Lower Animas River Watershed Based Plan

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Mountain Studies Institute
SAN JUAN MOUNTAINS, COLORADO

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Executive Summary

The Lower Animas Watershed Based Plan (LAWBP) focuses on the segment of the Animas River in New Mexico that flows south from the Colorado state line and reaches its southern terminus at the confluence with the San Juan River at Farmington, NM. The Lower Animas was listed on the State of New Mexico's impaired waters list in 2002, and since 2010 has exceeded water quality criteria for phosphorus, nutrients/eutrophication, *E. coli* bacteria, turbidity, and temperature.

A previous watershed based plan was developed in 2011 by BUGS (2011) that covered the entire Animas River watershed in Colorado and New Mexico, but the 2011 plan lacked several components necessary to prioritize management measures to address impairment. The EPA provided specific comments on how to revise and improve the 2011 plan in order to meet the required "9 Key Elements." These comments have been incorporated throughout the development of this plan and were vital to the progress that has been made in this new watershed planning effort.

The objective of the LAWBP is to combine water quality trends with land use data and the practical experience of local stakeholders to make informed decisions on how best to improve water quality on the Animas River. This plan utilizes two new data collection efforts initiated by the San Juan Watershed Group in 2013 and 2014: Microbial Source Tracking (MST) and 2014 Lower Animas Targeted Sampling. The MST study provided information regarding the sources of bacteria (e.g., human, ruminant, horse, dog, and waterfowl) that are most prevalent in the Animas and San Juan Rivers. The Lower Animas Targeted Sampling determined the nutrient and *E. coli* contribution of inflows (e.g., arroyos, tailwater ditches, field drains, and return flow from irrigation ditches) along the Animas River during low flow conditions. Data from these two new studies indicate the following:

- Measured concentrations and loads of nitrogen, phosphorus, *and E. coli* in 2014 often exceeded NM state water quality criteria, and total maximum daily load targets established for the Animas River, which confirms impairment.

- Nutrient and *E.coli* loads in the Animas River vary seasonally; during summer and fall precipitation events that cause an increase in river flow and turbidity, concentrations of nutrients and *E. coli* become elevated. High turbidity was correlated with total phosphorus and total nitrogen. This is likely due to stormwater runoff from the adjacent landscape.

- The primary source of nutrient and *E. coli* loads in the Animas River at low flow cannot be solely explained by inflows. It is possible that inflows do contribute a higher portion of the nutrient and *E. coli* load during storm events, but this remains an unknown since there is limited data from inflows along the lower Animas River during storm events.

- There is a very consistent source of ruminant bacteria in the Animas River (90% of samples positive), and a less pervasive but consistent source of human bacteria (60% samples positive).

From these recent datasets, we concluded that management measures should not solely focus on reducing pollutant loads from single, discrete inflows, but instead should take a more holistic watershed approach by addressing contributions from different land uses during low flow and especially during storm event conditions. Therefore, we proposed a menu of projects and outreach efforts that address the pollutant sources, impairments, and threats to watershed health organized based on project types specific to a given land use or pollutant source category:

- Septic, sewer, and wastewater management
- Agricultural best management practices (BMPs)
- Upland restoration and best management practices
- Urban stormwater projects
- Riparian restoration
- Streambank, wetland, and floodplain restoration
- Irrigation infrastructure improvements

For each of these land use or pollutant source categories, we described management measures, implementation strategies, implementation schedule, and possible funding sources. We summarized specific project locations, costs, and expected pollutant load reductions. In order to estimate the nutrient and sediment load reduction that can be expected from implementing best management practices for specific projects, we utilized an EPA model called STEPL (Spreadsheet Tool for Estimating Pollutant Loads). As this plan is updated through adaptive management over time, the management measures and implementation strategies should stay relatively the same, while specific project areas and costs will be updated as original projects are completed.

The long-term goal of this plan is to restore the Animas River to an unimpaired condition such that it meets all of its designated uses. This means that bacteria concentrations are reduced to a point where they don't impact recreation, and nutrient concentrations, functioning capacity, and sediments are improved to where they support healthy aquatic life. The effectiveness of this plan will be assessed by interim achievement criteria, progress milestones, and continued water quality monitoring.

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Acronyms Used

ARSG	Animas River Stakeholders Group
ATU	Advanced Treatment Unit
AWP	Animas River Partnership
BLM	Bureau of Land Management
BMP	Best Management Practices
BOR	Bureau of Reclamation
CFS	Cubic Feet per Second
CPW	Colorado Parks and Wildlife
DOT	Department of Transportation
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
HUC	Hydrologic Unit Code
LAWBP	Lower Animas Watershed Based Plan
LID	Low Impact Development
LWDR	Liquid Waste Disposal Regulations
MS4	Municipal Separate Storm Sewer System
MSI	Mountain Studies Institute
MST	Microbial Source Tracking
NMED	New Mexico Environment Department
NMGF	New Mexico Game and Fish
NMSLO	New Mexico State Land Office
NO3/NO2	Nitrate plus Nitrite
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
SJRIP	San Juan Basin Recovery and Implementation Program
SJSWCD	San Juan Soil and Water Conservation District
SJWG	San Juan Watershed Group
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SUIT	Southern Ute Indian Tribe
SWQB	Surface Water Quality Bureau
T&E	Threatened and Endangered
TMDL	Total Maximum Daily Load
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
USFWS	United States Fish and Wildlife Service
WBP	Watershed Based Plan
WWTP	Waste Water Treatment Plant

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1. Introduction

Watershed Based Plan Overview and Objective

The Animas is an ecologically and politically complex river, crossing three EPA regions, two states and one tribe, three counties, four cities, a diverse range of soils and geology, and multiple ecological life-zones as it flows from its alpine headwaters in the San Juan Mountains of Colorado to its confluence with the San Juan River in the semi-desert sage-brush scrub lands of Farmington, New Mexico.

The Animas River flows south into New Mexico from Colorado and Southern Ute Indian Tribe (SUIT) lands, and reaches its southern terminus at its confluence with the San Juan River at Farmington, NM. The San Juan River then flows west to the Colorado River (Maps 1 and 2).

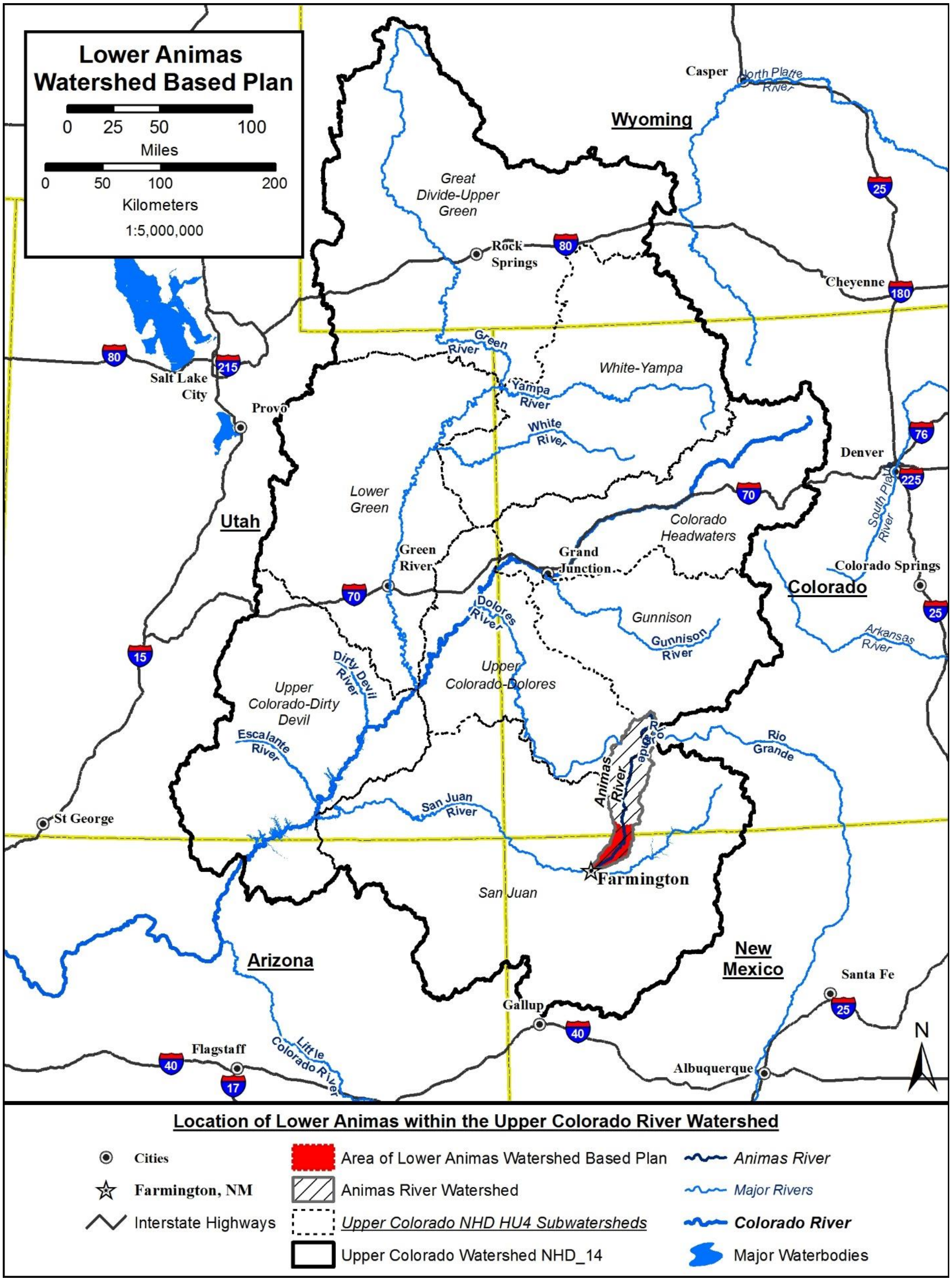
The Lower Animas Watershed Based Plan (herein referred to as "Watershed Plan") will focus on the Animas River Watershed (HUC 14080104) to specifically address the six 12-digit HUCs that encompass the New Mexico reaches of the river (herein referred to as the "Lower Animas"). Quantitative analysis of pollutant loading will be focused solely within the Assessment Units and subwatersheds listed in Table 1.

Table 1. Assessment Units and HUCs addressed in this plan

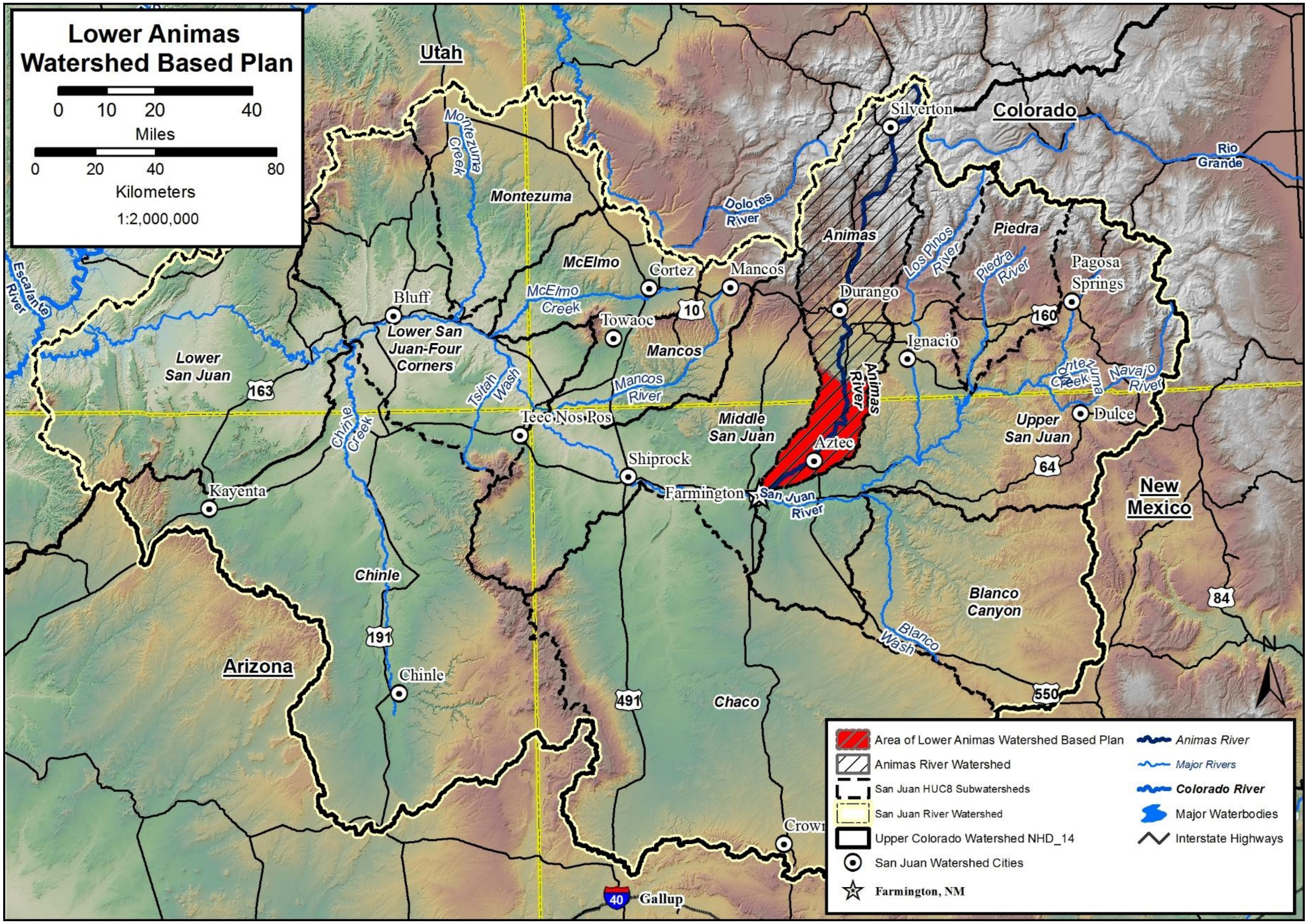
Assessment Unit	HUC ID	HUC Name	Area (mi^2)
Animas River Estes Arroyo to So. Ute Indian Tribe land (NM-2404_00)	HUC 140801041001*	Cox Canyon	41
	HUC 140801041002*	Ditch Canyon - Animas River	57
	HUC 140801041003	Tucker Canyon - Animas River	43
	HUC 140801041004	Estes Arroyo - Animas River	58
Animas River San Juan River to Estes Arroyo (NM-2403_A_00)	HUC 140801041005	Flora Vista Arroyo - Animas River	43
	HUC 140801041006	City of Farmington - Animas River	33

Note: *The Cox Canyon and Ditch Canyon HUCs include land in both New Mexico and Colorado. Quantitative analysis within this Plan will focus mainly on the New Mexico portion of these HUCs.

This Watershed Plan seeks to summarize water quality trends from the many studies conducted within the focus subwatersheds, as well as upstream on the Animas and in the neighboring San Juan River Basin. Water quality information has been combined with land use data and the practical experience of local stakeholders to make informed decisions on how best to improve water quality on the Animas River.



Map 1 – Location of the Lower Animas within the Upper Colorado Basin



Map 2 – Location of the Lower Animas within the San Juan River Watershed

Why are we writing this document?

The Animas River has been on the State of New Mexico's impaired waters list since 2002. As of 2010, the Animas River was exceeding water quality criteria for total phosphorus, nutrients/eutrophication, *E. coli* bacteria, turbidity, and temperature (See Section 3 "State of the Watershed" for details). Stakeholders began to address the nutrient issues after 2002, which led to several years of studies culminating in the 2011 Animas Watershed Based Plan (BUGS 2011).

The 2011 plan investigated nitrogen and phosphorus along the Animas River from near Hermosa, Colorado, to the confluence with the San Juan River in NM. While the 2011 plan did a thorough job of characterizing many aspects of the watershed, it stopped short on several aspects necessary to prioritize management measures to correct the identified loading problems, especially in the New Mexico reaches of the river. The EPA provided specific comments on how to revise and improve the 2011 plan in order to meet the required "9 Key Elements." These comments have been incorporated throughout the development of this plan, and were vital to the progress that has been made in this new watershed planning effort.

What have we learned since the last watershed plan?

Comments by Melissa May, San Juan Soil & Water Conservation District:

One of the main concerns with the 2011 plan was that it chose priority project locations based on which inflows had the highest nitrogen concentrations on just 2 sampling dates. When data from one sampling date was used instead of the other, the priorities changed. The inflows were also seen as problems on their own, without making a connection to upstream land uses. Reviewers at EPA saw this as a problem, and so did the team preparing the update to this plan.

We suspected that there was a lot of complexity within the watershed that would be overlooked if we based all future restoration efforts on the priorities laid out in the 2011 plan, and that opportunities to do valuable work could be missed. We set out to create a plan that collected and incorporated new data, was realistic about data gaps, identified cost effective projects that could be implemented my multiple groups, and that capitalized on the strengths of the groups already working within the watershed.

In addition to the water quality data collected for the 2011 plan, this plan incorporates two new sets of water quality data. The first set sought to replicate some of the sampling done for the original plan, targeting the "hot spot" inflows identified as priorities, and looking a little further upstream in these drainage networks to see if new information could be discerned about the sources of nutrient pollution. The results of this sampling mirrored the original dataset in two important ways: First, the "hotspots" still varied from sampling to sampling, and second, when we looked at the *loads* from each inflow instead of the concentrations, the cumulative loads flowing *into* the Animas were much lower than the load already in the mainstem of the river.

This is where the second new dataset helped to fill an important data gap. The microbial source tracking study identified the most prevalent bacterial sources to be ruminants and humans (more on this later). It also measured bacteria and nutrient concentrations much more frequently than any previous studies had, allowing us to get a much better picture of the variability in nutrient and bacteria loads over the course of a year. While a two-fold increase in total nitrogen load from one site to another might seem quite substantial on a single sampling day, it looks quite different in the context of a site that ranged from 200 to 20,000 lbs of nitrogen per day over the course of a year. This type of variability was seen for nitrogen, phosphorus, and *E.coli* loads.

Looking closer at this variability, pollutant loads at a single spot on the river were routinely 100 times higher following storm events than when it hadn't rained. Without directly sampling inflows during storms, it is still unknown which tributaries contribute the most during storm events, and the proportion of pollutant loads that are stored or recycled within the channel remains a data gap as well. However, if even 1% of storm loads were retained, that could account for almost the entirety of the loads observed at baseflow.

These two datasets changed our focus from searching for "smoking gun" inflows, to targeting pollutant sources on the landscape, especially ones that reach the river via storm runoff. Directing on-the-ground restoration efforts at addressing runoff throughout the watershed will make it much easier to address pollutant sources by land-use category, and recommend specific management measures to achieve the load reductions we need.

Who is writing this document?

San Juan Watershed Group (SJWG) was formed in 2001 with the goal of identifying and solving surface water quality problems in the San Juan River watershed. It is an ad-hoc stakeholder group that has taken a lead role in coordinating water quality sampling in the San Juan watershed, and has received grant funding for several on-the-ground projects to improve water quality.

The SJWG has decided to focus its planning efforts on the Animas River since it is the largest tributary to the San Juan River and has several water quality impairments.
SJWG led the community outreach efforts in relation to this Watershed Plan.

San Juan Soil and Water Conservation District (SJSWCD)
The District took on the roles of project management and technical leadership for the development of the LAWBP, and seeks to incorporate the implementation of this plan into the District's ongoing work on water quality, riparian restoration, woody invasive removal, invasive weed control, outreach to agricultural groups, and public conservation education.

The mission of the San Juan Soil & Water Conservation District is to protect, restore enhance and promote the wise use of natural resources and promote stewardship through education and to provide financial and administrative assistance to the citizens and groups in the district. As part of this mission, the District acts as the fiscal agent for SJWG projects (since 2011).

Mountain Studies Institute (MSI) is a non-profit organization that focuses on using research, education, and partnerships to enhance understanding of the San Juan Mountains. MSI was contracted to carry out the technical portions of the LAWBP effort, including water quality sampling, data analysis, modeling, mapping and GIS. MSI is an active partner in both the SJWG and AWP, and their involvement on the LAWBP ties in with several other projects they are carrying out within the Animas Watershed.

Animas Watershed Partnership (AWP) is another stakeholder group that is working on improving water quality in the Animas, and mainly works on the river south of Baker's Bridge, CO. AWP led the charge on the 2011 Animas Watershed Based Plan. AWP is currently focusing on the Colorado reach of the Animas, but participated as a partner agency and gave input in developing this Watershed Plan. The 2011 Plan served as a building block for this Watershed Plan and we use much of the same language from the 2011 plan.

2. Watershed Background

General Description

The Animas River is a politically and ecologically complex river. The headwaters originate in southwestern Colorado in the San Juan Mountains at altitudes greater than 12,000 feet, starting in the Alpine Life Zone and within the highly mineralized San Juan Caldera. The Animas River then flows through the towns of Silverton, CO, Durango, CO, Aztec, NM, Flora Vista, NM, and finally to the confluence with the San Juan River within the town of Farmington, NM. On its way it passes through the lands of the Southern Ute Tribe, as well as three EPA regions: Region 8 in Colorado, Region 9 in Southern Ute Tribal lands, and Region 6 in New Mexico. At the confluence, the river has dropped in elevation to 5,500 feet, into the semi-desert sagebrush scrublands and highly erosive sedimentary strata of the San Juan Basin.

