Develop new water storage facilities.
- Ensure adequate water for future needs.

12.0 Project Recommendations

Based on the water quality impairments and concerns identified in this Plan, recommendations are provided below as next steps towards improving the water quality in the LSPW. As resources become available, these are some initially identified potential projects, but are not limited to this short list. It is expected this list will expand based on resources and needs identified in the future.

12.1 Beaver Creek watershed

The lower part of Beaver Creek between the Fort Morgan Canal and the South Platte River (segment no. 2b) has a high priority for developing a TMDL for addressing the following two contaminants: *Escherichia coli* and selenium (Se). In addition, the confluence of Beaver Creek and the South Platte River is highly degraded for stream and fish community health. As a result, it is recommended that the Beaver Creek watershed be the target for a project(s) that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) remove segment no. 2b from the 303(d) list before a TMDL is finalized; 2) identify what contribution, if any, the upper watershed is contributing to the contaminant load; 3) possibly have the Se standard for the watershed be changed by the Colorado Water Quality Control Commission (WQCC) to one that reflects background Se levels; and, 4) create good stream habitat and fish community health conditions at the confluence of Beaver Creek and the South Platte River. The contamination levels may now be lower than the concentration thresholds as a result of completion of the projects put in place under the 2005 Beaver Creek Watershed Plan.

1. Identify the source(s) of *Escherichia coli* contamination; identify how much *E. coli* loading needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed load reduction.
2. Identify the source(s) of Se contamination. If natural sources are the main cause, request that the WQCC raise the Se standard for the watershed. If a nonpoint source activity(ies) is

a significant cause of the Se contamination, identify how much Se loading needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed load reduction.

3. Conduct monitoring of the creek to demonstrate whether implemented activities result in *E. coli* and Se concentrations being reduced to below threshold levels.
4. If the contaminants cannot be removed from the 303(d) list, write a TMDL for listed contaminants by no later than 13 years after the water impairment was identified.
5. Identify the cause(s) of the highly impaired stream and fish community health and institute activities that return the site to good health (e.g, in conjunction with the South Platte Native Fish Conservation Plan).

12.2 Citizen-based water monitoring throughout the Plan area

During the public input process, there was a consistent message from the stakeholders of wanting more monitoring by local citizens to provide information on water quality throughout the Lower South Platte basin. Implementation of the vetted, citizen-based "River Watch Program", in cooperation with the Colorado Water Quality Monitoring Council, would:

1. Involve youth in the monitoring process, developing awareness and engagement of future decision-makers in water quality issues.
2. Provide monitoring by local interests, addressing the concerns of stakeholders for locally-led monitoring efforts.
3. Provide basin-wide information on water quality and potential impairments. The involvement of school/youth/citizen groups along the Lower So. Platte River and selected tributaries will assist in increasing the number of sampling locations and verifying entry points and possible sources of waterway impairments.
4. Assist in monitoring the effectiveness of installed BMPs in improving water quality.
5. Add to the data set available for making water quality management decisions and tracking trends through data sharing through the Colorado Water Quality Monitoring Council.

12.3 Constructed Wetlands Demonstration Project

Constructed Wetlands Demonstration Project

Several of the impairments to water quality identified in this plan, including nitrogen, phosphorus, nitrates, and selenium, have been shown to be significantly reduced through the implementation of constructed wetlands in strategic locations to mitigate water quality issues (Lin and Terry, 2003 and Kovacic et al, 2000). As a result a project(s) is needed that focuses on the activities below:

1. With other stakeholders and partners, identify potential sites for constructed wetlands in the plan area.
2. Implement ongoing water monitoring protocols above and below the demonstration site selected by the participating partners to establish baseline water quality levels.
3. Conduct educational programs to provide information on the constructed wetland to citizens within the LSP watershed.
4. Secure appropriate agreements to provide the land for the proposed project and establish agreements among the partners for ongoing maintenance of the wetland as needed.
5. Initiate construction of the wetland, incorporating current technologies and BMPs.
6. Upon completion of the wetland, evaluate the process so the process can be replicated in other parts of the LSP watershed.

7. Continue to monitor water inflow and outflow from the constructed wetland to measure its effectiveness in reducing contaminants.

12.4 Education/outreach

In response to a survey sent to farmers who use irrigation in the South Platte basin, 31% of respondents cited salinity as a water quality concern, 19% cited nitrate, 8% cited bacteria/pathogens, and 3% cited selenium as concerns (Bauder and Waskom, 2005). While irrigated farmers are not necessarily representative of all residents of the LSPW, the results indicate a need for education to raise the awareness of water quality issues in the watershed that need to be addressed. It is suggested that an educational program target multiple classes of land users and other stakeholders all over the LSP basin, with programs occurring at least biannually for five years or more.