The full Animas River watershed is 1,357 square miles. The Colorado portion is approximately 1,085 mi^2 and of that, 170 mi^2 are within the boundaries of the SUIT Reservation. The Lower Animas watershed within New Mexico is approximately 270 mi^2. As discussed in the introduction, this Watershed Plan will focus primarily on the New Mexico reach of the Animas River. For a full characterization of the CO and SUIT reaches, please see the 2011 Animas River Watershed Based Plan (BUGS 2011). http://animaswatershedpartnership.org/wp-content/uploads/2012/10/Final-Animas-Watershed-Management-Plan-12-22-11.pdf

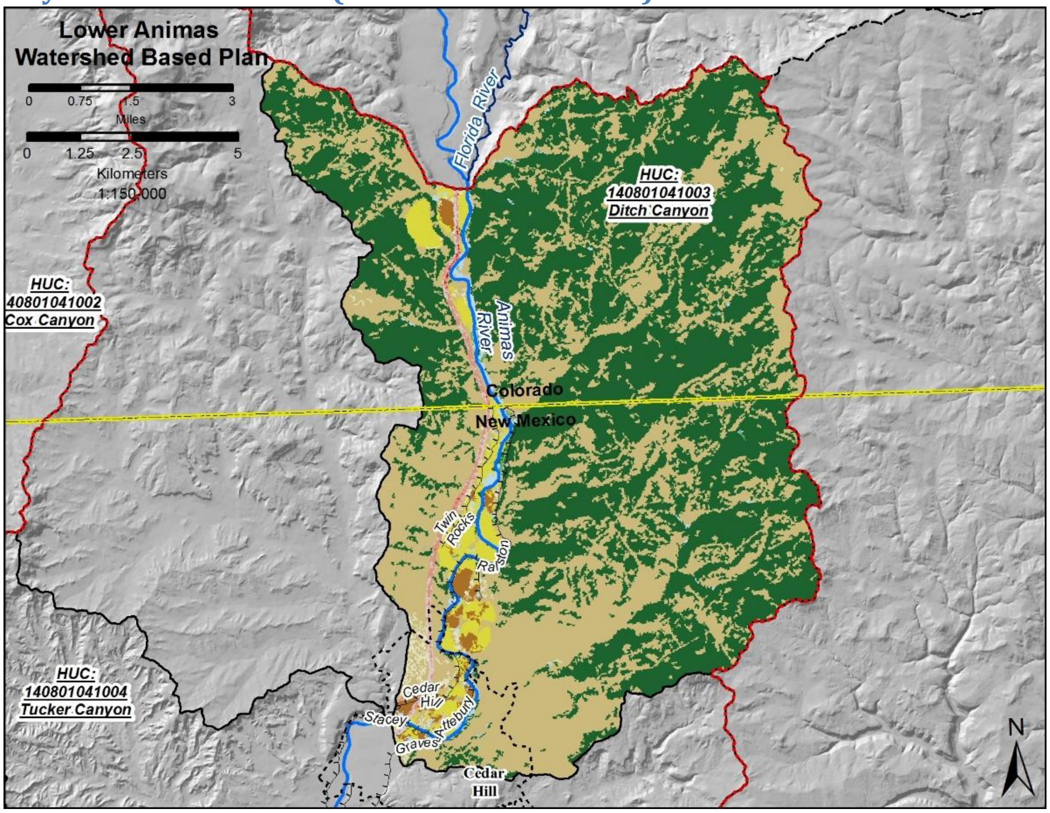
The six HUC12 subwatersheds that are the focus of this plan encompass several ephemeral and intermittent tributaries to the Animas, but include no perennial streams other than the mainstem. Despite the lack of perennial tributaries, an extensive network of irrigation ditches adds considerable hydrologic complexity to the focus area, with many ditches crossing subwatershed boundaries as they flow parallel to the Animas River through the valley. This renders subwatershed boundaries less relevant than political boundaries or irrigation ditch networks in some cases, as will become clear in the project descriptions at the end of this document.

Surface ownership within the Lower Animas Watershed (as shown in Map 9) is 35.5% private, with the majority of private land falling within one mile of the river. 42.11% of the watershed land area is federally managed (42.1% BLM and 0.01% National Park Service), 15.9% is Southern Ute Tribal Lands, and 6.4% is administered by the New Mexico State Land Office (Source: CO and NM BLM). Land use (Map 12) includes 8.9% forest, 74.7% shrub-scrub, 5.9% agriculture, 7.5% urban/developed, 2.7% riparian/open water, and less than 0.2% barren land (NLCD, Homer et al. 2011).

Each of the six focus subwatersheds is described in more detail in Maps 3-8 on the following pages.

Subwatershed Focus Areas

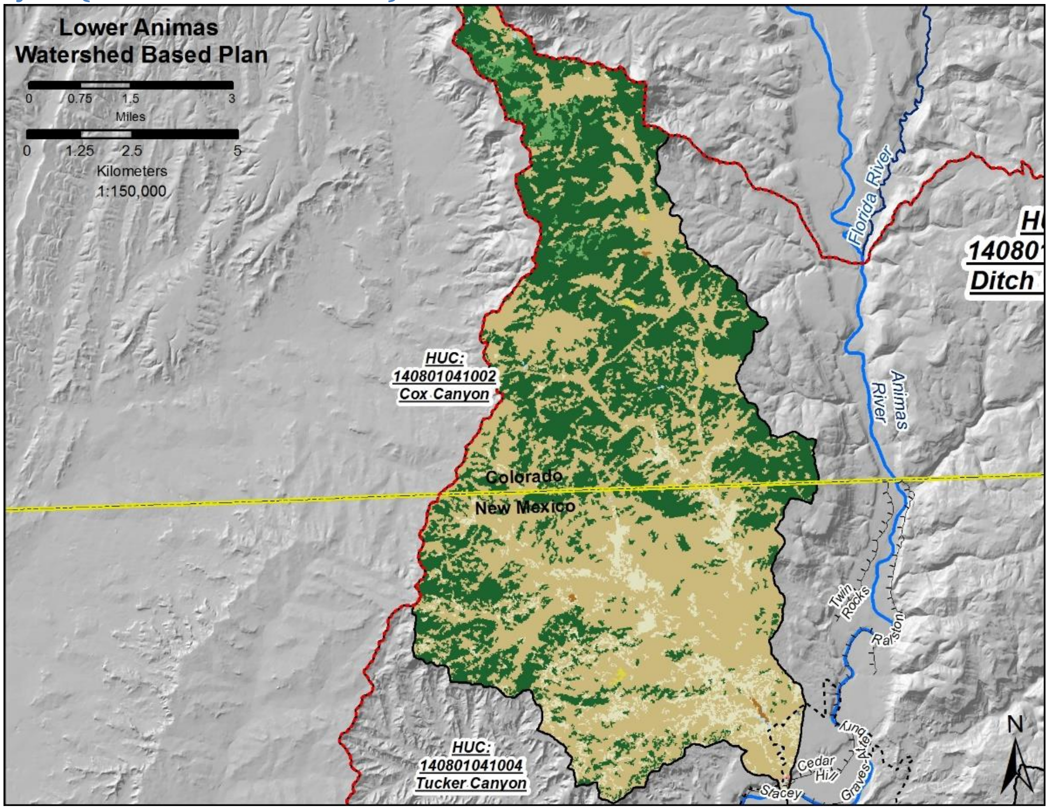
Ditch Canyon – Animas River (HUC 140801041002)



Map 3 – Ditch Canyon-Animas River HUC aka "State Line to Cedar Hill"

Description: This subwatershed includes the Animas River mainstem from downstream of the Florida River confluence in CO, across the state line to Cedar Hill, NM. It includes several ephemeral drainages, the largest of which is Ditch Canyon entering on the east side of the Animas just upstream of Cox Canyon.
Area: 57 mi^2 total; 28 mi^2 in New Mexico .
Land Use: Land use in the river valley includes irrigated cropland/pasture including several large center-pivot sprinklers, and the small, low-density residential community of Cedar Hill. Land use in the pinon-juniper uplands is oil and gas and rangeland.
Communities: Cedar Hill, Dutchman's Hill Subdivision, Animas River RV Park, 5 BLM range allotments: Lonetree Mt., Holmberg Lake, Ruins, Mt. Nebo AMP, Tank Mountain Community
Irrigation Ditches: The Twin Rocks and Ralston irrigation ditches start and terminate within the watershed, while Cedar Hill, Graves-Attebury, and Stacey ditches all begin in the watershed and continue downstream.
Impairment Status: Mainstem downstream of state line is impaired for Total Phosphorus, E.coli, Temperature, Turbidity
Restoration Needs*: Riparian pasture improvements, upland vegetation management and erosion control, diversion improvements for Cedar Hill ditch

Cox Canyon (HUC 140801041001)

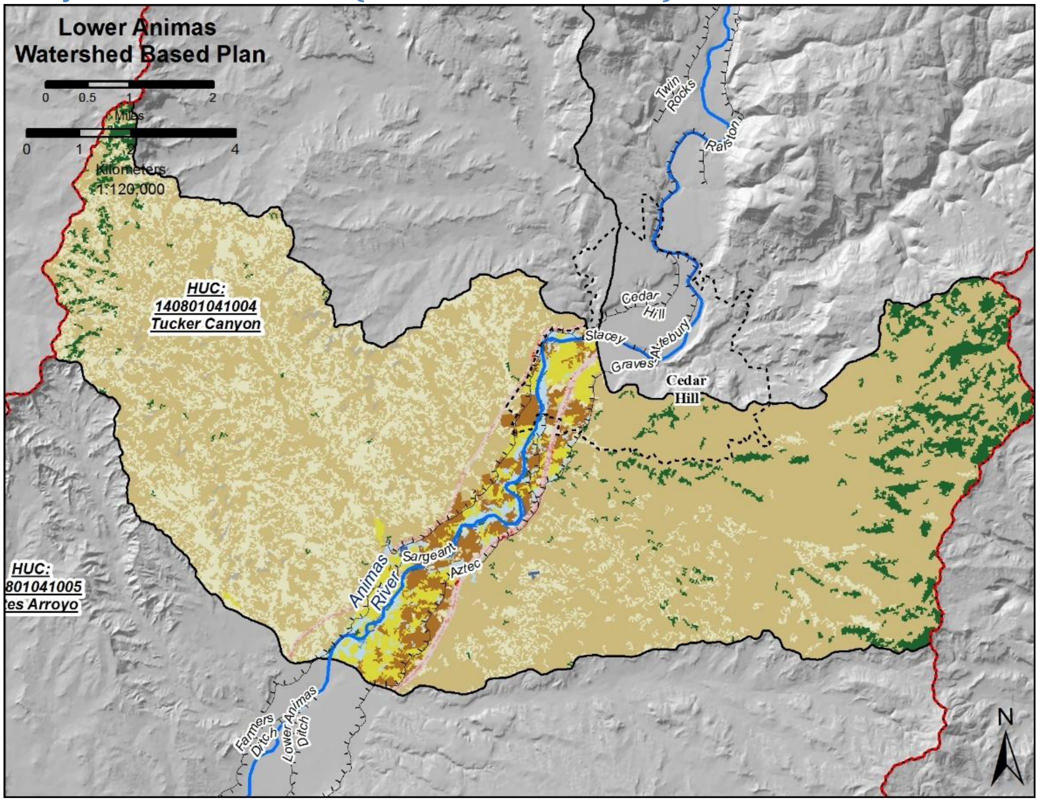


Map 4 – Cox Canyon HUC

Description: Cox canyon is a large ephemeral to intermittent wash entering the Animas from the west, and is the only true tributary watershed in the focus area (the rest include the mainstem).
Area: 41 mi^2 total; 20 mi^2 in New Mexico
Land Use: Land use in the pinon-juniper upland includes oil and gas well pads, roads, and rangeland
Communities: 2 BLM range allotments: Lonetree Mountain, Holmberg Lake
Irrigation Ditches: The Cedar Hill ditch terminates in the lower reach of Cox Canyon before it flows into the Animas.
Impairment Status: Cox Canyon is not a state-assessed water, but discharges into a reach of the Animas impaired for Total Phosphorus, E.coli, Temperature, and Turbidity
Restoration Needs*: Upland erosion control, in-stream bank stabilization/erosion control, upland vegetation management

*Restoration needs are discussed in greater detail in Chapter 5, and are summarized here for easy reference.

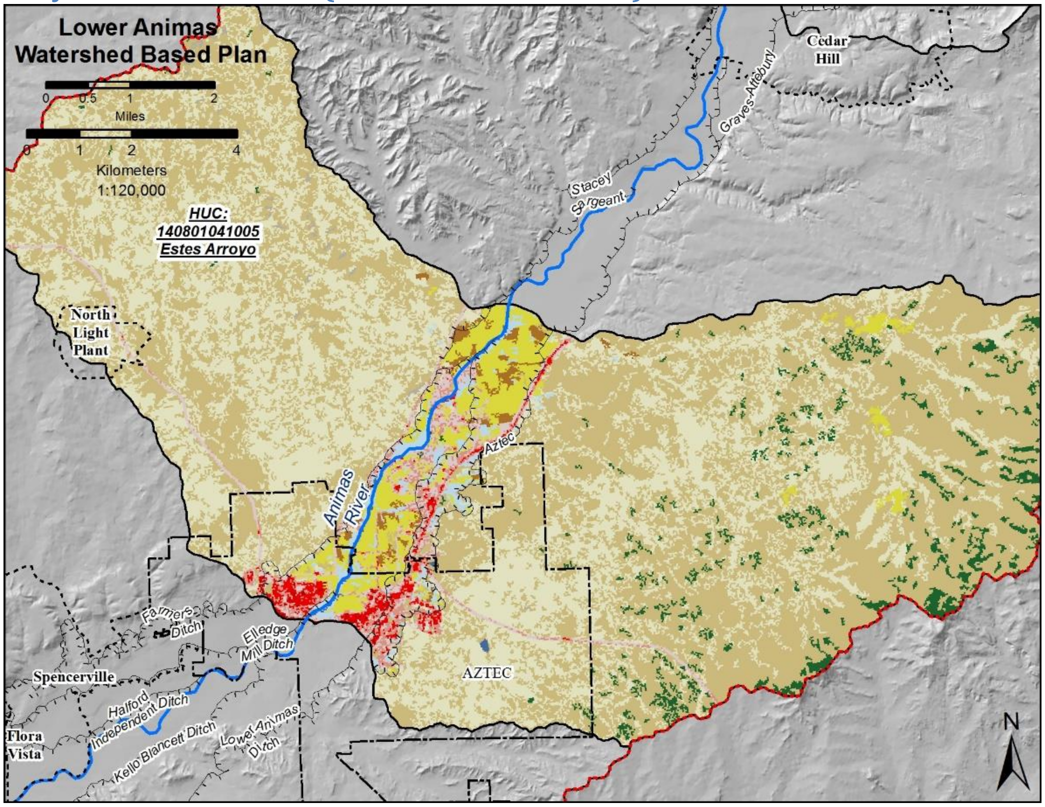
Tucker Canyon – Animas River (HUC 140801041003)



Map 5 – Tucker Canyon-Animas River HUC aka "Cedar Hill to Center Point"

Description: This subwatershed includes the Animas River mainstem south of the old Cedar Hill railroad bridge on 550, and ephemeral and intermittent tributaries on both sides of the river, including Kiffen and Tucker Canyons on the west and Miller and Arch Rock Canyons to the east.
Area: 43 mi^2
Land Use: Irrigated hay, pasture, cropland and low density residential in valley; Oil & gas roads and well pads in scrub-shrub uplands.
Communities: Includes southern part of Cedar Hill, Center Point community on the SE side of the river, and 3 BLM range allotments: Kiffen Canyon, Riverside Community, and Animas
Irrigation Ditches: Graves-Attebury ditch ends in this subwatershed, as does the Stacey Ditch, which terminates in the lower reach of Kiffen Canyon. Sargent and Aztec ditches both start in this subwatershed and continue downstream.
Impairment Status: Mainstem impaired for Total Phosphorus, E.coli, Temp, Turbidity. Kiffen Canyon identified in previous studies as a high nutrient loader, but is not a state-assessed water.
Restoration Needs*: Upland and in-stream erosion control in Kiffen Canyon, riparian buffer improvements, upland vegetation management

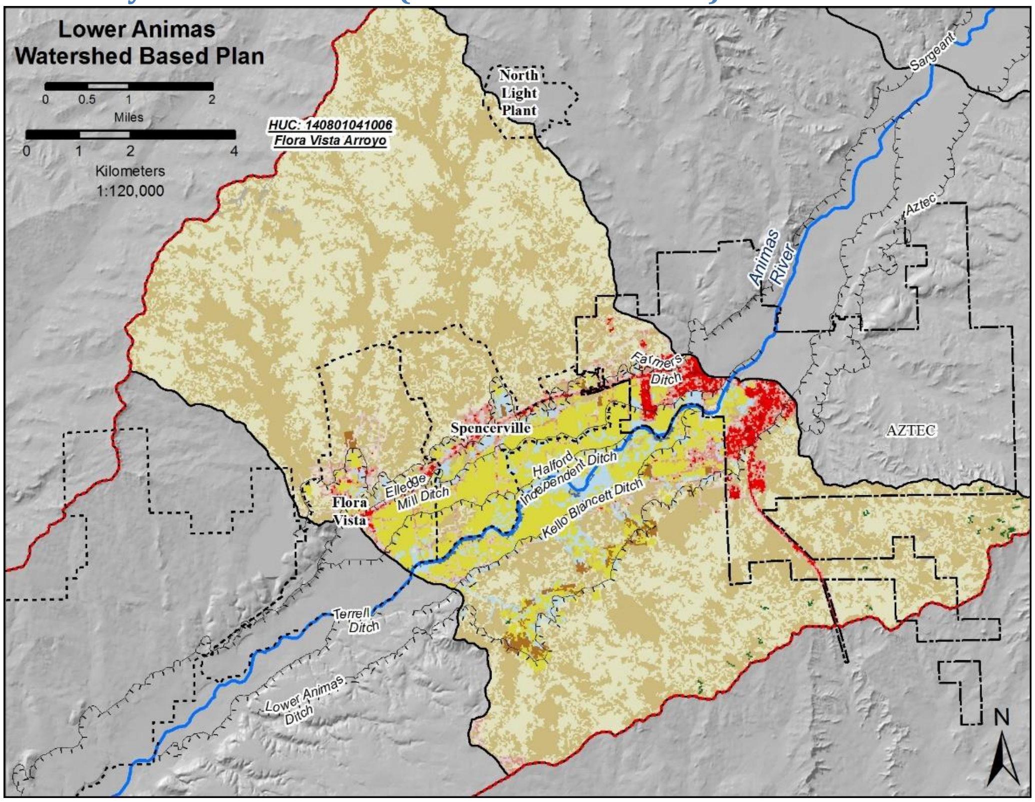
Estes Arroyo – Animas River (HUC 140801041004)



Map 6 – Estes Arroyo-Animas River HUC aka "Center Point to Aztec"

Description: This HUC includes the Animas River mainstem and ephemeral/intermittent tributaries on both east and west sides of river. Hart Canyon and Jones Arroyo enter from the East, and Bohanan Canyon, Farmer Arroyo, and Estes Arroyo enter from the West.
Area: 58 mi^2
Land Use: Valley contains low, medium, and high density residential and commercial property interspersed with irrigated agriculture. Oil & gas roads and well pads in scrub-shrub uplands.
Communities: The City of Aztec upstream (N and E) from the "Money Saving Bridge" on 516, Aztec Ruins National Monument, Ruins Road RV Park, 4 BLM range allotments: Knicker Bocker Ranch, Hart Spring, Adobe Downs, and Kiffen Canyon
Irrigation Ditches: The Sargent ditch terminates near the north end of this watershed, while the Aztec ditch runs the length of the HUC and terminates at City of Aztec drinking water reservoirs. The Farmers ditch and Lower Animas ditch have their diversions on opposite sides of the river near the north end of this HUC and continue downstream. Eledge Mill ditch diverts at the south side of this HUC below Aztec Ruins, and also flows out of the watershed and continues downstream.
Impairment Status: Mainstem impaired for Total Phosphorus, E.coli, Temp, Turbidity.
Restoration Needs*: Upland/urban stormwater management, riparian pasture improvements, septic/sewer infrastructure, streambank floodplain improvements