Additional ongoing educational efforts would also be implemented to offer a variety of delivery methods for residents of all ages to receive updated information on the plan's progress, water quality references, and to communicate about emerging water quality issues in the LSP. Examples of delivery methods to be used include:

- Website
- Watershed tours
- Displays at community events
- Interpretive signs

12.4 Selenium and manganese in the South Platte River

The entire length of the South Platte River within the LSPW is impaired (i.e., on the 303(d) list) for Se; segment no. 1 (from Weld/Morgan line to Nebraska) also is impaired for manganese (Mn). The TMDL priorities for the two segments are low and medium. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) remove segment nos. 1 and 1b from the 303(d) list before a TMDL is finalized; and, 2) possibly have the Se and Mn standards for the segments changed by the WQCC to levels that reflect background Se and Mn levels.

1. Identify the source(s) of Se contamination. If natural sources are the main cause, request that the WQCC raise the Se standard for the watershed. If a nonpoint source activity(ies) is a significant cause of the Se contamination, identify how much Se loading needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed load reduction.
2. Identify the source(s) of Mn contamination. If natural sources are the main cause, request that the WQCC raise the Mn standard for the watershed. If a nonpoint source activity(ies) is a significant cause of the Mn contamination, , identify how much Mn loading needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed load reduction.
3. Conduct monitoring of the river to demonstrate whether implemented activities result in reductions of Se and Mn to below threshold levels.
4. If the contaminants cannot be removed from the 303(d) list, write a TMDL for listed contaminants by no later than 13 years after the water impairment was identified.

12.5 Prospect Lake and Horse Creek Reservoir

These water bodies are located near the south edge of Weld County and the LSPW. Both lakes are impaired for pH and ammonia; Prospect Lake also is impaired for dissolved oxygen (D.O.). While Horse Creek Reservoir is not impaired for D.O., the Colorado Water Quality Control Division is required to monitor and evaluate the reservoir for D.O. The TMDL priorities for these water bodies are low and medium. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) remove both lakes from the 303(d) list before a TMDL is finalized; and, 2) prevent Horse Creek Reservoir from being listed as impaired for D.O. Because the inlet drainages for these lakes originate in Adams County, a cooperative effort with watershed stakeholders in that county may be necessary to improve water quality in the lakes.

1. Identify the source(s) of pH contamination; identify how much pH needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed reduction.
2. Identify the source(s) of ammonia contamination; identify how much ammonia needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed reduction.
3. Identify the source(s) of high D.O. levels; identify how much D.O. needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed reduction.
4. Conduct monitoring of the lakes to demonstrate whether implemented activities result in reductions of pH, ammonia, and D.O. to below threshold levels.
5. If the contaminants cannot be removed from the 303(d) list, write a TMDL for listed contaminants by no later than 13 years after the water impairment was identified.

12.6 Salts in the South Platte River and alluvial aquifer

The entire lengths of the river and alluvial aquifer have excess salts that are degrading irrigated crop land, decreasing crop yields, and affecting drinking water quality. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goal of the project(s) is to provide good quality irrigation and drinking water.

1. Identify target salt concentrations for irrigation and drinking water use.
2. Identify the source(s) of salt contamination; identify how much salt loading needs to be decreased; institute activities (e.g., BMPs) that reduce the loading to target levels.
3. Conduct monitoring of the river and ground water to demonstrate whether implemented activities result in salt concentrations being reduced to below target levels.

12.7 North Sterling, Jackson, and Jumbo Reservoirs

These reservoirs are required to be monitored and evaluated by the Colorado Water Quality Control Division for pH and selenium; North Sterling Reservoir also is impaired for dissolved oxygen (D.O.). In addition, Jackson and Prewitt Reservoirs have eutrophic conditions. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) prevent North Sterling, Jackson, and Jumbo reservoirs from being listed as impaired for pH, selenium, and D.O., as applicable; and, 2) prevent Jackson and Prewitt Reservoirs from degrading to hypertrophic status.

1. Identify the cause(s) of elevated pH levels; identify how much the pH needs to be changed; conduct activities (e.g. BMPs) that accomplish the needed change.
2. Identify the source(s) of Se contamination; identify how much Se loading needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed loading reduction.
3. Identify the cause(s) of high D.O. levels; identify how much D.O. needs to be decreased; conduct activities (e.g. BMPs) that accomplish the needed reduction.
4. Identify the cause(s) of the eutrophic conditions in Jackson and Prewitt Reservoirs; conduct activities (e.g. BMPs) that moves the trophic status of the lakes to mesotrophic.

5. Conduct monitoring of the lakes to demonstrate whether implemented activities result in reductions of pH, Se, and D.O. to below threshold levels, and whether mesotrophic conditions are observed at Jackson and Prewitt Reservoirs.

12.8 Nutrients in the South Platte River

The entire length of the South Platte River potentially has excess nutrients (N and P) that are affecting the quality of the river and reservoirs that it supplies. Excess nutrients are a major cause of high algae growth in water bodies. As a result, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goals of the project(s) are: 1) reduce nutrient levels in the river to below threshold values that will be set by the Colorado Water Quality Control Commission (WQCC); and, 2) prevent the river from being placed on the 303(d) list for nutrients.

1. Keep appraised of when the WQCC approves regulatory nutrient standards and note what the nutrient threshold standard(s) are for the lower South Platte River.
2. Identify the source(s) of nutrient contamination; identify how much nutrient loading needs to be decreased; institute activities (e.g., BMPs) that reduce the loading to threshold levels.
3. Conduct monitoring of the river to demonstrate whether implemented activities result in nutrient concentrations being reduced to below threshold levels.

12.9 Nitrate-nitrogen in South Platte alluvial aquifer

Nitrate-nitrogen levels that exceed the maximum allowable level of 10 mg/l under the federal Safe Drinking Water Act exist in some locations of the alluvial aquifer of the South Platte River. Such levels can affect the use of the water for human consumption. Therefore, a project(s) is needed that focuses on the activities listed below, at minimum. The suggested goal of the project(s) is to reduce the nitrate-nitrogen levels in the alluvial water to below 10 mg/l.

1. Identify the source(s) of nitrate-nitrogen contamination; identify how much nitrate-nitrogen loading needs to be decreased; institute activities (e.g., BMPs) that reduce the loading to target levels.
2. Conduct monitoring of the alluvial water to demonstrate whether implemented activities result in nitrate-nitrogen concentrations being reduced to below 10 mg/l.

12.10 Degraded stream habitats and fish communities

The confluences of the South Platte River and St. Vrain Creek and Lone Tree Creek, at minimum, are degraded for stream habitat and fish community health. The South Platte River at the Colorado/Nebraska state line is moderately degraded for fish community health. Therefore, a project(s) is needed that focuses on the activity listed below, at minimum. The suggested goal of the project(s) is to create good stream habitat and fish community health conditions at the three locations identified above.

1. Identify the cause(s) of the impaired stream and fish community health at the three sites and institute activities that return the sites to good health (e.g, in conjunction with the South Platte Native Fish Conservation Plan).

12.11 Protection of Gaura neomexicana ssp. Coloradensis

Gaura neomexicana Woot. ssp. *coloradensis* (Rybd.) P.H. Raven & Gregory is a threatened plant that is critically imperiled globally and statewide because of its rarity. As a result, a project(s) is needed that focuses on protecting the few plants and their habitat located along Lone Tree Creek.

Any of the above recommended projects, or combination of projects, could be started and successfully completed where the following parameters are all in place:

- Significant stakeholder support;
- Sufficient human and material resources; and,
- Adequate funding

13.0 Financial Plan

Under development – finalized after priorities and plan initially reviewed by Core Committee and stakeholders.

14.0 Adaptive Watershed Management

The Lower South Platte Watershed Plan development process revolved around the concept that the plan would be dynamic; evolving to deal with changes in water quality concerns brought on by natural or man-made circumstances. The emphasis on extensive water quality monitoring all over the basin will be beneficial to the watershed plan partners as they adjust objectives and practices to correct or prevent emerging water quality problems.

Adaptive management strategies in the Lower South Platte Watershed will include:

- Continuous evaluation of monitoring data to gauge the success of implemented programs and BMPs to improve water quality.
- Providing up-to-date information to LSP citizens about the impacts on water quality concerns through a variety of methods including news releases, website postings, social media, and presentations to decision makers at all levels.
- Additional or adjusted human, technical and financial resources will be procured to address any revision to the watershed plan.
- The LSP Watershed Plan will be reviewed every two years by partners and stakeholders to redirect efforts and resources as needed.
- Data obtained through River Watch and other monitoring protocols will be coordinated and shared for the benefit of all entities working to protect water supplies in the LSP.
- Adjustments to management decisions and practices applied will also be communicated to the basin's citizens.