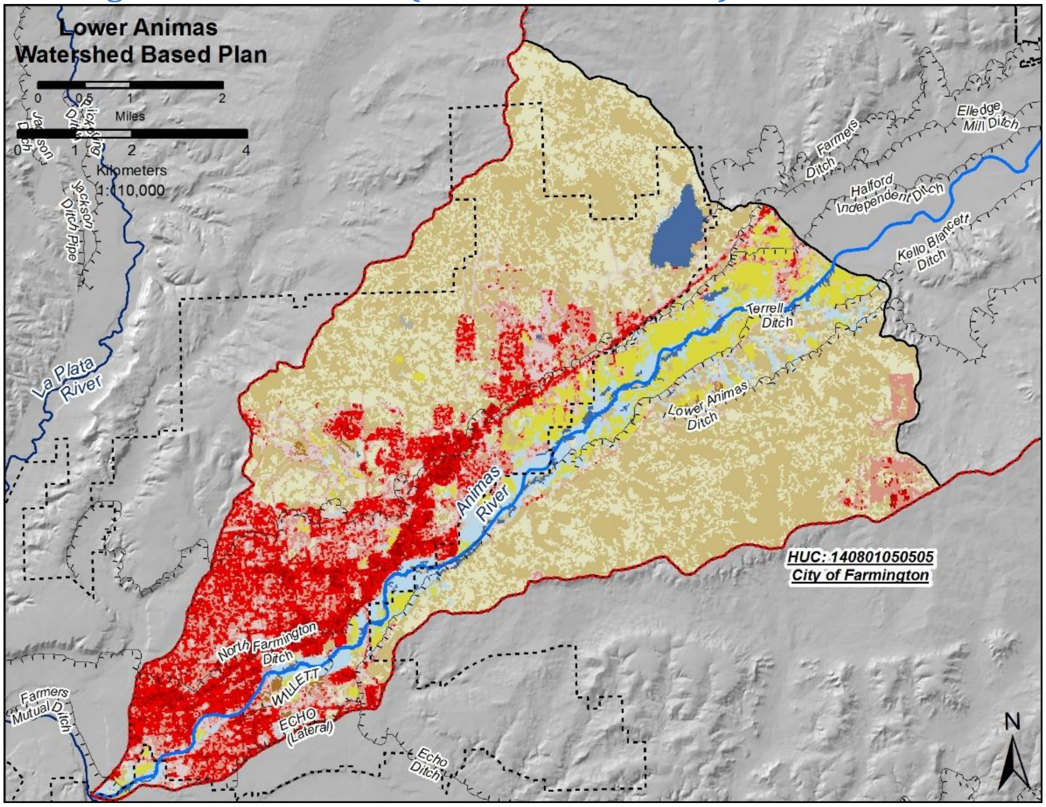
Flora Vista Arroyo – Animas River (HUC 140801041005)



Map 7 – Flora Vista Arroyo-Animas River HUC aka "Aztec to Flora Vista"

Description: Animas River mainstem from the "Money Saving Bridge" in Aztec to just upstream of Flora Vista 350 Bridge. Flora Vista arroyo is ephemeral in the uplands, becoming perennial in the valley with intercepted groundwater and irrigation return flows. Several other arroyos enter on both sides of the river, including Williams Arroyo in Aztec.
Area: 43 mi^2
Land Use: Increasingly residential, with medium-high concentrations in the floodplain and low uplands. Continued irrigated agriculture. Oil & gas roads and well pads in scrub-shrub uplands.
Communities: The south side of the City of Aztec, Spencerville, NE portions of Flora Vista. Parts of Crouch Mesa community, including the County landfill are in the uplands on the south side of the river. 3 BLM range allotments: Crouch Mesa, Barton Arroyo, Flora Vista
Irrigation Ditches: Five irrigation ditches traverse this subwatershed, with the Farmers, Eledge Mill, and Lower Animas ditches all starting in the upstream watershed and continuing downstream. The Halford-Independent and Kello-Blancett ditches both begin within the watershed but also continue downstream, meaning there are no ditch terminuses within this subwatershed.
Impairment Status: Mainstem impaired for Nutrients/Eutrophication, E.coli, Temperature.
Restoration Needs*: Septic/sewer infrastructure, riparian pasture improvements, streambank floodplain improvements, upland erosion control and vegetation management

City of Farmington – Animas River (HUC 140801041006)



Map 8 – City of Farmington-Animas River HUC aka "Flora Vista to Farmington"

Description: This HUC includes the Animas River mainstem from approximately the County Road 350 Flora Vista bridge, to the San Juan River confluence in Farmington. Between Flora Vista and Farmington, many ponds exist within the floodplain, and were likely dug out in areas that formerly functioned as wetlands. Porter and Hood Arroyos flow through the City of Farmington.	
Area: 33 mi^2	
Land Use: Land use is increasingly high density commercial and residential as you move downstream, with development occurring up to the river's edge in many places.	
Communities: The majority of Farmington's population lives within this subwatershed. Small portion of Flora Vista BLM range allotment	
Irrigation Ditches: 4 irrigation ditches that start upstream terminate in this watershed: Farmers, Eledge Mill, Kello-Blancett, and Lower Animas. The Halford-Independent flows into and through the subwatershed, terminating in Farmington Glade. Six more ditches have diversions in this subwatershed and either terminate or flow towards the San Juan: Ranchmans-Terrell, Willett, Star, Farmington-Echo, North Farmington, and Farmers Mutual.	
Impairment Status: Mainstem impaired for Nutrients/Eutrophication, E.coli, Temperature.	
Restoration Needs*: Diversion improvements, floodplain restoration, urban stormwater BMPs and detention basins, in-stream restoration	

Geology & Soils

All of the Lower Animas defined in this plan is located in the San Juan Basin (Map 2), a large depressed region in northwestern New Mexico and southwest Colorado known for its rich coal, oil and gas deposits. Cretaceous and Paleogene sedimentary rocks bow down in the San Juan basin into a large shallow sag approximately 100 miles across (Campbell and Brew 1996). The geology of the Lower Animas watershed is predominantly comprised of the Paleocene Nacimiento Formation, with limited areas of the San Jose Formation. The Lower Animas river corridor consists of Quaternary alluvium (NMBGMR 2003). The sedimentary rocks that fill the San Juan Basin contain both source rocks and natural reservoirs for oil and gas found from 550 to 4000 feet below the surface (Campbell and Brew 1996). The San Juan Basin contains over 35,000 well sites and a vast network of connecting roads and pipelines, which contribute to erosion issues in the uplands (Map 14).

Upstream from the focus area of this plan, the Animas headwaters begin in the Silverton Caldera, which is comprised of volcanic rocks formed during the massive eruptions of the Eocene throughout the San Juan Mountains (Ellingson 1996). This area is highly mineralized (Bove et al. 2007), and as a result the Upper Animas is affected by natural acid rock drainage exacerbated by the anthropogenic effects of hard rock mining (Besser et al. 2007). Ore deposits (both underground and exposed) contain sulfides of iron, copper, antimony, arsenic and zinc. Exposing iron pyrite located in these deposits to the atmosphere directly or indirectly results in a series of reactions with water and oxygen to produce ferric hydroxide (Bove et al. 2007). Ferric hydroxide precipitates out of waterways rapidly as a result of its insolubility, coating rocks in the stream bed with light yellow/orange precipitate (Besser et al. 2007). The chemical reactions that produce ferric hydroxide also increase the acidity of the waters draining from historic mines into the upper Animas River watershed. This increase in acidity increases the dissolved load of metals with lead, arsenic, zinc, and aluminum being of concern for impairments to aquatic life and human health (Besser et al. 2007).

As it leaves its upper watershed, the Animas River passes through Proterozoic metamorphic and granitic strata then the sedimentary strata of the Paleozoic and Cenozoic eras (von Guerard, et al. 2007). It has been observed that, likely due to the changes in geology upon leaving the Silverton caldera, the dissolved metal load, in the Animas River, from acid mine drainage and natural processes, decreases considerably between Silverton and Bakers Bridge (US EPA 2015). It is probable, except for aberrant events like the Gold King mine release, that dissolved metal loads from the upper watershed pose little concern for the area defined in this plan.

Due to the geology of the area defined in this plan and a number of contributing subwatersheds along the middle reaches of the Animas River, high sediment loads are normal during certain times of the year, especially during the later summer monsoon season. Both the naturally erodible geology and upland uses (both energy extraction and grazing) contribute to occasionally high sediment loads. Due to the types of soils originating from the geologic strata of the San Juan Basin, these sediment pulses could contribute to the phosphorus load of the Animas River, though at the moment this still remains a data gap.

Vegetation

The vegetation communities of the Lower Animas are dominated by Inter-Mountain Basin and Colorado Plateau shrublands, with *Artemisia tridentate* (big sagebrush), Chrysothamnus sp. (rabbitbrush), Ephedra sp. (Mormon tea), and Coleogyne ramosissima (blackbrush) making up much of these shrub comminutes (Map 13) (SWReGAP 2011). In the higher elevations of the Lower Animas, Pinon-Juniper woodlands and *Quercus gambelii* (Gamble oak) shrublands can be found (SWReGAP 2011). While characterized as "Forest" in land-use models, this vegetative community differs in both form and function from closed canopy forests.

Due to both historic and recent grazing pressures in the uplands, and human alteration within the riparian corridor throughout much of the Lower Animas, the native communities of upland grasslands and lowland riparian species are no longer present in many areas. The Animas watershed has been observed to be deficient in the herbaceous components as identified by the Ecological Site Descriptions (SWReGAP 2011 and Homer et al. 2015). These herbaceous components, historically consisting of perennial grasses and annual forbs, have a key role of slowing down surface water flow and promoting infiltration which in turn reduces the overall erosion and its subsequent problems. Uplands identified to have a reduced herbaceous component have been observed to be susceptible to erosion and accelerated soil loss.

The woody invasive species Russian olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix* sp.), have changed the historic fire regimes of the riparian ecosystems and have taken over the flood zones, irrigation canals, and local arroyos to the point of creating an extreme fire hazard to residents and firefighting agencies (SJB CWPP 2014). Historically, these ecosystems supported low-frequency, low-intensity fires that did not adversely affect the cottonwoods as they are not fire-adapted (USFWS, 2002) and generally intolerant of fires (Quigley, 2013). Current conditions show a higher intensity and severity of fires; with all species consequently burning including the cottonwood, which are less resilient to fires compared to salt cedar (USFWS 2002). Fires tend to reduce cottonwood populations and allow the establishment of more fire-tolerant species such as salt cedar (Smith, 2009). Many of the BMPs addressed later in this document address invasive species by the re-introduction of native communities throughout the watershed.

Climate and Hydrology

The climate in the watershed is characterized by a declining precipitation gradient where average annual precipitation ranges from 22 inches in Silverton, Colorado (9,300 ft) to 8 inches in Farmington, New Mexico (5,300 ft) (WRCC 2015). Winter snowfall and late summer monsoonal thunderstorms are the primary sources of precipitation in the watershed, and winter snowpack is an essential element of water storage. Lemon Reservoir on the Florida River, a major Animas River tributary, was built in order to store runoff from snowmelt and precipitation after the snowmelt season, primarily for irrigation purposes. Lake Nighthorse provides off-river storage from the Animas to fulfill multi-purpose water deliveries as part of the Animas La Plata Project, and Farmington Lake provides off-river storage for Farmington's municipal water supply.

Streamflow in the Lower Animas is dominated by snowmelt runoff, which typically occurs between April and July, peaking in late May or early June and decreasing in July. With only off-channel storage, the Animas is one of the last undammed rivers in the nation. Snowmelt runoff is augmented by monsoonal storm events from July through September, though peak annual flows can occur in any month. Low stream flow conditions typically exist from late August to March (Figure 1). Base stream flow in the Lower Animas is maintained by groundwater flows.

Monsoonal precipitation events can be very small in area and short in duration, but often dump a lot of precipitation in a short period of time. These high-intensity short-duration storms cause flashy peaks in the hydrograph and vary greatly from year to year.

Historical and live streamflow conditions in Colorado can be found at: http://waterdata.usgs.gov/co/nwis/current/?type=flow&group_key=huc_cd and in New Mexico at: http://waterdata.usgs.gov/nm/nwis/current/?type=flow.

Though still unpublished as of spring 2016, the New Mexico Bureau of Geology is developing a report that includes piezometric mapping of the alluvial aquifers of the Lower Animas watershed. This is being developed to determine which times of year the surface water is influencing groundwater and vice versa, as well as how unlined diversions may be affecting the hydraulic gradient. The report will likely be available at https://www.env.nm.gov/riverwatersafety/ once published.

Structures that divert surface water occur within the Animas River channel throughout the watershed. Water from the Animas is diverted for a variety of uses including irrigated agriculture, commercial and public drinking water, irrigated lawns and golf courses, and other municipal and industrial uses (SJB Regional Water Plan 2016).

There are 17 canals and ditches operating along the Lower Animas (See Maps 3-8 for close-ups). These diversions, and their average discharge, are presented in Table 2. Diversions can significantly reduce the volume of water in the river channel, especially during late summer and early fall. Summer minimum flows at Cedar Hill are close to 200cfs higher than downstream at Farmington (Figure 1), much of which can be attributed to diversions. Improving diversion infrastructure (such that ditches do not have to divert as much water to successfully get their adjudicated flow rate, See Table 2) is an opportunity to maintain in-stream flows and reduce the concentration of pollutants at low flows.

Once water is diverted, some of it returns to the river via irrigation return flows (tailwater), seepage into shallow groundwater from earthen lined ditches, or carriage water that remains in ditches at the end of their length. Each of these is also a pathway by which pollutants can reach the river. It should also be noted that the majority of the canals and ditches are earthen and lose water volume to seepage; this affects the groundwater hydrology and may also support a larger zone of riparian vegetation and even wetlands.

Due to a high desert climate, most of the Lower Animas HUC 12 subwatersheds do not contain a perennial stream other than the mainstem of the Animas River (Map 11). The complex irrigation network includes flumes which cross arroyos and natural watershed boundaries, making topography alone insufficient to analyze pollutant sources. While the ephemeral arroyos and dry washes do not directly influence the river during baseflow, they can contribute large pulses of sediment and nutrients from the uplands during monsoonal storm events. These loads are unpredictable and ephemeral, but have a significant impact on the river when they occur.

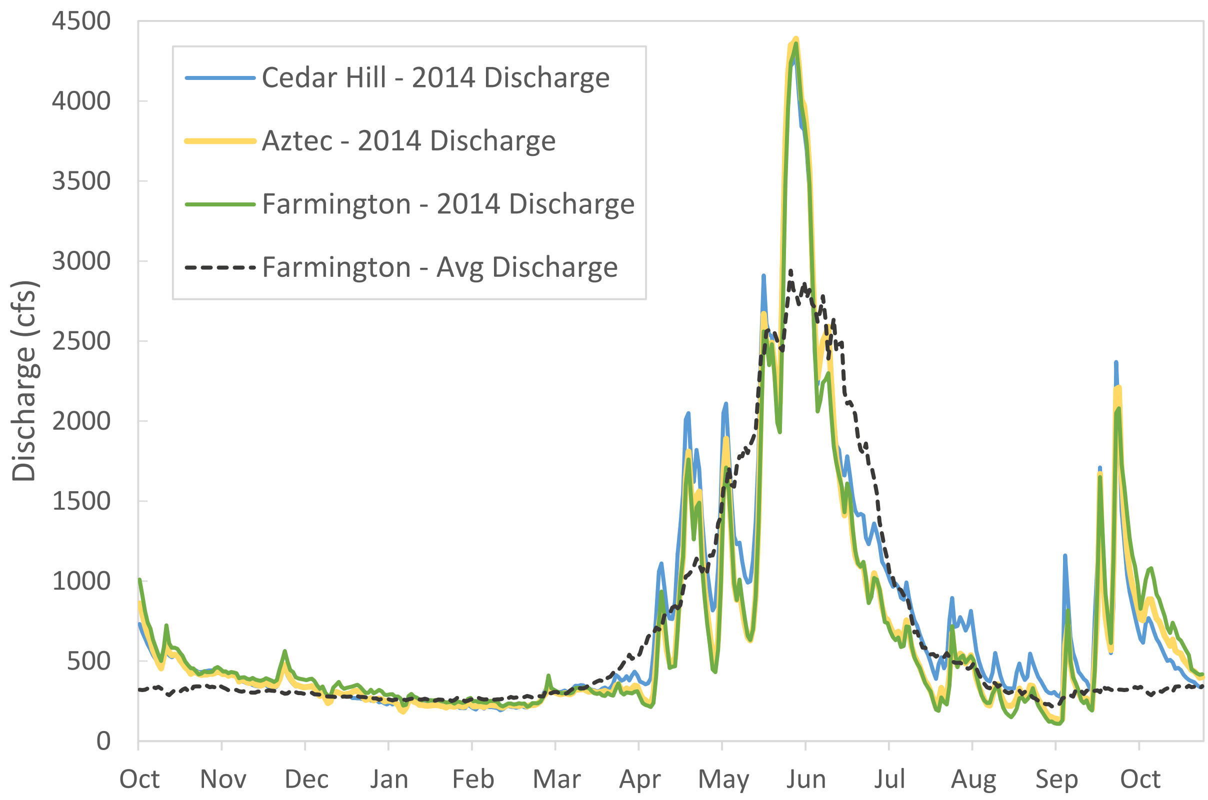


Figure 1. Discharge of the Animas River in 2014

Cedar Hill (9363500), Aztec (9364010), and Farmington (9364500) USGS gages. One-hundred year average of Animas River discharge at Farmington is also included.

Table 2. Average 2015 diversion versus adjudicated flow rate for 17 Animas ditches

(NM Office of the State Engineer, provisional data as of 10/2/2015, subject to change). Ditches are listed by diversion location from up to downstream. See HUC12 subwatershed maps (Maps 3-8) for ditch locations.

Diversion Name	Average Diversion (cfs)	Adjudicated Flow Rate (cfs)	Notes
Twin Rocks	17	8.62	
Ralston	22	9.52	
Cedar	11	8.52	
Graves-Atterbury	23	17.76	
Stacey	25	12.08	Diversion includes Sargents ditch
Aztec	44	34.57	Includes 2-3 cfs for the City of Aztec
Sargent	6	4.5	
Lower Animas	43	56.57	
Farmers Irrigation	46.17	32.66 + 50	50 is for City of Fmtn.
Eledge	22	25.79	
Kello-Blancett	13	13.15	
Halford-Independent	25	85.48	
Ranchmans-Terrell	5	8.63	
Farmington Echo	38	55.86	
North Farmington	5	43.8	Ditch turned off one month for construction; see 2014 for avg. data
Willett	NA	206.61	Most of water returned to river before final diversion
Farmers Mutual	83	104.53	

Agriculture

Private land in the Animas Valley is concentrated along the river corridor (Map 9), and so is irrigated agriculture (Map 12). Wells are rarely used for irrigation in this area, so the irrigated land must rely on surface water and thus it is all hemmed in between a ditch and the river. While agricultural lands make up only 5.9% of the total watershed area, cropland or hay/pasture dominates 26 % of the area within one mile of the Animas River and 63% of all croplands in the area defined in this plan are within 1 mile of the Animas (USDA 2012). This means that edge-of-field runoff has a short path to the river and can thus have a disproportionate effect on water quality.

Due to the low annual rainfall, non-irrigated agricultural activity is limited to rangeland grazing in the sagebrush and pinon/juniper uplands. Many livestock producers rotate their fields seasonally between irrigated hay and winter pasture, moving livestock based on seasonal forage availability. Cattle are the dominant livestock animal, with some sheep, goats and horses as well.

Irrigated agriculture within the Lower Animas watershed is characterized by small acreage: mean parcel size is 25.4 acres, while median is 6.3 acres (San Juan County Assessor data, accessed by NRCS staff Sept 2015). There are only 16 landowners in the watershed who manage 100 acres or more, meaning that outreach to many landowners is necessary to ensure wide implementation of agricultural best management practices. Alfalfa and grass hay are the most common crops, along with pastures for livestock (Map 17). Refer to HUC12 subwatershed maps, Maps 3-8, for greater detail. Most farmers in the area grow a hay crop or manage livestock in addition to holding full-time, off-farm jobs. This leads to single crops and simple, inexpensive management methods such as flood irrigation being more common than more expensive, management intensive methods that may yield higher benefits for a full-time operation. These details are important to keep in mind for agricultural outreach efforts.

Looking at the whole Animas watershed, the majority of irrigated agricultural land is found within the Florida River drainage, the last perennial tributary to the Animas River. The Florida enters the Animas immediately upstream of this plan's focus area, and is a known contributor of agricultural related pollutants (SJSWCD 2015, BUGS 2011). The Animas Watershed Partnership is currently working on several active restoration projects on the Florida that can be used as models for future work in the Lower Animas watershed.

Discharge Permits

There are five NPDES individual permits along the Lower Animas: City of Aztec water supply; City of Aztec wastewater treatment plant (WWTP); and the City of Farmington's WWTP, Animas Steam Plant (NPDES permit terminated as of March 26, 2015), and Bluffview Generating Plant. The Aztec WWTP is the only plant currently under a regulated waste load for nitrogen and phosphorus as part of the nutrient Total Maximum Daily Load (TMDL) for the Animas River (NMED 2006). The City of Farmington's WWTP is located near the San Juan confluence, and discharges to the San Juan River which is not currently subject to nutrient regulation.

The Aztec and Farmington WWTPs serve the only sewered areas in the Lower Animas watershed. All areas outside these service areas use on-site liquid waste disposal (ie: septic tanks).

In Colorado, there are a number of NPDES individual permits along the Animas River including the City of Durango wastewater treatment plant and a number of other smaller wastewater treatment plants that serve resorts, subdivisions, or mobile home parks (ECHO

2015). In previous studies (BUGS 2011), the Durango WWTP was found to be the single largest source of nutrient load on the Animas. The plant is currently scheduled for upgrades in preparation for Colorado's new nutrient regulations.

Drinking Water Sources

Surface water from the Animas River is the primary source of drinking water for the communities of Farmington, Aztec, and Flora Vista, as well as outlying rural communities and several downstream communities on the San Juan. Water used by Farmington is delivered and stored in Farmington Lake via the Farmers Ditch and Animas River Pumping Station #2 at Penny Lane. Farmington has another point of diversion (Animas River Pumping Station #1) on Willett Ditch which delivers water directly to Water Treatment Plant #1. Aztec water is delivered to their storage reservoirs via the Aztec Ditch, and two secondary surface water sources. There is also a pipeline connecting the cities of Aztec and Bloomfield, from which drinking water can be shared in an emergency. Table 3 shows the five water systems in New Mexico with permits to deliver drinking water originating from the Animas River; locations for drinking water sources can be viewed at https://gis.web.env.nm.gov/EGIS/. Individual domestic wells are also in use within the watershed, with details available at the following link: https://www.env.nm.gov/riverwatersafety/150808LSTAnimasDomesticWells.pdf

Table 3. Public drinking water systems

Water System Name	Population Served	Water System ID
Northstar MDWCA	3,976	NM3520024
Aztec Domestic Water System	6,800	NM3509824
Farmington Water System	47,000	NM3510224
Flora Vista Mutual Domestic	4,300	NM3510024
Morningstar Water Supply System	6,423	NM3510524

Source: http://iaspub.epa.gov/enviro/sdw_query_v3.get_list?wsys_name=&fac_search=fac_beginning&fac_county=San%20Juan&pop_serv=500&pop_serv=3300&pop_serv=10000&pop_serv=100000&pop_serv=100001&sys_status=active&fac_state=NM&page=1 Oct 13, 2015

A source water protection plan is currently being developed for the city of Farmington with the assistance of NMED's Drinking Water Bureau's Source Water Protection Program. Source water protection plans for Aztec, Northstar, Flora Vista and Morningstar Public Drinking Water Systems may be developed as a result of the 2015 Gold King Mine Spill into the Animas River. Primary concerns are that sediment containing heavy metals from the spill could enter the drinking water systems after being mobilized during spring runoff or storm events. The source water protection plans will identify those risks and include methods to prevent the entry of heavy metals and other pollutants to the systems. Coordinating the protection of drinking water and overall watershed health can lead to unique partnerships with entities like the Source Water Protection Program and Drinking Water State Revolving Fund also benefiting surface water quality. This information was provided by David Torres with the Source Water Protection Program.

Demographics

The population estimate for San Juan County, NM in 2014 was 123,785 people (See Table 4). While not all of these people live within the Lower Animas focus area, it gives an idea of the number of people frequenting the metropolitan area of Farmington. Table 4 shows the populations of the counties and cities that overlap with or are entirely within the Animas watershed (Source: http://quickfacts.census.gov/). Along the Lower Animas, population and intense urban development are confined to a few areas, with the section of the Animas between Farmington and Aztec being the most populated, Map 10.

Table 4. County and city populations in 2014

County/City	Population Estimate 2014
San Juan County, CO	720
La Plata County, CO	53,989
Durango	*17,834*
San Juan County, NM	123,785
Aztec	*6,419*
Farmington	*44,445*

Threatened and Endangered Species

There are six threatened and endangered animal species with potential to occur along the Lower Animas River (Table 5). Although there is critical habitat designated along the San Juan River (Colorado pikeminnow, Razorback sucker, and the Yellow-Billed Cuckoo), there is no critical habitat designated for these species on the Animas River.

Management of the Colorado Pikeminnow and the Razorback Sucker is significant to the Animas River because critical habitat areas for the recovery of these fish species have been designated downstream on the San Juan River by the San Juan Recovery Implementation Program (SJRIP). The purpose of SJRIP is to recover endangered fishes in the San Juan River basin while water development and management activities continue in compliance with all applicable Federal and State laws.

Management and activities within riparian areas have the potential to affect habitat for Southwest Willow Flycatcher, Yellow-billed Cuckoo, and the New Mexico Meadow Jumping Mouse. These species exclusively inhabit vegetation adjacent to streams, and seek out dense native willow thickets (or *Tamarix* spp. in their absence), old growth cottonwood stands, and dense herbaceous areas, respectively (USFWS 2014).

Actions taken to benefit endangered fish and the riparian species above (ie: improving diversions to reduce fish entrainment, maintaining minimum base flows, and planting of riparian buffer vegetation) will provide auxiliary benefits to water quality on the Animas.

The Southern Ute Indian Tribe, the Colorado Parks and Wildlife (CPW), New Mexico Game and Fish Department (NMG&F), SJRIP, and USFWS are the management agencies primarily involved in the monitoring and habitat restoration for these species. All state and federal agencies must comply with the National Environmental Policy Act to minimize impacts to T&E species, however, and should keep in mind the multiple benefits that habitat improvements can have within the watershed.

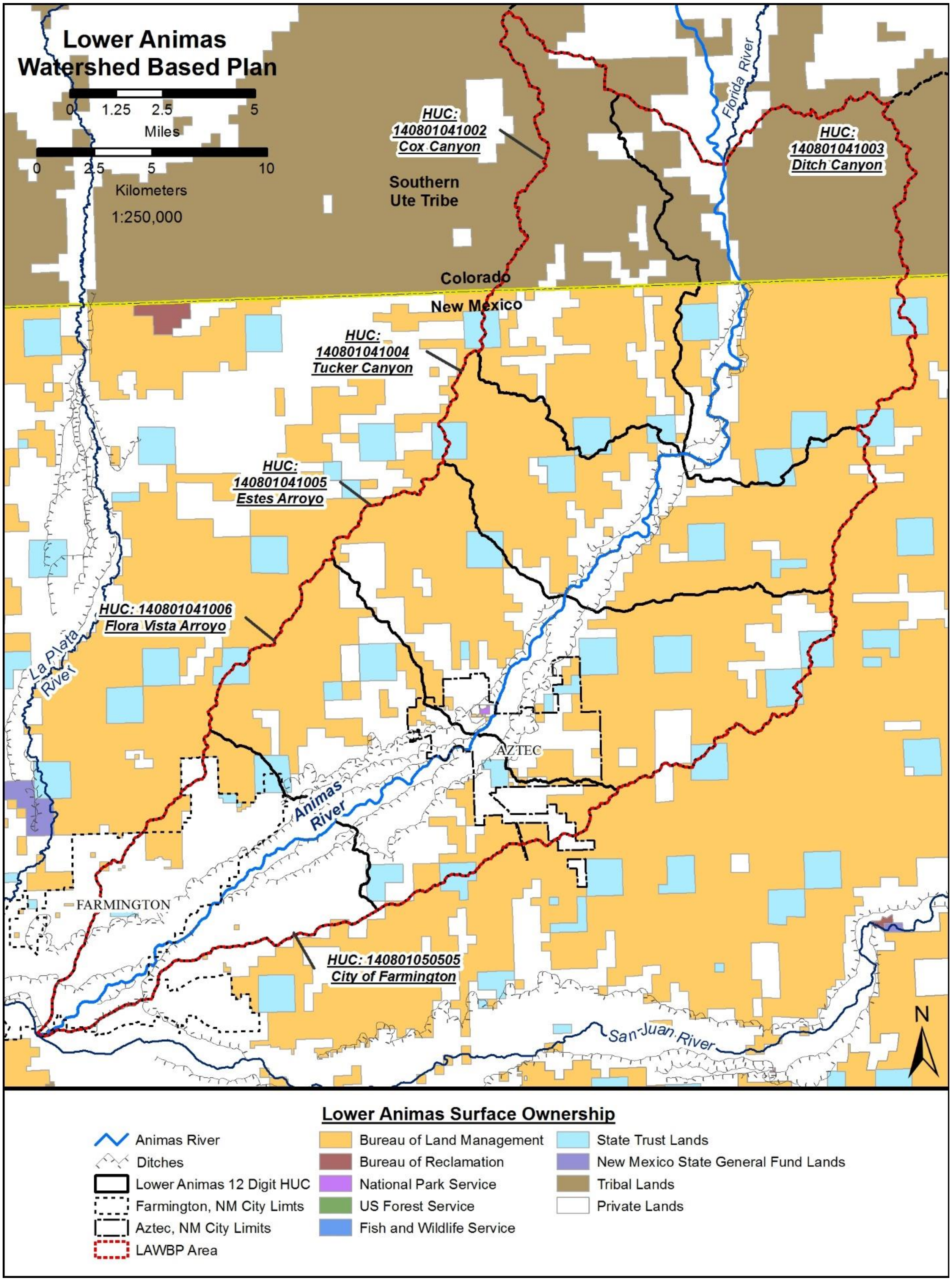
Table 5. Threatened and Endangered species with potential to occur along the Lower Animas River
(USFWS 2014, 2015)

Species Name	Status	Habitat Description
Colorado Pikeminnow *(Ptychocheilus Lucius)*	Endangered; Critical Habitat is designated on the San Juan River, but not the Animas River	
Razorback Sucker *(Xyrauchen texanus)*	Endangered; Critical Habitat is designated on the San Juan River, but not the Animas River	
Zuni Bluehead Sucker *(Catostomus discobolus yarrow)*	Endangered; Critical Habitat is not designated on the Animas River or the San Juan River	
New Mexico Meadow Jumping Mouse *(Zapus hudsonius luteus)*	Endangered	Riparian habitat dominated by tall, herbaceous species (especially sedges, and reed canarygrass) with adjacent, intact upland areas.
Southwest Willow Flycatcher *(Empidonax traillii extimus)*	Endangered	Dense, shrubby riparian vegetation; usually in close proximity to surface water or saturated soil.
Yellow-billed Cuckoo *(Coccyzus americanus)*	Threatened; Critical Habitat is designated on the San Juan River, but not the Animas River	Riparian woodlands in arid to semi-arid landscapes. Preferred nesting habitat includes mature woodland with dense understory at least 42 acres with a minimum of 7 acres being closed-canopy broad-leaved trees.

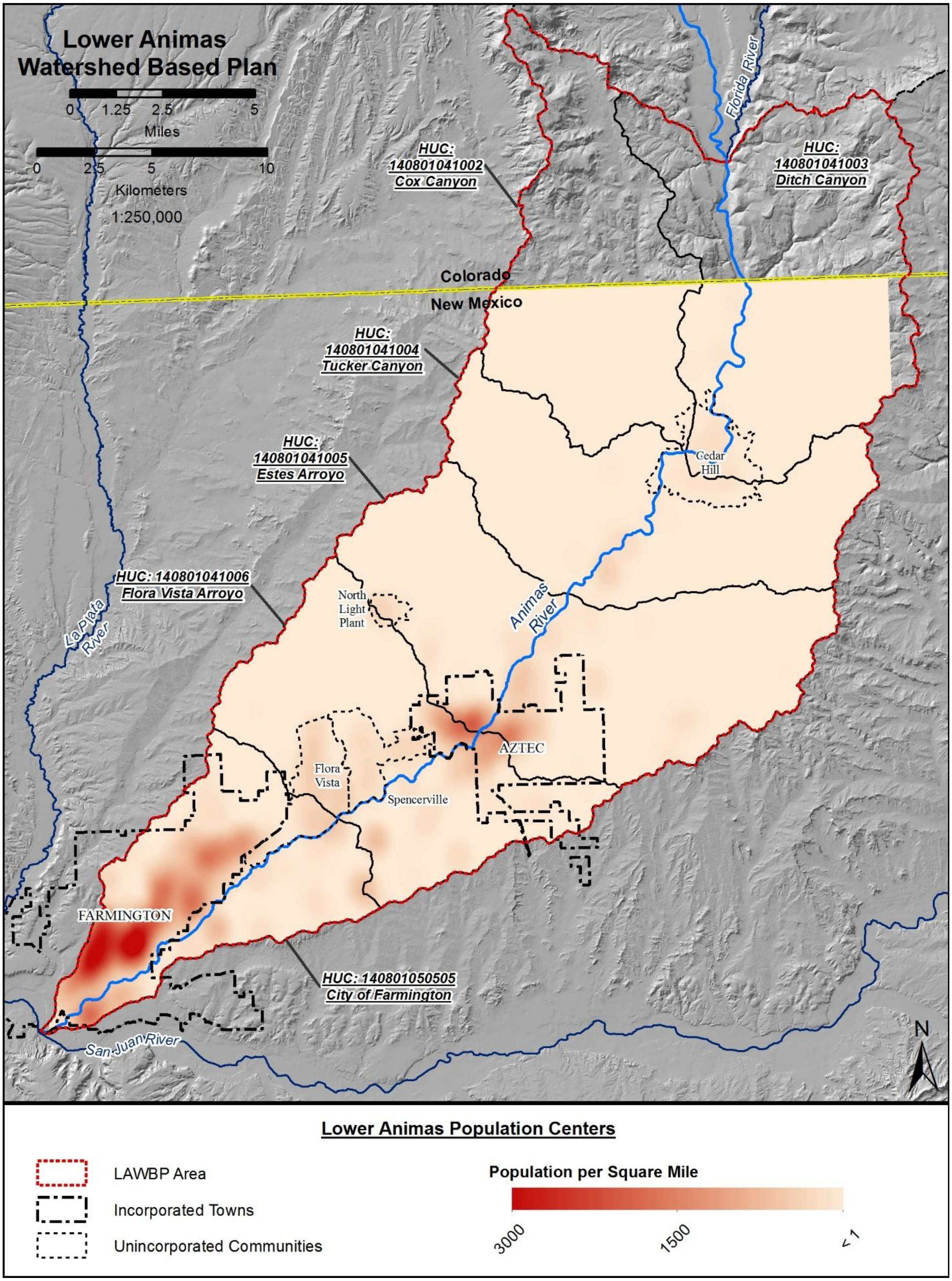
Maps

The following pages include maps developed to help the reader better understand the watershed. They include surface ownership, population centers, topography and hydrology, land cover, vegetation cover type, surface disturbance, river miles from the confluence with the San Juan River, location of 2014 water sampling sites, agricultural census data, and soils.

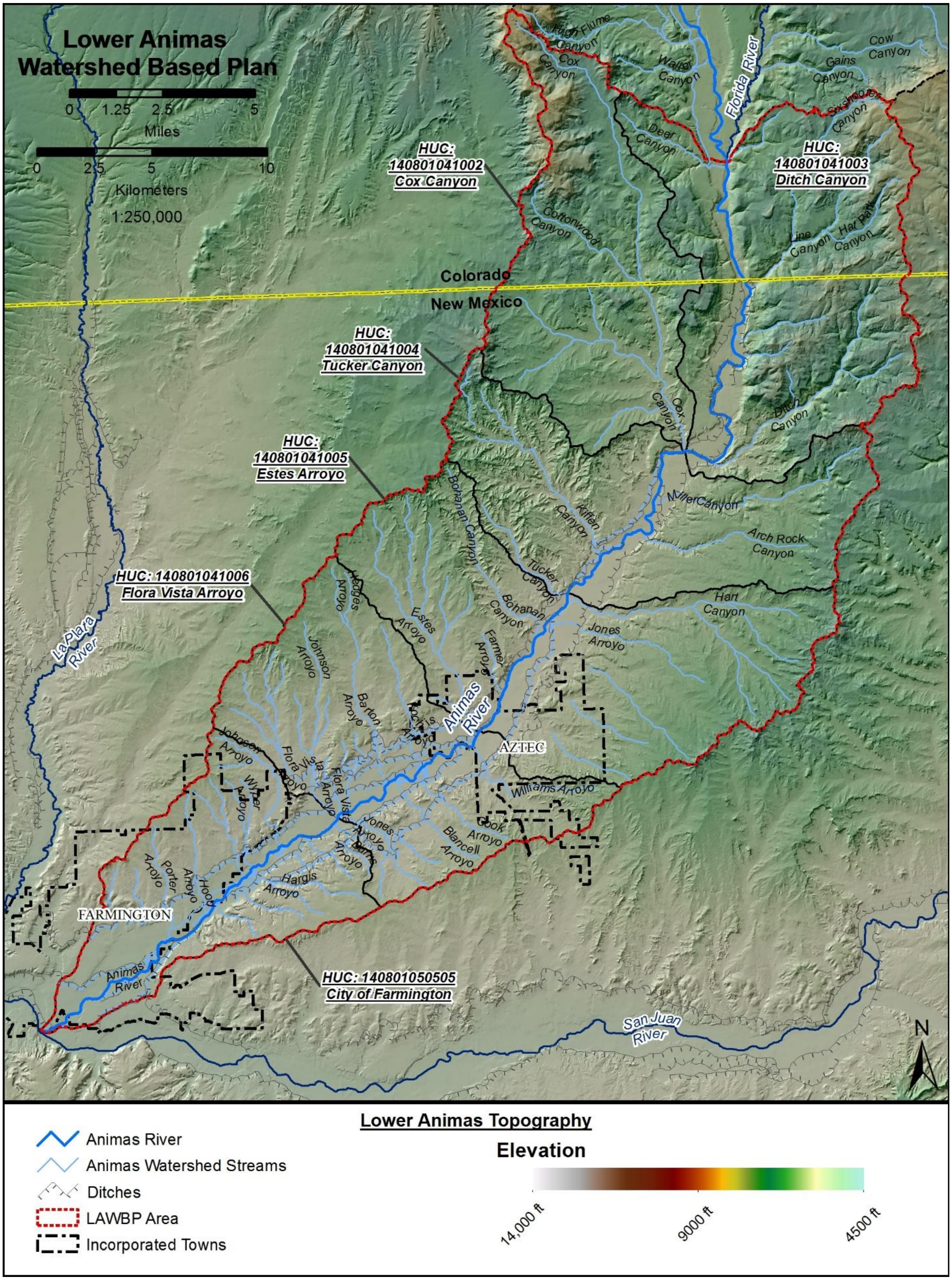
The two soils maps (Maps 18 and 19) represent the approximations for soil erosion and nutrient contribution from soils. On the wind erosion index (WEI) map, the higher numbers represent a higher potential for erosion from all mechanisms. The cation-exchange capacity (CEC) is a little more abstract; the lower the number the less absorptive a soil is and therefore has a greater potential for nutrient pollution contribution.