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Appendix A

9 Elements of a Watershed Plan

Section PENDING

Appendix B

List of the Lower South Platte Watershed Plan Stakeholders

As of 5/31/2011

Appendix B: List of Lower South Platte Watershed Plan Stakeholders as of 5/31/11

City/County/Regional Govt.	Logan County	Commissioner	Jack McLavey
City/County/Regional Govt.	Morgan County	Commissioner	Laura Teague
City/County/Regional Govt.	Phillips County	Commissioner	Jerry Beavers
City/County/Regional Govt.	Phillips County	Commissioner	Bud Biesemeier
City/County/Regional Govt.	Phillips County	Commissioner	Susan Roll Walters
City/County/Regional Govt.	Sedgwick County	Commissioner	Gene Bauerle
City/County/Regional Govt.	Sedgwick County	Commissioner	Jim Beck
City/County/Regional Govt.	Sedgwick County	Commissioner	Glen Sandquist
City/County/Regional Govt.	Washington County	Commissioner	David Foy
City/County/Regional Govt.	Washington County	Commissioner	Bruce Johnson
City/County/Regional Govt.	Weld County	Commissioner	Doug Rademacher
City/County/Regional Govt.	Weld County	Commissioner	David Long
City/County/Regional Govt.	Weld County	Commissioner	Bill Garcia
City/County/Regional Govt.	Northeast Colorado Health Department	n/a	Julie McCaleb
City/County/Regional Govt.	Town of Platteville	n/a	David Brand
City/County/Regional Govt.	Metro Wastewater	n/a	Amy Woodis
City/County/Regional Govt.	City & County of Broomfield	n/a	David Allen

City/County/Regional Govt.	Weld County Dept. of Public Health & Environment	n/a	Mark Thomas
City/County/Regional Govt.	Town of Timnath	n/a	John Jordan
City/County/Regional Govt.	City of Evans	n/a	Earl Smith
City /County/Regional Govt.	City of Longmont	n/a	Larry Wyeno
City/County/Regional Govt.	City of Fort Collins	n/a	Carol Webb
City/County/Regional Govt.	City of Greeley	n/a	Dennis Schump
City/County/Regional Govt.	City of Greeley Water & Sewer	n/a	Colleen Young
City/County/Regional Govt.	Town of Severance	n/a	John Holdren
City/County/Regional Govt.	Town of Erie	n/a	John Mays
City/County/Regional Govt.	City of Loveland	n/a	Steve Adams
City/County/Regional Govt.	Lost Creek Ground Water Management Dist.	n/a	John Sauter
City/County/Regional Govt.	City of Thornton	n/a	Brian Foss
City/County/Regional Govt.	Logan County	Planning Dept.	Kris Pennington
City/County/Regional Govt.	City of Aurora	n/a	Mike McHugh
Political	Colorado House of Representatives	n/a	Rep. Jerry Sonnenberg
Political	United States House of Representatives	Regional rep. for Rep. Betsy Markey	Lori Ozzello
Schools	Colorado State University Extension	Extension Water Quality Specialist	Troy Bauder
Schools	Colorado State University Extension	Logan County	Randy Buhler
Schools	Colorado State University Extension	Morgan County	Bruce Bosley
Schools	Colorado State University Extension	Weld County	Keith Maxey

Schools	Colorado State University	Colorado State Forest Service	Norland Hall
State Govt.	Colorado Division of Wildlife	n/a	Wendy Figueroa
State Govt.	Colorado Division of Wildlife	n/a	Devon Young
State Govt.	Colorado Division of Wildlife	n/a	Brian Sullivan
State Govt.	Colorado Dept. of Agriculture	Commissioner	John Stulp
State Govt.	Colorado Dept. of Agriculture	Conservation Services	Eric Lane
State Govt.	Colorado Dept. of Agriculture	Colorado State Conservation Board	Cindy Lair
State Govt.	Colorado Dept. of Agriculture	Agricultural Chemical and Groundwater Protection Program	Karl Mauch
State Govt.	Colorado Dept. of Public Health & Environment – Water Quality Control Division	n/a	Dick Parachini
State Govt.	Colorado Dept. of Public Health & Environment – Water Quality Control Division	n/a	Greg Naugle
State Govt.	Colorado Dept. of Public Health & Environment – Water Quality Control Division	n/a	Randy Ristau
Non-Profit	Lower South Platte Watershed Assn.	n/a	Nancy Berges
Non-Profit	Centennial Conservation Dist.	n/a	XXXXXXXXX
Non-Profit	Sedgwick County Conservation Dist.	n/a	Nancy Berges
Non-Profit	Sedgwick County Conservation Dist.	n/a	Jerry Miller
Non-Profit	Morgan Conservation Dist.	n/a	Val Loose
Non-Profit	Washington County Conservation Dist.	n/a	Jamie Axtell
Non-Profit	Washington County	n/a	Veryl Eschen