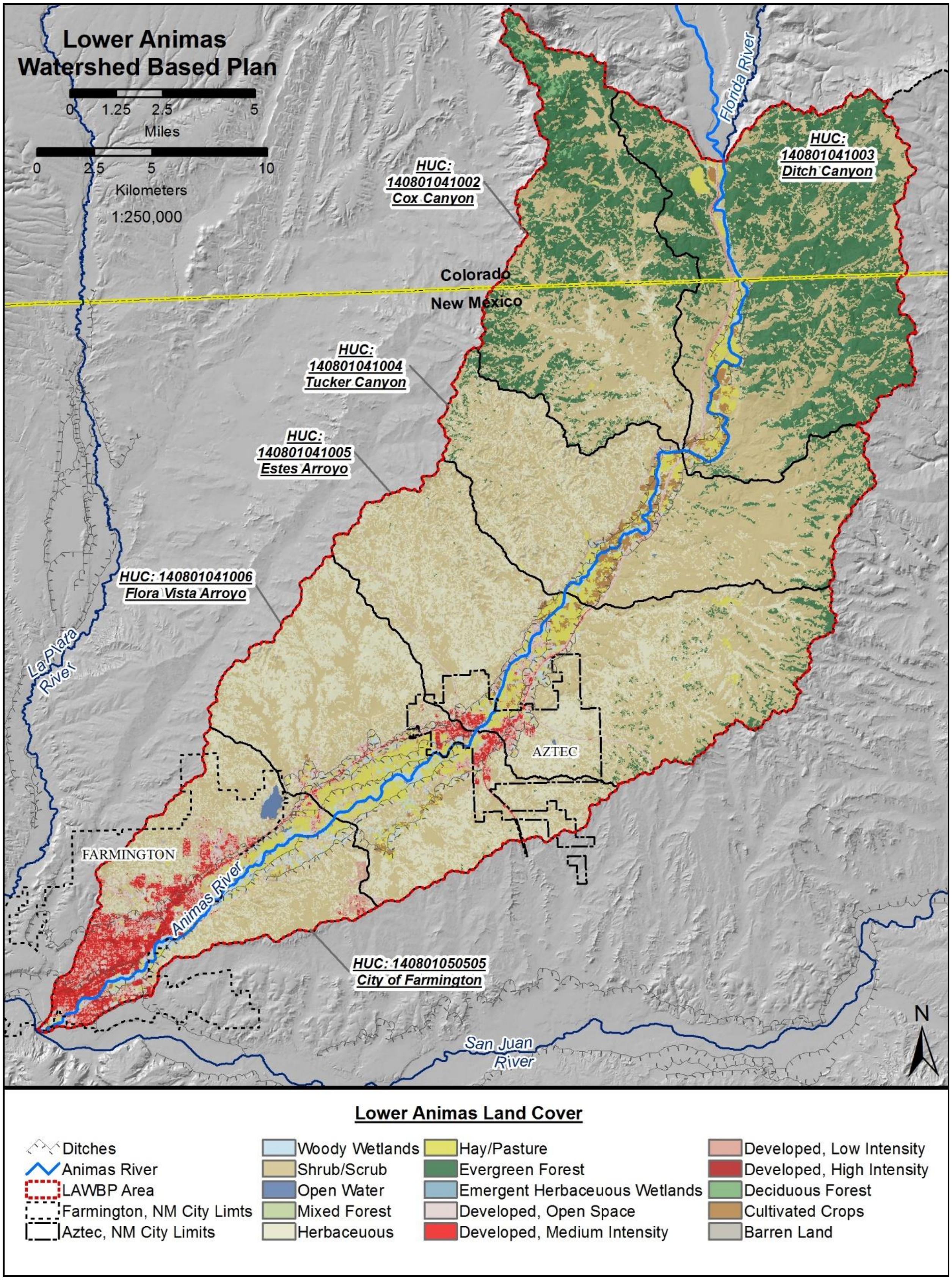
Map 9 – Lower Animas Surface Ownership



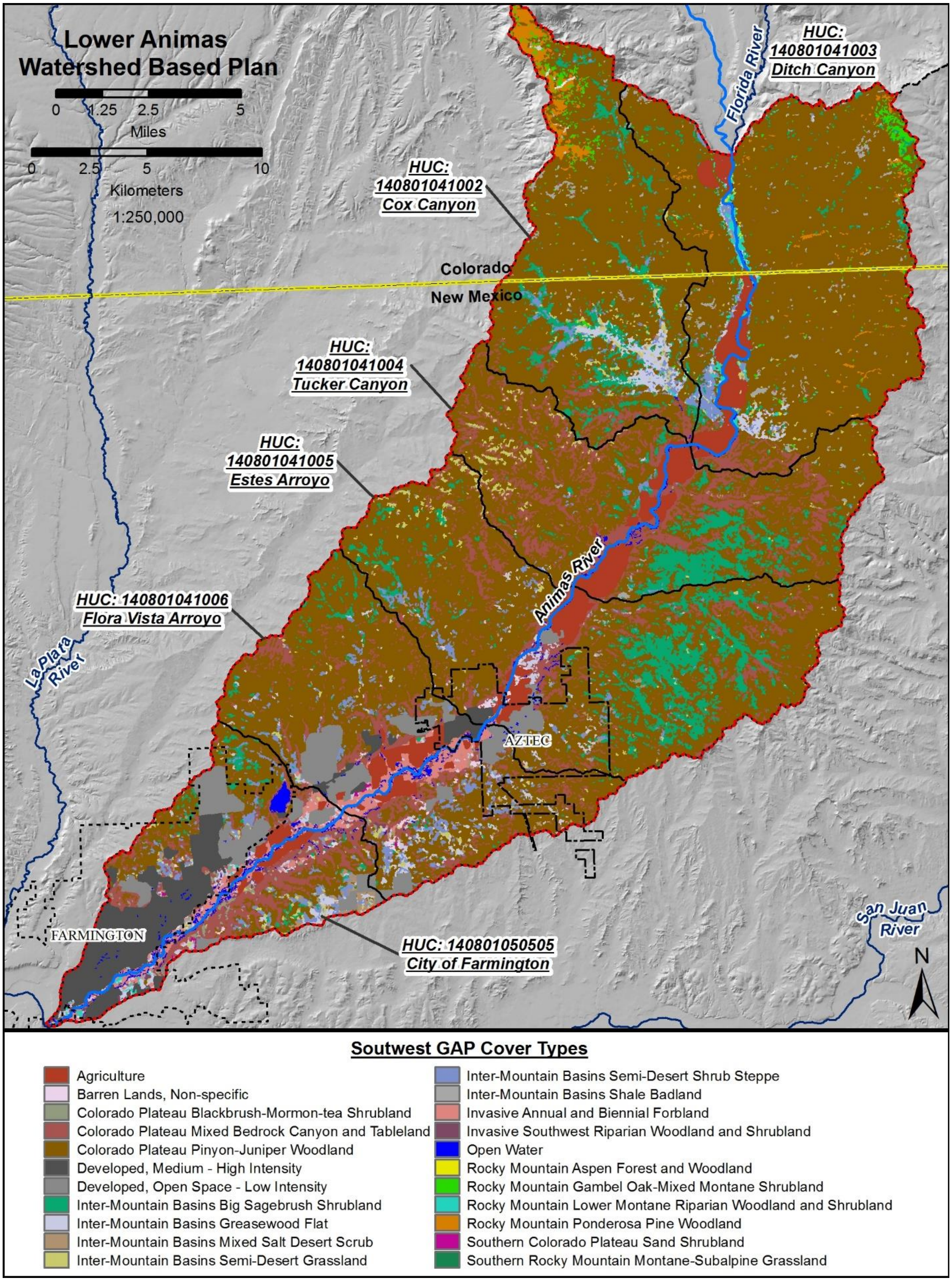
Map 10 – Lower Animas Population Centers.



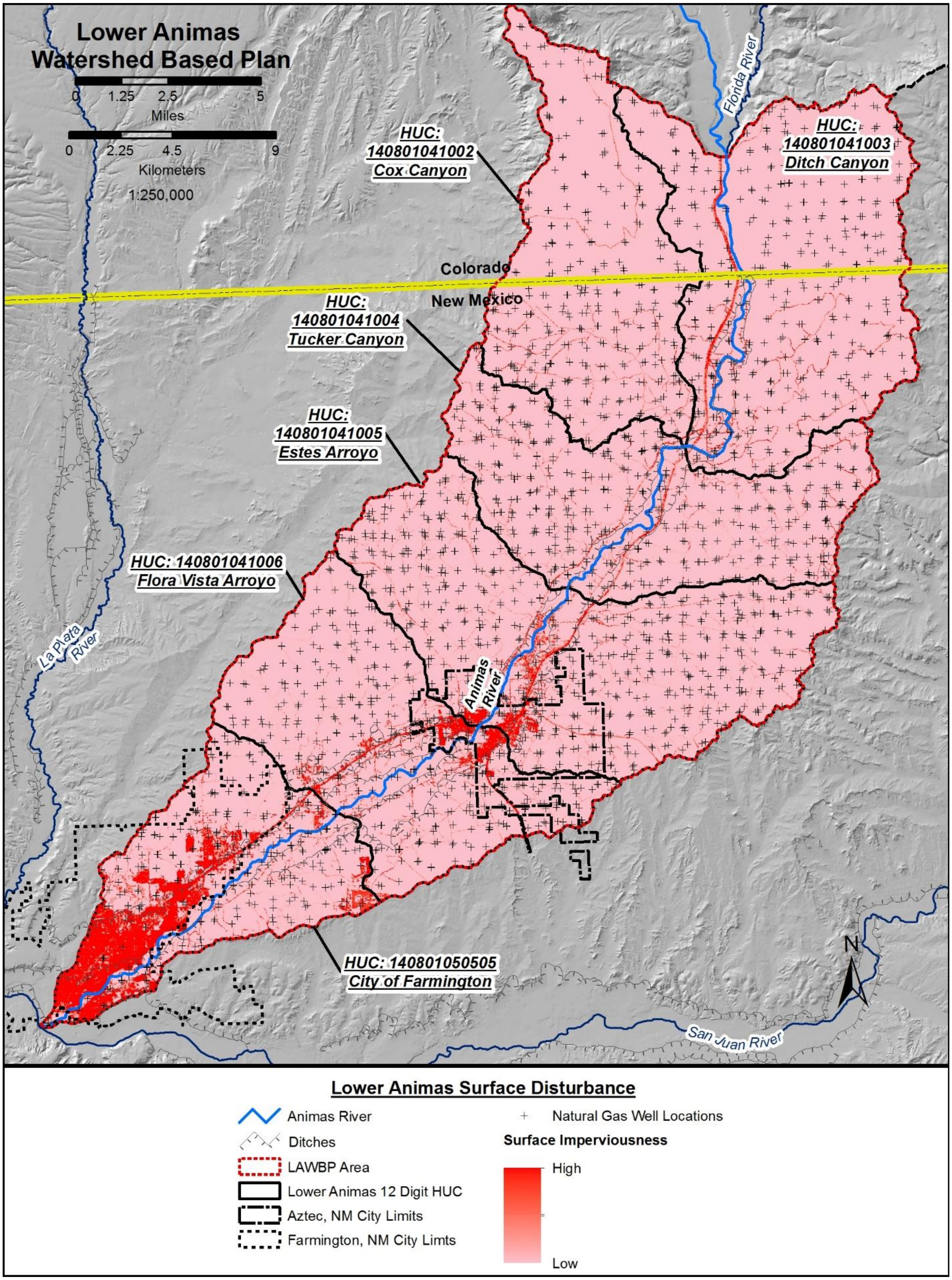
Map 11 – Topography and Hydrology of the Lower Animas.



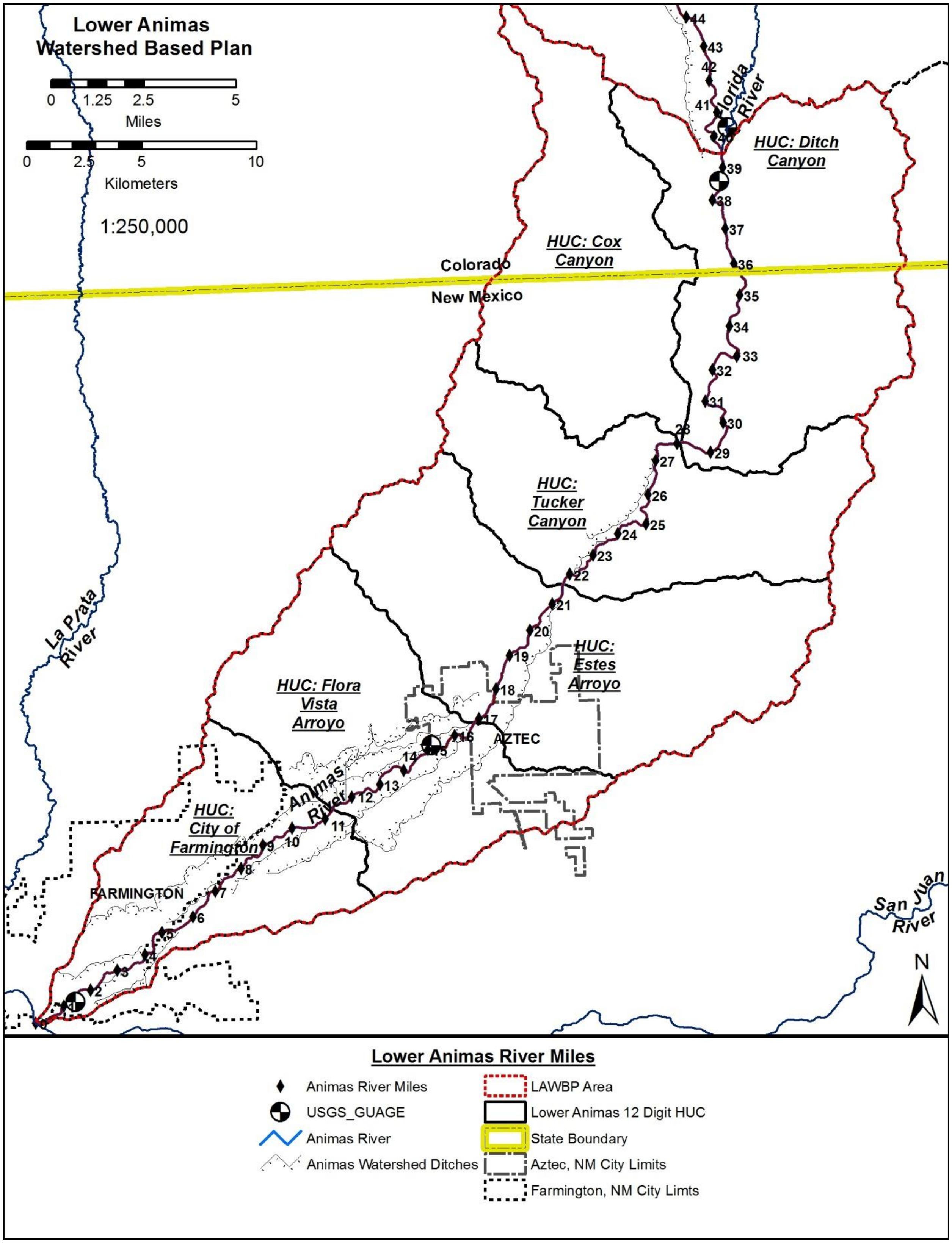
Map 12 – Lower Animas Land Cover; 2011 NLCD.



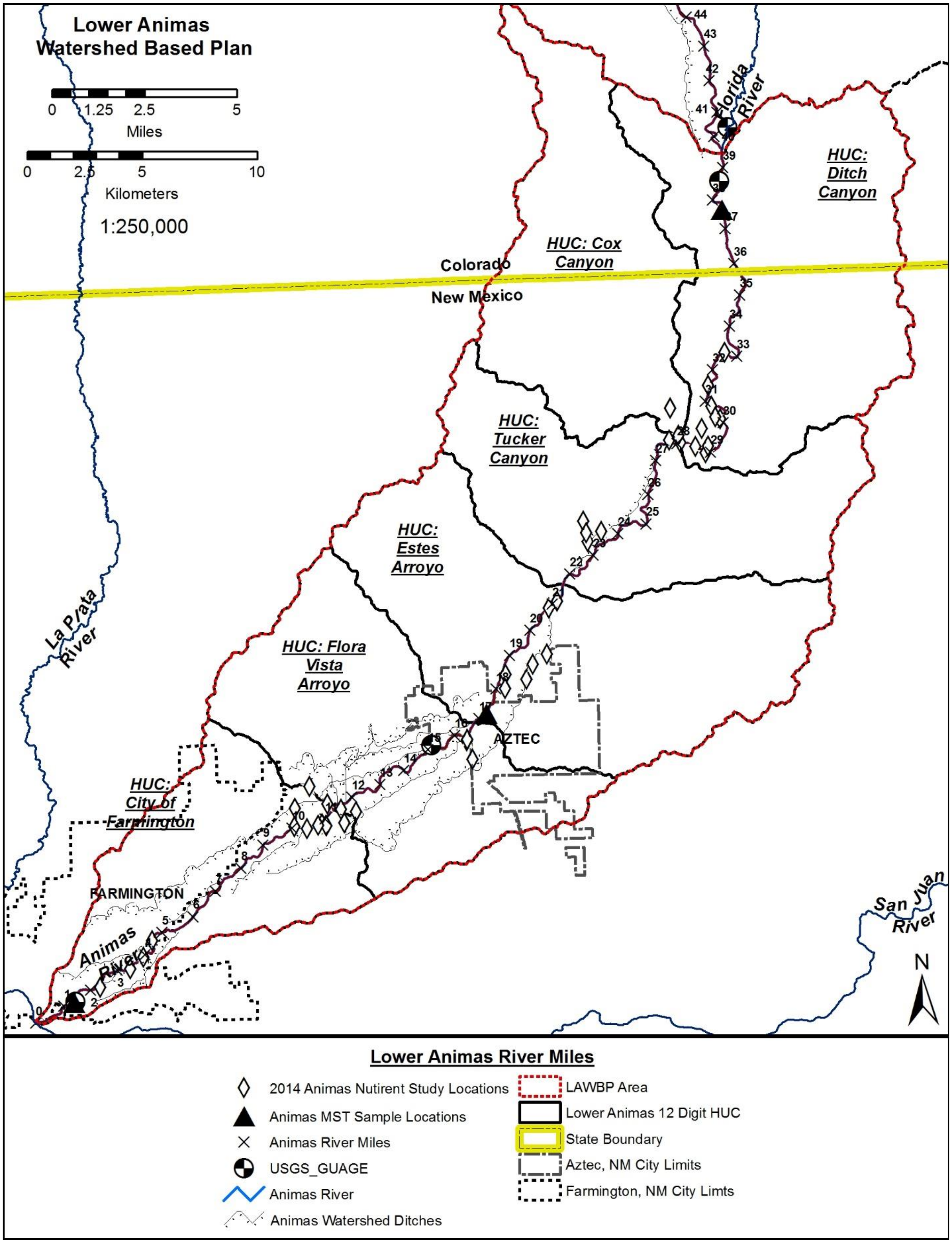
Map 13 – Lower Animas Vegetation Cover Types; Southwest GAP.



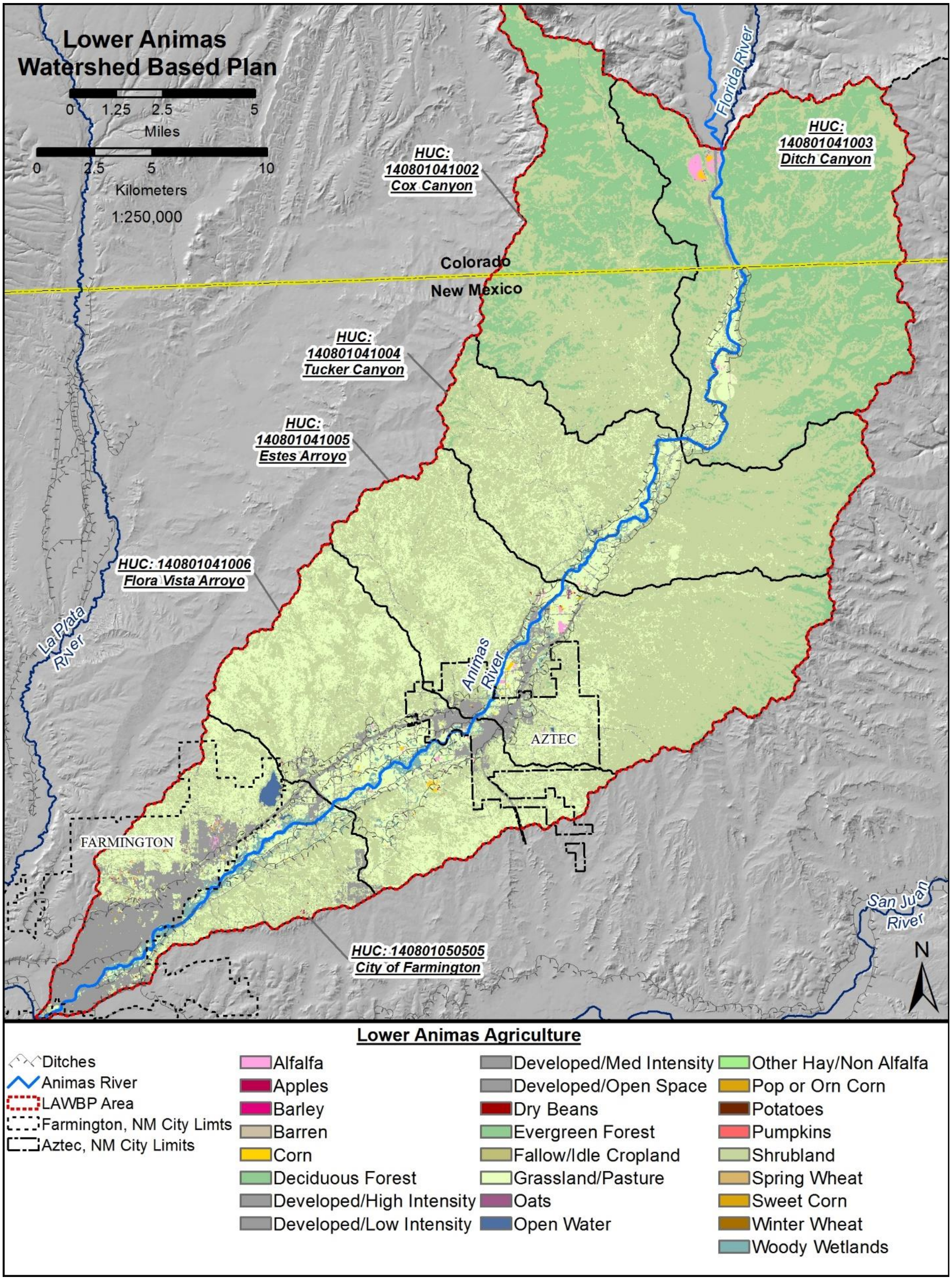
Map 14 – Lower Animas Surface Disturbance.



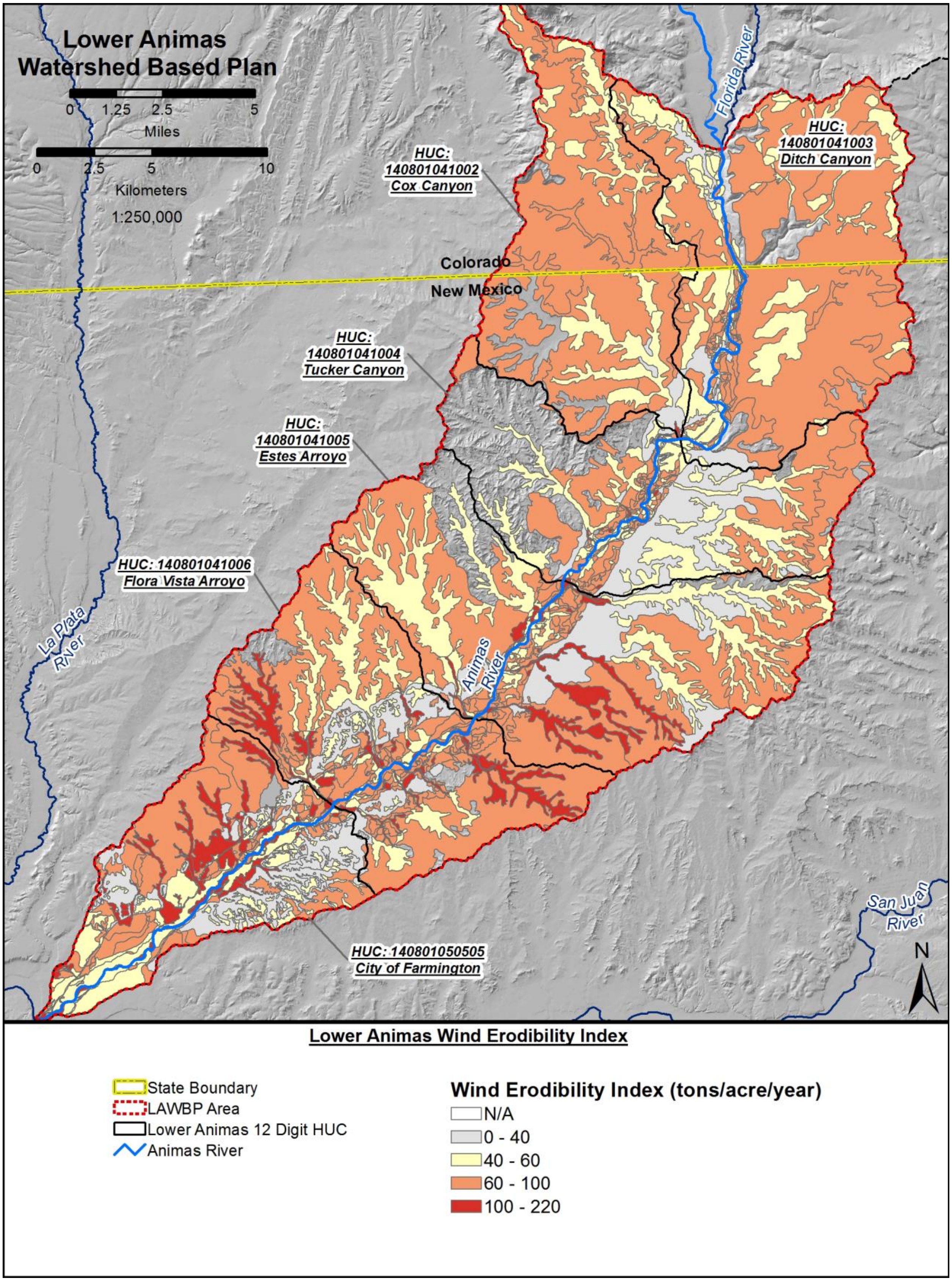
Map 15 – Animas River River Miles from the confluence with the San Juan River.



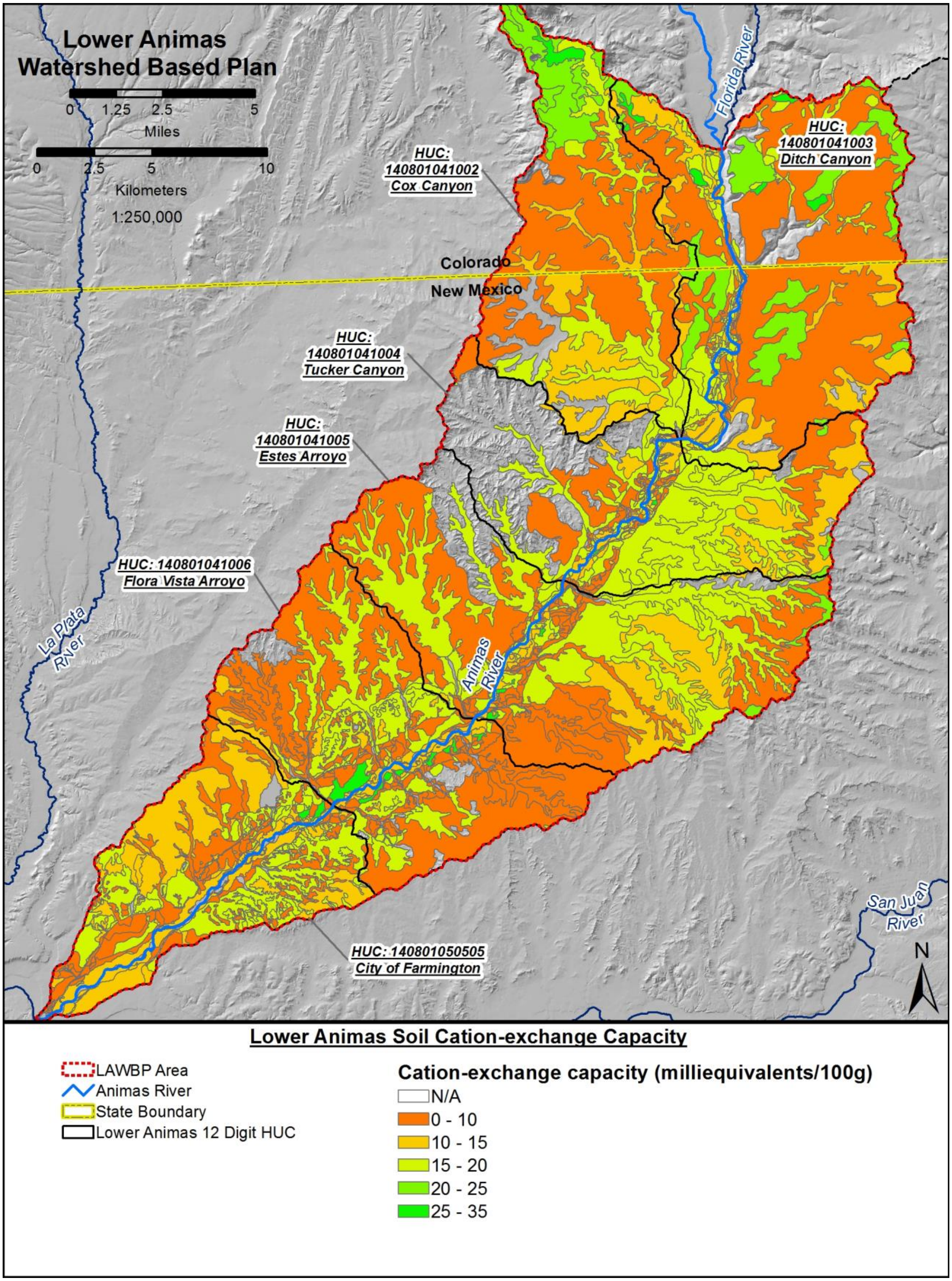
Map 16 – Location of 2014 Sample Locations.



Map 17 – Lower Animas Agriculture; 2014 USDA Agriculture Census Data.



Map 18 – Lower Animas Soil Erodibility Index; Soil Survey Data



Map 19 – Lower Animas soil cation exchange capacity; Soil Survey Data

3. State of the Watershed

Water Quality Impairments

Water quality impairments addressed in this plan

The San Juan Watershed Group (SJWG) and Animas Watershed Partnership (AWP) have prioritized nutrient enrichment and bacteria pollution as the most problematic water quality issues in the New Mexico portion of the Animas River watershed.

Nutrients were identified as a problem in the watershed in 2002, when severe algae blooms choked the river and sparked widespread concern about eutrophication. A TMDL for nutrients was developed for the Estes Arroyo-San Juan River reach in 2006, and a TMDL for total phosphorus was developed for the SUIT-Estes Arroyo reach in 2013 (See Table 6). Both nitrogen and phosphorus were addressed in the 2011 plan, with nitrogen concentrations being the driver for site prioritization.

The Animas was first listed for *E. coli* in 2012, indicating that the river was not meeting its primary contact designated use, which is designed to protect recreation activities "including swimming, bathing, tubing, water play by children, and similar activities where a high degree of bodily contact with water, immersion and ingestion are likely" (CWA Section 304(a)(1)). A TMDL for *E.coli* was developed in 2013.

Because of the long-standing nature of the nutrient problem, and the public health concern related to bacteria, SJWG wanted to collect more detailed information regarding both impairments for use in this plan. NMED standards for primary contact include two different water quality criteria for *E. coli*. The monthly geometric mean for *E. coli* should not exceed 126 colony forming units (cfu)/100mL and single *E. coli* samples should not exceed 410 cfu/100 mL. Because SWQB sampling in 2010 was infrequent (about once a month), there were usually not enough samples to calculate geometric means, and impairments had to be decided by the single sample criterion (SWQB 2010). Similarly, nutrient TMDLs had been developed using as few as 8 samples. SJWG conducted extensive sampling in 2013 and 2014 to address this data gap (25-40 samples per site each year), the results of which are discussed in greater detail in the "Recent Water Quality Trends" section of the plan.

Sediment loading is also addressed in this plan, but was not studied in as great of detail as nutrients and *E.coli*. Sediment reduction models were readily available however, so it is mainly addressed in the context of erosion control BMPs. Sediment loading is also of interest because high *E.coli* and nutrient concentrations have been correlated with runoff events that also exhibit high turbidity. For the most part, reductions in sediment loading discussed in this plan are an auxiliary benefit to BMPs that primarily address either bacteria or nutrients. Table 6 presents the official causes of impairment in the New Mexico portion of the Animas River, as of the 2014-2016 303(d) list.

Table 6. Causes of impairment, TMDLs, and associated water quality criteria

For the New Mexico portion of the Animas River. (NMED 2006; 2013; 2014; NMAC 2013).

Assessment Unit	Designated Uses	Impairments	First Listed	Water Quality Criteria	TMDL Date	TMDL
Animas River Estes Arroyo to So. Ute Indian Tribe land (NM-2404_00)	Coldwater Fishery, Irrigation, Livestock Watering, Wildlife Habitat, Municipal and Industrial Water Supply, and Secondary Contact	*E. coli*	2012	126/410 cfu [a]	2013	2.7×10^{11} cfu/day
		Total Phosphorus	2012	0.1 mg/L (segment specific criterion) [b]	2013	46.6 lbs/day
		Temperature	1998		-	-
		Turbidity	2012		-	-
Animas River San Juan River to Estes Arroyo (NM-2403_A_00)	High Quality Coldwater Fishery, Irrigation, Livestock Watering, Wildlife Habitat, Municipal and Industrial Water Supply, and Secondary Contact	*E. coli*	2012	126/410 cfu [a]	2013	2.3×10^{11} cfu/day
		Nutrients-Phosphorus	2004	0.07 mg/L [c]	2006	33.5 lbs/day
		Nutrients-Nitrogen	2004	0.42 mg/L [c]	2006	201 lbs/day
		Temperature	2012	24^0C Max/ 29^0C 6T3 [d]	2013	165.34 J/m^2/s/day

[a] 126cfu/100mL monthly geometric mean; 410cfu/100mL single sample maximum (NMED 2013)
[b] Segment specific criterion: phosphorus (unfiltered sample) (NMAC 2013)
[c] USGS Ecoregion 22 criteria adopted as TMDL Target Concentrations (NMED 2006)
[d] Maximum=24^0C; 6T3 (temperature not to be exceeded for six or more consecutive hours in a 24-hour period on more than three consecutive days)= 20^0C (NMED 2013).

Water quality data used in this plan

Extensive water quality data has been collected along the Lower Animas over the past couple of decades by NMED, Animas Watershed Partnership, BUGS Consulting, San Juan Watershed Group, USGS, and others. Data include physical measures (such as river discharge, electrical conductivity, and temperature), chemical measures (such as organic compounds, nutrient concentrations, metal concentrations) and biological measures (such as macroinvertebrate community, algal biomass, and bacteria) (BUGS 2011).

The 2011 Watershed Plan (BUGS 2011) summarized data collected on the New Mexico reach of the Animas in 2006 and on the Colorado/SUIT reach in 2010. The New Mexico dataset included sampling runs in July and October 2006 to assess non-storm related nutrient loading at 71 inflow sites and in-stream load at 31 sites. Total Nitrogen (TN) and Total Phosphorus (TP) were collected along with discharge, specific conductivity, pH, and temperature. Chlorophyll-a, nitrogen isotopes (Delta Air), and macroinvertebrates were also quantified at a subset of sample sites during the July 2006 sampling event. These protocols were repeated in 2010 at 31 sites in the Colorado/SUIT reach (BUGS 2011).

In 2013 and 2014, the San Juan Watershed Group (SJWG) initiated two new major sampling efforts. The Lower Animas Targeted Sampling study was designed specifically to be used as part of this Watershed Based Planning effort and was funded as part of the same grant. The Microbial Source Tracking study was initiated by the group as a separate project.

1) Microbial Source Tracking (MST) Study: The objective of the MST study was to determine what sources of bacteria (ie: human, ruminant, horse, dog, waterfowl) are most prevalent in the Animas and San Juan Rivers. The SJWG collected weekly samples from early April through late October of 2013-14 at three sites along the Lower Animas as well as additional sites upstream in Colorado and on the San Juan River in New Mexico. The *E.coli* and nutrient data collected for this project utilized an EPA approved Quality Assurance Project Plan (QAPP) (Appendix E). Selected results are presented in the "Water Quality Trends" section of this document; for a full report see www.sanjuanswcd.com/watershed.

2) 2014 Lower Animas Targeted Sampling: The objective of the 2014 Lower Animas Targeted Sampling project was to investigate inflows along the Lower Animas River and determine their nutrient and *E. coli* contribution during low flow. Sampling sites were selected in clusters based on hotspots identified in the 2011 plan. The Mountain Studies Institute (MSI), in cooperation with the SJWG, collected samples in April, July, and October of 2014 from 43 locations along the Lower Animas River. The QAPP including study design and full sampling scheme is attached in Appendix D, and tables of sampling results can be found in Appendix B.

Sites included in the MST and the 2014 Lower Animas Targeted Sampling study are presented in Map 16 with sample location coordinates provided in Appendix B.

What did we find? Recent Water Quality Trends

Water Quality Criteria and TMDLs exceeded in 2014

Data from 2014 (Lower Animas Targeted Sampling, MST Study) indicate that measured concentrations and loads of nitrogen, phosphorus, and *E. coli* often exceeded both NM state water quality criteria (WQC), and TMDL targets established for the Animas River (Table 7; Figures 2-7; See Table 6 for greater detail on TMDLs).

Table 7 shows the percent of sites exceeding water quality standards on the mainstem of the Animas sampled during the Lower Animas Targeted Sampling. Note that although none of the sites in the Estes Arroyo to SUIT boundary reach exceeded the single sample criteria for *E.coli* during the Targeted Sampling, Table 8 shows that the monthly geometric mean standard was exceeded in 6 out of 14 months (based on data collected weekly and semi-weekly) during the MST study.

When both sets of data are incorporated, all of the impairments listed in Table 6 for *E.coli*, Total Phosphorus, and Nutrients are confirmed. These data were submitted to NMED SWQB and were used in development of the 2016-2018 303(d) list.

Figures 2 through 7 compare concentration and load for nitrogen (Figure 2-3), phosphorus (Figure 4-5), and *E.coli* (Figure 6-7). As is evident from the higher percentage of TMDL exceedances versus WQC exceedances shown in Table 7, there are often instances of a water sample at a site on a given date being lower than the target concentration, but still carrying a load that far exceeds the TMDL. This brings up the concept of *carrying capacity*.

TMDLs are calculated such that if the same load was delivered to the river daily throughout the year, the concentration targets would still be met during *critical low flow* conditions, ie: when carrying capacity is lowest and there is the least amount of water in the river to dilute a pollutant load. These target loads serve to protect aquatic life and other designated uses throughout the year.

Table 7. 2014 percent of Animas River sites in Lower Animas Targeted Sampling that exceeded water quality criteria and TMDL for nutrients and *E. coli* in 2014.

Assessment Unit	Impairments	Water Quality Criteria	% of Sites Above Water Quality Criteria			TMDL	% of Sites above TMDL		
			April	July	October		April	July	October
Animas River Estes Arroyo to So. Ute Indian Tribe land (NM-2404_00)	*E. coli*	410 cfu [a]	0%	0%	0%	2.7 x 10^{11} cfu /day	100%	100%	100%
	Total Phosphorus	0.1 mg/L [b]	0%	20%	80%	46.6 lbs/day	100%	100%	80%
Animas River San Juan River to Estes Arroyo (NM-2403_A_00)	*E. coli*	410 cfu [a]	0%	20%	0%	2.3 x 10^{11} cfu /day	100%	100%	100%
	Nutrients-Phosphorus	0.07 mg/L [c]	60%	60%	100%	33.5 lbs/day	100%	80%	100%
	Nutrients-Nitrogen	0.42 mg/L [c]	40%	40%	40%	201 lbs/day	100%	40%	100%

[a] 100mL single sample maximum (NMED 2013)
[b] Segment specific criterion: phosphorus (unfiltered sample) (NMAC 2013)
[c] USGS Ecoregion 22 criteria adopted as TMDL Target Concentrations (NMED 2006)

Table 8. *E. coli* standard exceedances on the Animas River in 2013-2014 MST study.

Assessment Unit	Water Quality Criteria	% of Samples Above Water Quality Criteria			TMDL	% of Samples above TMDL		
		April-June	July-Aug	Sept-Oct		April-June	July-Aug	Sept-Oct
Colorado/SUIT Jurisdiction 2 sites: State Line (2013 and 2014) and Bondad (2014 only)	410 cfu [a]	0%	3%	14%	2.7×10^{11} cfu/day[c]	100%	86%	81%
	30 day mean >126 cfu (# months exceeding/ total months)	0%	0%	25% [b]				
Animas River Estes Arroyo to So. Ute Indian Tribe land (NM-2404_00) 1 site: Aztec	410 cfu [a]	0%	14%	7%	2.7×10^{11} cfu /day	100%	100%	100%
	30 day mean >126 cfu (# months exceeding/ total months)	17%	75%	50%				
Animas River San Juan River to Estes Arroyo (NM-2403_A_00) 1 site: Boyd Park	410 cfu [a]	3%	41%	21%	2.3×10^{11} cfu /day	100%	100%	100%
	30 day mean >126 cfu (# months exceeding/ total months)	0%	100%	75%				

[a] 100mL single sample maximum (NMED 2013)
[b] Colorado uses a 60 day mean which yields a geo mean slightly less than 126 for Sept 2014 and would not lead to an impairment listing in Colorado
[c] NM TMDL does not apply in Colorado reach, but exceedances are shown for reference since sampling sites were only 2-4 miles upstream from NM assessment unit.

The E.coli data referenced above was submitted to NMED SWQB for a 2015 data call, and was used by the agency to confirm the *E.coli* impairment listings for the Animas River.

Several figures in this section (Figures 2-7) present Animas River data from the Lower Animas Targeted Sampling study with respect to river miles. River miles begin at the confluence of the Animas and San Juan Rivers (river mile 0) and extend north to the Colorado-New Mexico border. Farmington, NM is located at approximately river mile 4; Flora Vista, NM at river mile 11; Estes Arroyo and Aztec, NM at river mile 17; and the NM-Colorado state line at river mile 35. See Map 15 for river miles reference.

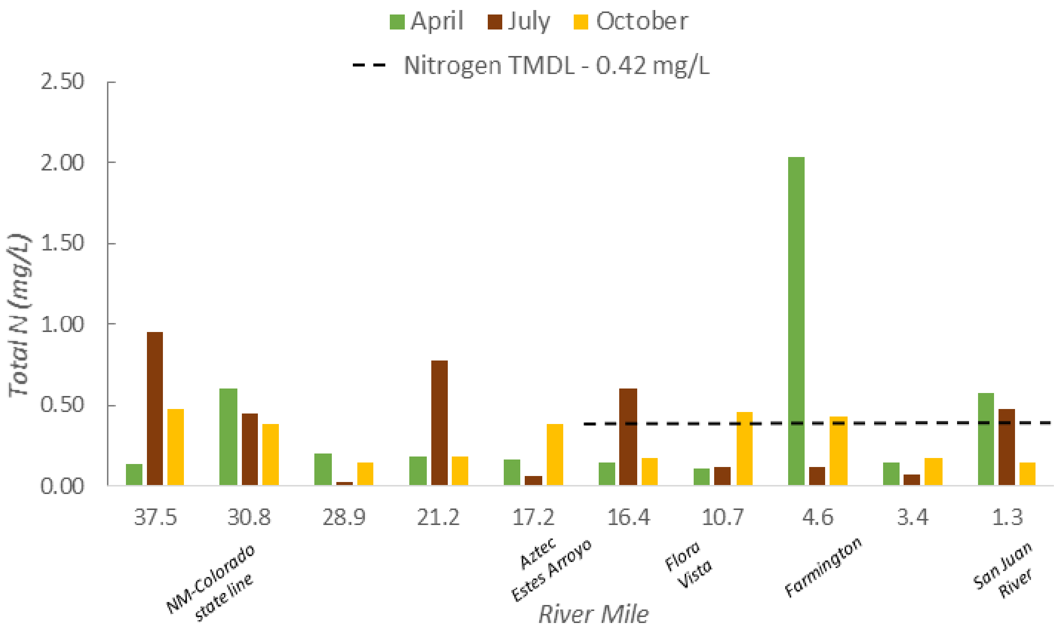


Figure 2. Total nitrogen concentrations measured in the Animas River in 2014.

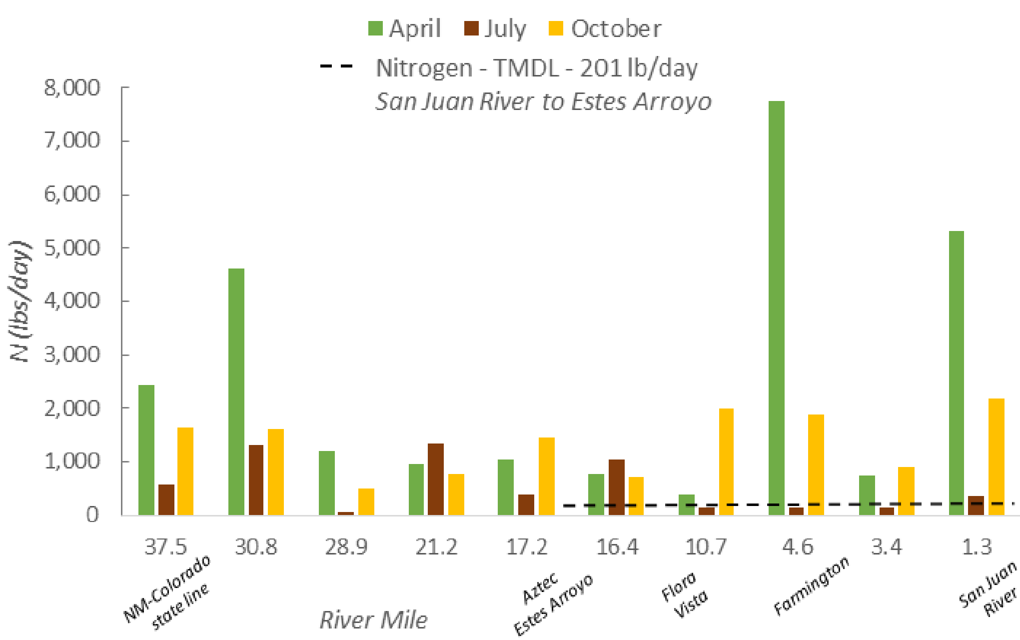


Figure 3. Total nitrogen load measured in the Animas River in 2014.