	Conservation Dist.		
Non-Profit	West Greeley Conservation Dist.	n/a	Joyce Wallace
Non-Profit	Haxtun Conservation District	n/a	Denise Swanson
Non-Profit	Central Colorado Water Conservancy Dist.	n/a	Justin Bieri
Non-Profit	Northern Colorado Water Conservancy Dist.	n/a	Brad Wind
Non-Profit	Lower South Platte Water Conservancy Dist.	n/a	Joe Frank
Non-Profit	Colorado Audubon	Interim Exec. Director	Ken Strom
Non-Profit	Colorado Audubon	Important Bird Areas Coordinator	Stephanie Demattee
Non-Profit	North Front Range Water Quality Planning Assn.	n/a	Connie O'Neill
Non-Profit	Colorado Water Quality Monitoring Council	n/a	Barb Horn
Non-Profit	Northeast Colorado RC&D Council	n/a	David Colburn
Non-Profit	South Platte Roundtable	Representative	Don Ament
Non-Profit	Colorado Open Land	n/a	Brian Ocepek
Non-Profit	St. Vrain Sanitation Dist.	n/a	Eric Doering
Non-Profit	Box Elder Sanitation Dist.	n/a	Fred Walker
Non-Profit	Julesburg Irrigation Dist.	n/a	Bruce Gerk
Non-Profit	Julesburg Irrigation Dist.	n/a	Larry Frame
Non-Profit	Colorado Corn	n/a	Charlie Bartlett
Non-Profit	Colorado Corn	Executive Director	Mark Sponsler
Non-Profit	Colorado Livestock Assn.	Director, Quality Resources	Ivan Steinke

Non-Profit	Colorado Cattlemen's Assn.	n/a	Terry Fankhauser
Non-Profit	Colorado Assn. of Conservation Districts	n/a	Tracee Bentley
Non-Profit	Colorado Assn. of Conservation Districts	Board Director	Brian Starkebaum
Non-Profit	Riverside Irrigation Dist.	n/a	Don Chapman
Non-Profit	Morgan County Economic Development Council	n/a	Kari Linker
Non-Profit	Colorado Farm Show	n/a	Brian Foss
Non-Profit	Good Neighbor Law	n/a	Roni Sylvester
Non-Profit	Morgan County Quality Water Dist.	n/a	Dave Musgrave
Non-Profit	Morgan County Quality Water Dist.	n/a	Mark Kokes
Media	The Greeley Tribune	n/a	Bill Jackson
Media	The Brian Allmer Radio	n/a	Brian Allmer
Media	The Sterling Journal-Advocate	n/a	Judy Debus
Media	Free-lance writer	n/a	Bob King
Landowner			Dean Forrest
Landowner		Greeley, CO	Ed Meyer
Landowner		Hillrose, CO	Vic Quint
Landowner		Brighton, CO	Don Hirsch
Landowner		Fort Morgan, CO	Rob Seiber
Landowner		Wiggins, CO	Dave Knievel
Landowner		Greeley, CO	Doug Meyer
Landowner		Brush, CO	Chuck Miller
Landowner		Hillrose, CO	Nadia Elias
Landowner		Hillrose, CO	D. Lott
Landowner		Sterling, CO	Dick Dixon
Landowner		Sterling, CO	Margaret McIntire
Landowner		Sterling, CO	Rocky Samber

Landowner		LaSalle, CO	Chuck Sylvester
Landowner		Hudson, CO	Ken Bollers
Landowner		Platteville, CO	John Hoffman
Landowner		Kersey, CO	Carl Hergenreder
Federal Govt.	USDA-Natural Resources Conservation Service	Area 2 Conservationist	Leroy Hall
Federal Govt.	USDA-Natural Resources Conservation Service	Dist. Conservationist	Dawn Jackson
Federal Govt.	USDA-Natural Resources Conservation Service	Dist. Conservationist	Cindy Einspahr
Federal Govt.	USDA-Natural Resources Conservation Service	Dist. Conservationist	C.W. Scott
Federal Govt.	USDA-Natural Resources Conservation Service	Dist. Conservationist	Ray Mowery
Federal Govt.	USDA-Natural Resources Conservation Service	Asst. State Conservationist-Water Resources	Frank Riggle
Federal Govt.	USDA-Natural Resources Conservation Service	State Resource Conservationist	Eugene Backhaus
Federal Govt.	U.S. Geological Survey	n/a	Tracy Yager
Other	EBWB, Inc. Consultants	n/a	Jennifer Migliorato
Other	Wildland Management	n/a	Rick Sandquist
Other	Schmale Realty	n/a	Andy Pickens