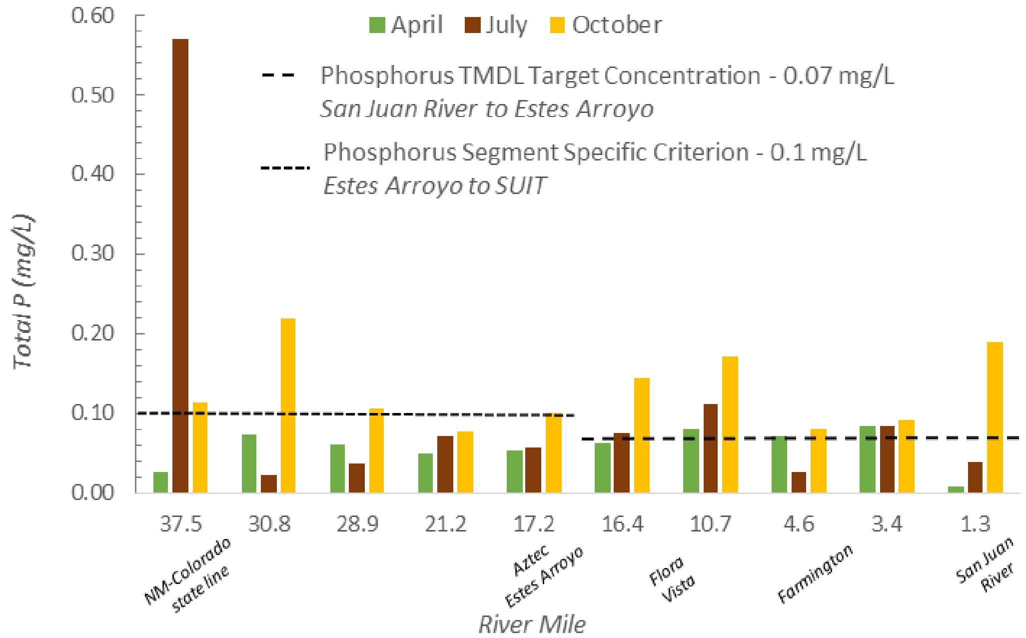


Figure 4. Total phosphorus concentration measured in the Animas River in 2014.

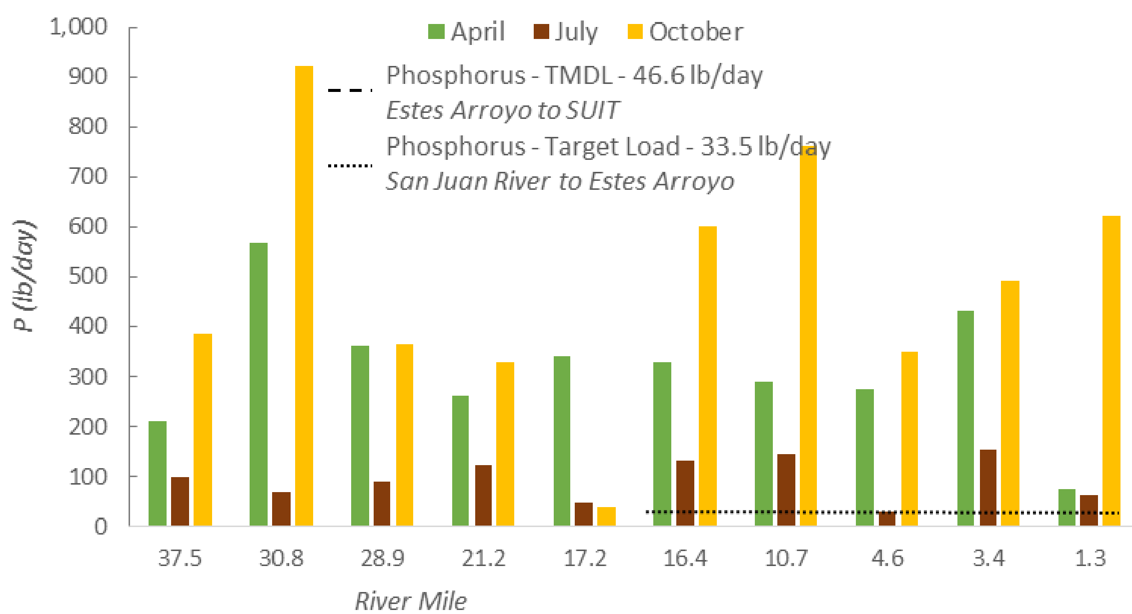


Figure 5. Total phosphorus load measured in the Animas River in 2014.

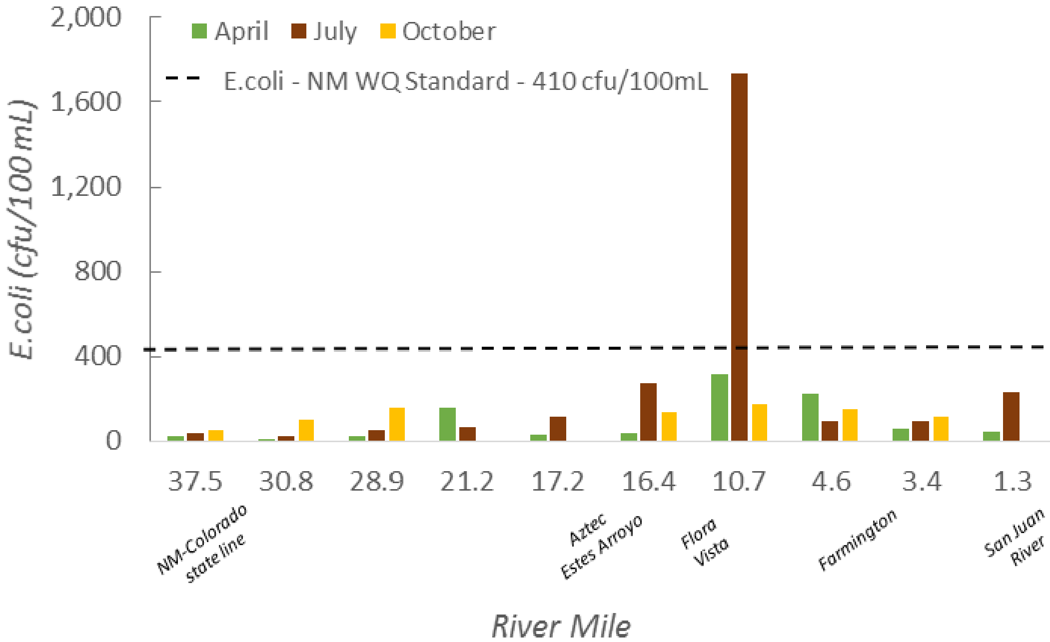


Figure 6. *E. coli* concentration measured in the Animas River in 2014.

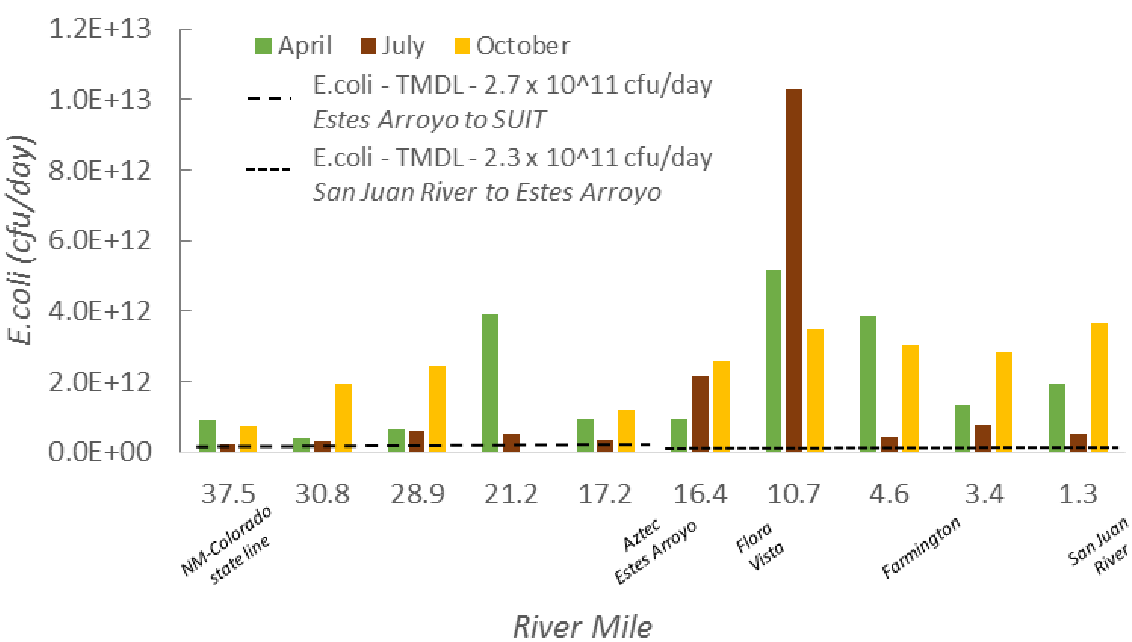


Figure 7. *E. coli* load measured in the Animas River in 2014.

Seasonal variability of pollutant loading

Measured nutrient and *E. coli* loads in the Animas River vary seasonally. During spring runoff, nutrient and *E. coli* concentrations remain relatively stable. However, during summer and fall precipitation events when there is an increase in river flow, nutrient and *E. coli* concentrations become elevated. These spikes in nutrient and *E. coli* concentrations are likely caused by stormwater runoff from the adjacent landscape (Figure 8-9). These findings are consistent with data presented in the 2006 San Juan River Watershed TMDL (NMED 2006, part 1).

The majority of the bacteria exceedances occurred in the months of July through October (Table 8), which corresponds to monsoon season (Figure 9), but also overlaps with a heavy recreation season during the heat of the summer. The data indicate that significant quantities of fecal material are reaching the river during these periods, and care should be taken by all swimmers not to ingest river water. (SJSWCD 2015).

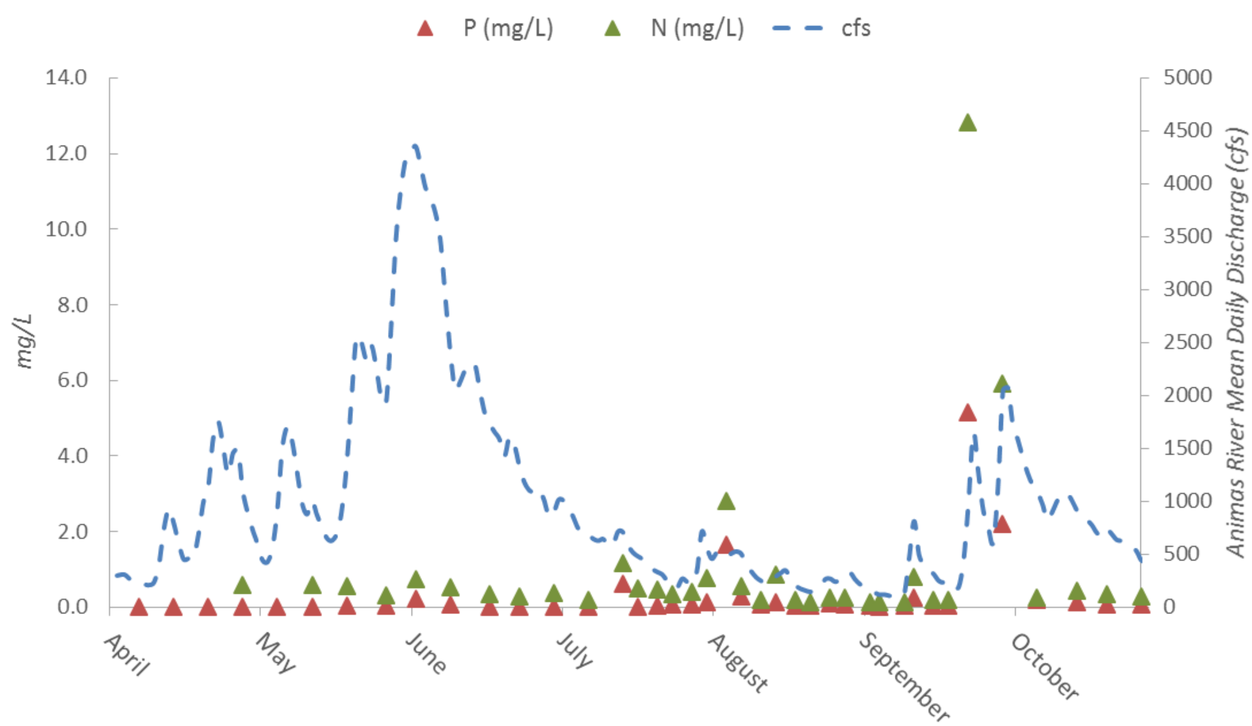


Figure 8. Total nitrogen, phosphorus, and mean daily discharge on the Animas River at Boyd Park in Farmington in 2014.

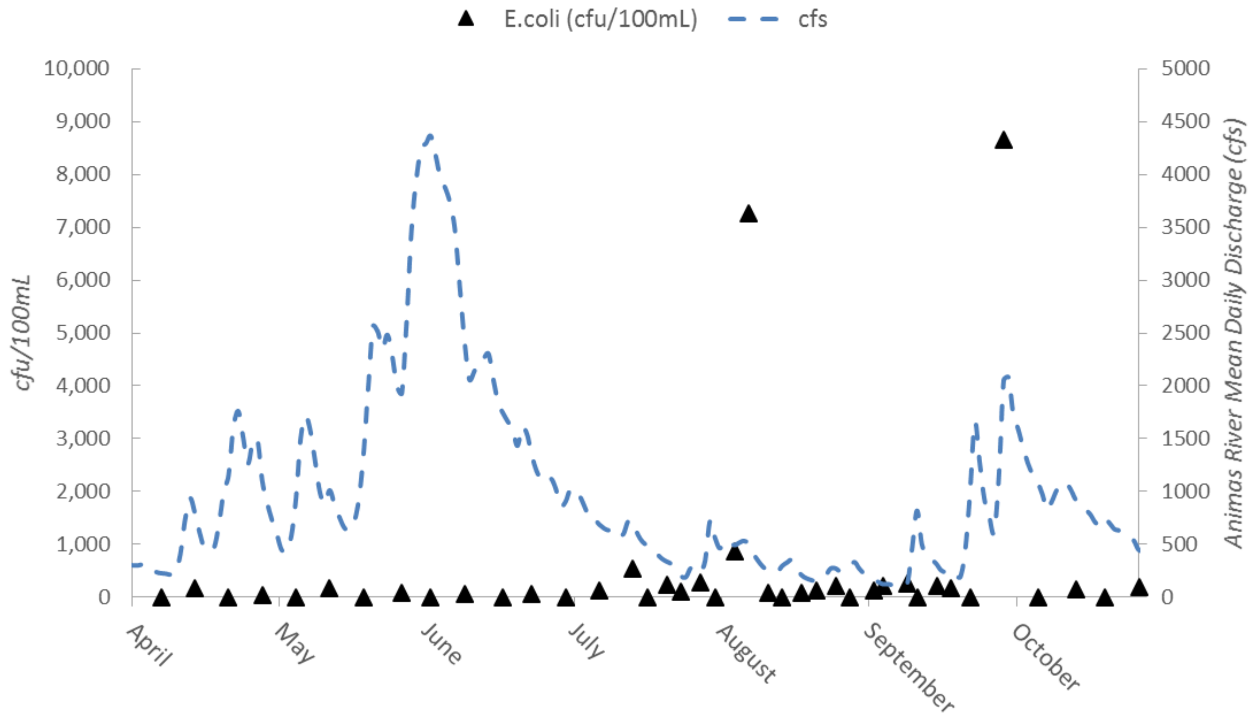


Figure 9. *E. coli* concentration and mean daily discharge on the Animas River at Boyd Park in Farmington in 2014.

Inflows do not account for load in mainstem

The nutrient and *E. coli* loads measured in the Animas River mainstem at low flow in 2014 were observed to be much higher than the loads entering the river from sampled inflows (e.g., arroyos, tailwater ditches, field drains, return flow from irrigation ditches). Figures 10, 11, and 12 show the loads from these sampled inflows, as compared to the mainstem loads. These data suggest that the primary sources of nutrient and *E. coli* loads in the Animas River at low flow cannot be solely explained by "hotspot" inflows. This finding is consistent with previous studies of inflows to the Animas River (e.g., BUGS 2011). If the loads in the Animas at low flow *were* driven primarily by inputs from specific inflows, we would expect to see jumps in the mainstem load following inputs from these "hotspots," with an overall trend of increasing mainstem loads from up to downstream. As shown in Figures 10-12, this was not the case.

It is possible that these same inflows do contribute a higher portion of the nutrient and *E. coli* load during storm events, but this remains an unknown since no inflow sampling occurred during storm events for this project. See discussion on data gaps at the end of this section for more information.

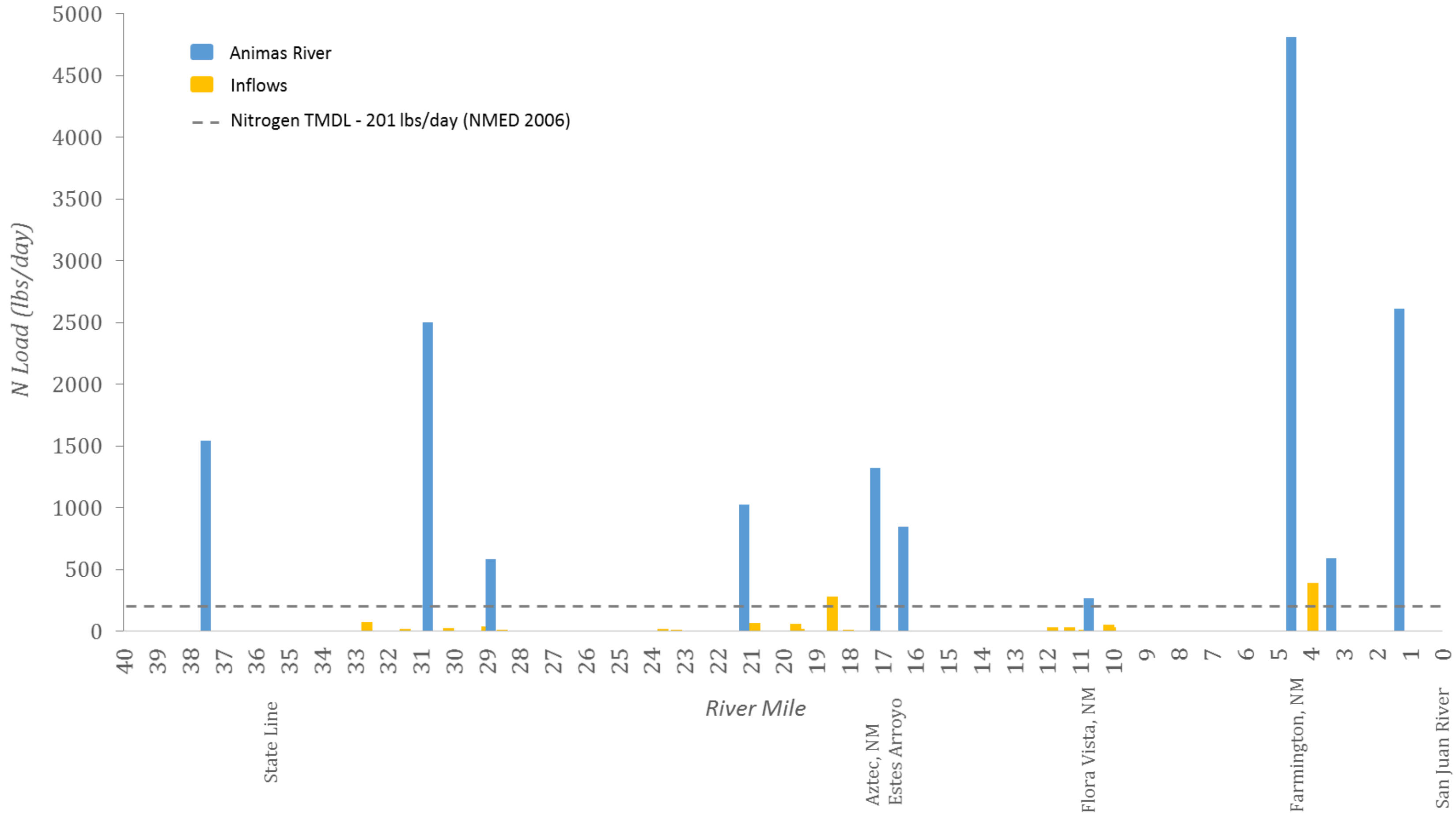


Figure 10. Average total nitrogen load in 2014

Average of three sample events (April, July, and October of 2014) for the Animas River and inflows to the Animas River. River miles start at the confluence with the San Juan River (River Mile 0).

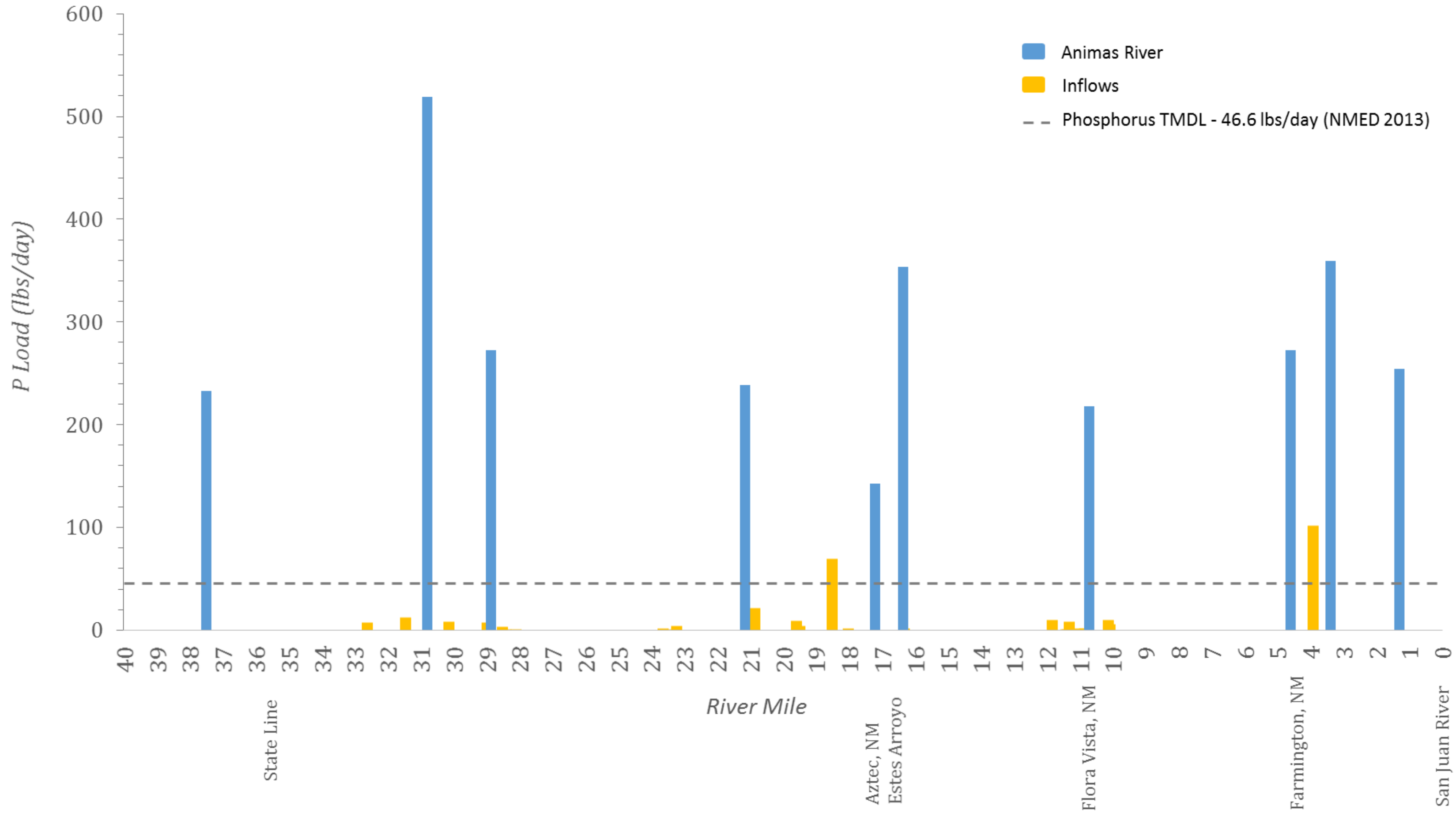


Figure 11. Average total phosphorus load in 2014.

Average of three sample events (April, July, and October of 2014) for the Animas River and inflows to the Animas River. River miles start at the confluence with the San Juan River (River Mile 0).

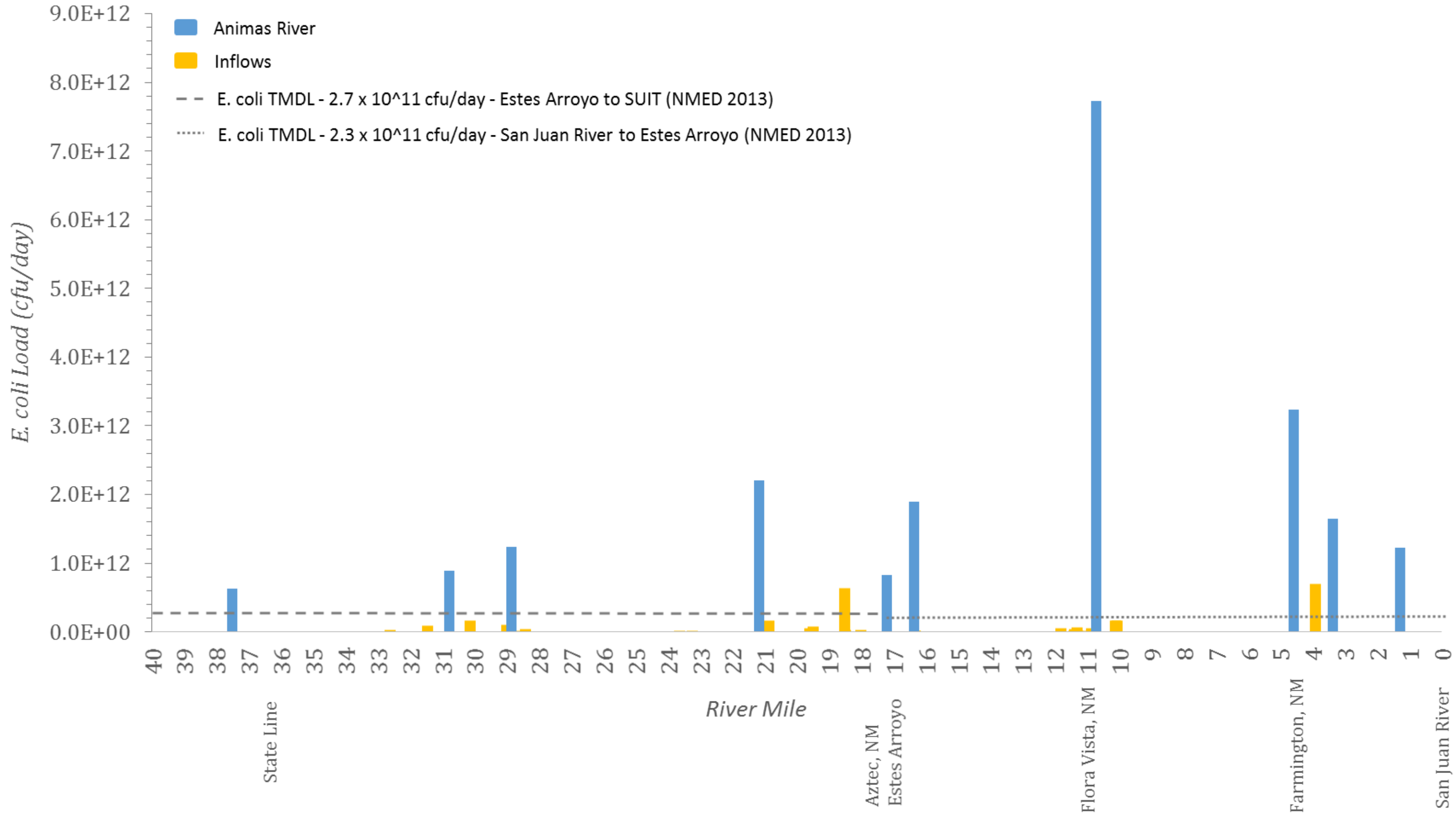


Figure 12. Average *E. coli* load in 2014.
Average of three sample events (April, July, and October of 2014) for the Animas River and inflows to the Animas River. River miles start at the confluence with the San Juan River (River Mile 0).

Footnote to Figures 10-12: The two inflows that do appear like they could be potential "hotspots" occur at river miles 4 and 18.5, and had average nitrogen, phosphorus, and E.coli loads that exceeded TMDLs (Figures 10-12 above). The "inflow" at river mile 4 is actually a 0.5 mile long side channel of the Animas River located in the city of Farmington near the intersection of Browning Parkway and East Main Street. It is essentially carrying a portion of the load already in the mainstem, and so the majority of the load measured at the "inflow" had already been in the river at the mainstem sampling site (river mile 4.5) just upstream.

For the site at river mile 18.5, the load from the inflow did not directly translate to a consistent increase in the pollutant load in the Animas River at the next downstream site (Load did increase for nitrogen, Figure 10, but decreased for phosphorus and E.coli, Figures 11-12). The inflow at river mile 18.5 is located north of Aztec (Site 49A in targeted sampling, see Appendix B) and receives flow from irrigation ditches, Knowlton and Calloway canyons, and residential and agricultural runoff. Regardless of the inconsistencies in loading, the watershed upstream of this site will be considered for further investigation and remediation efforts.

The management conclusions that follow from this information are that focusing on management measures which address single inflows (prioritized based on their contribution to baseflow loads) will **not** have a significant impact on reducing overall pollutant loads. For instance, improvements in irrigation practices alone (without addressing contributions from agricultural lands during storm events) will not significantly reduce pollutant loads to the river.

Prevalence of ruminant and human source bacteria

The Microbial Source Tracking (MST) study tested for six bacteria markers that indicate fecal contribution from specific biological sources. The study was designed to target the sources thought most likely to be contributing bacteria in the Animas and San Juan Rivers: humans, cattle, horses, dogs, birds (including chickens, waterfowl, and other wild birds), and ruminants (which include cattle, deer, elk, goats, and sheep). The study included two independent human markers, and utilized adaptive management to make mid-study changes and hone in on the most likely contributors to fecal pollution (For more detail on the study, see SJSWCD 2015 or sanjuanswcd.com/watershed.

The MST study revealed a very consistent source of ruminant bacteria on the Animas River (90% of samples positive), and a less pervasive but consistent source of human bacteria (60% samples positive for the more sensitive of two human markers). Bacteria from birds were present about a third of the time (Figure 13). By comparison, the two sites sampled on the San Juan River showed similar quantities of bird and ruminant bacteria, but human bacteria sources were positive more frequently (90% of samples positive) and in higher concentrations (SJSWCD 2015). In contrast to the two downstream Animas sites, the site at river mile 37.5 (just upstream of the state line) had 100% of samples test positive for human bacteria.

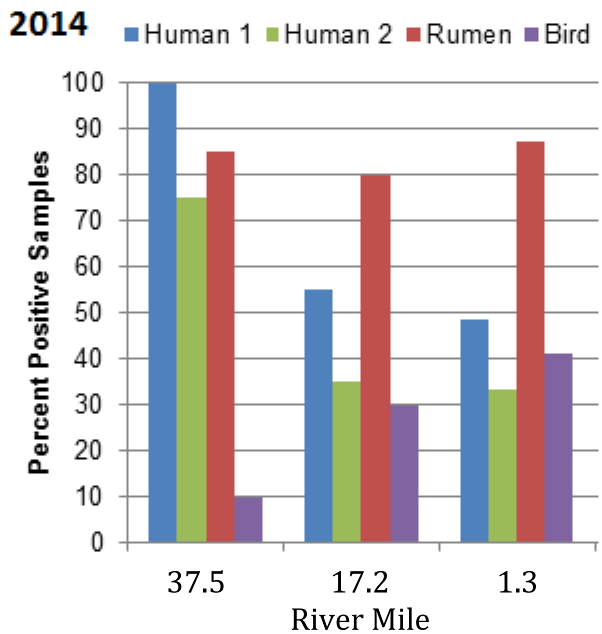


Figure 13. Percent of positive source tracking samples for top three sources

At three Animas sites sampled in 2014. n=25 for site at mile 37.5, n=40 for other two sites. Human 1 is a more sensitive test then Human 2.

Evidence for the strong influence of stormwater

As observed in the Lower Animas Targeted Sampling, both concentrations and loads of nutrients and bacteria were extremely variable, with minimum and maximum loads varying by 2-3 orders of magnitude at each site throughout the year (Figures 3, 5, and 7). As discussed in the "Seasonal Variability of Pollutant Loading" section, this variation largely occurred during monsoon season. Figure 14 provides further evidence for this trend; turbidity increases during storm runoff events, and high turbidity is positively correlated with both total phosphorus and total nitrogen. Interestingly, TKN had a stronger correlation to turbidity than did nitrate and nitrite, which are negatively charged ions that are associated more with groundwater transport. Turbidity and other pollutants did not increase to the same extent during spring runoff (which had similar high flow), making it difficult to directly correlate flow and pollutant concentrations. In this case, turbidity provides an excellent proxy for evaluating storm events.

Figure 15 uses a flow duration analysis, where flows are ranked from highest to lowest and plotted in rank order against pollutant concentrations (with spring runoff points excluded). If higher concentrations are associated with high flows from storm events, there will be strong negative slope, as seen for Boyd Park (River Mile 1.3) sites in Figures 15b, 15c, and 15d. Figure 15a is shown for comparison, where there is no significant slope relating *E.coli* and flow at river mile 37.5. This again supports the conclusion that stormwater contributes a significant bacteria load to the Animas River between the NM state line and the San Juan confluence.

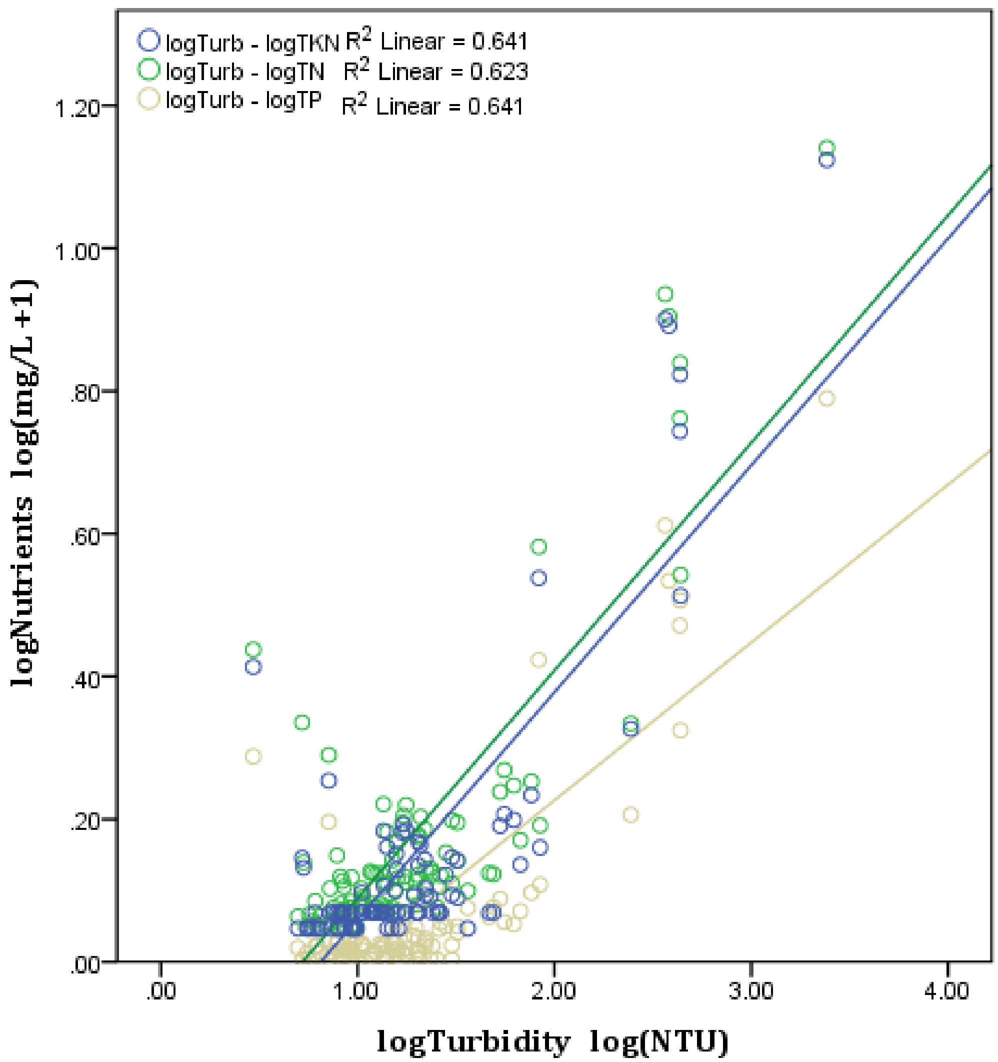


Figure 14. Regressions of total phosphorus, total nitrogen, and total Kjeldahl nitrogen vs. turbidity in 2014.

Regressions of log-transformed data collected at four Animas River sites and one Florida River site in 2014. See SJSWCD2015 for full data analysis. R^2 relationships for TP, TKN, and TN shown on graph; R^2 for NO3/NO2 vs. turbidity is 0.269 (not pictured).

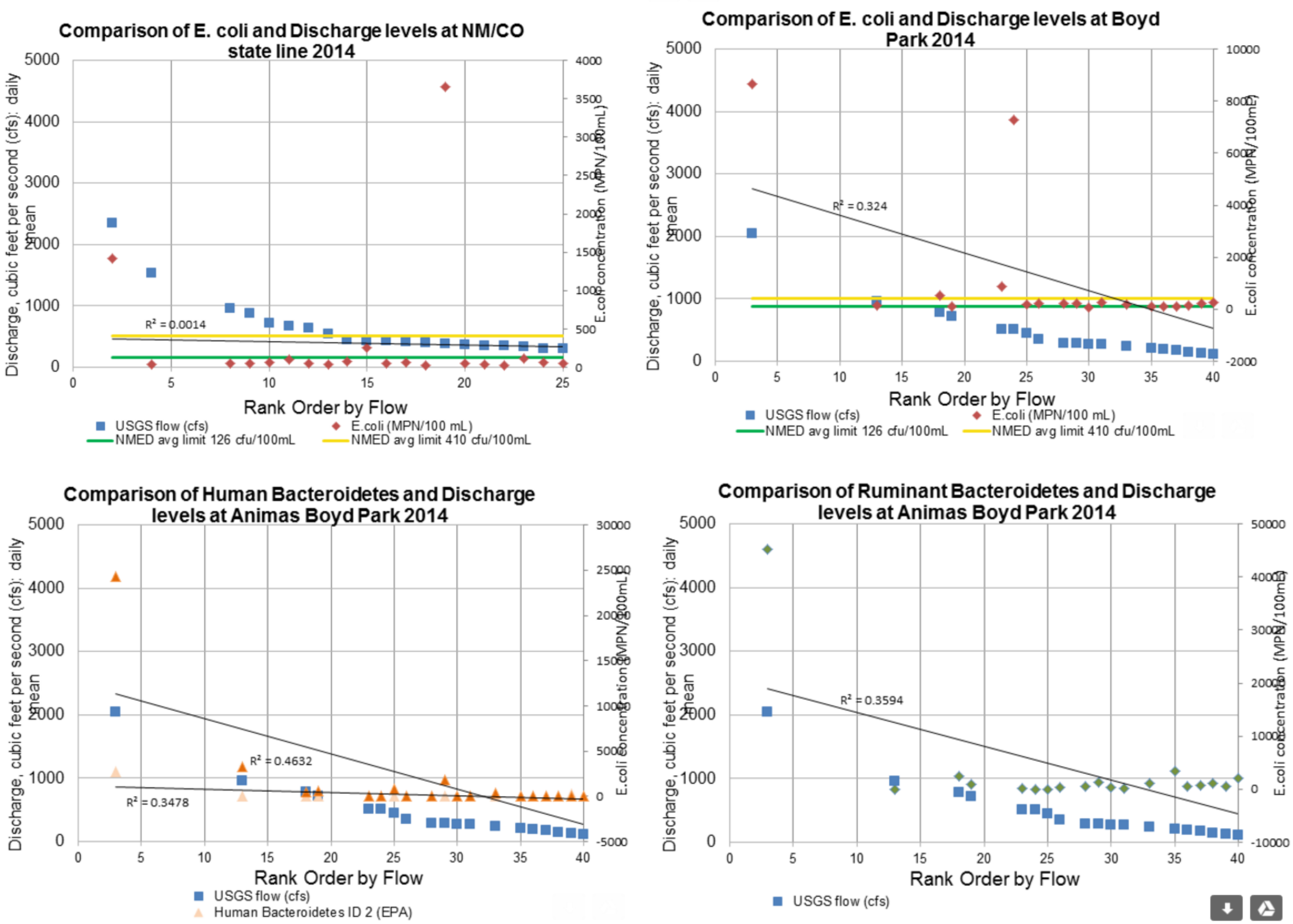


Figure 15 a-d. Flow duration curves comparing ranked E.coli, Human Bacteroides, and Ruminant Bacteroides vs. flow for two sites on the Animas River in 2014.

Samples taken during spring runoff were excluded from this analysis, so as not to overshadow moderately high flows seen during storm events.

Data Gaps

Several data gaps exist that limit our understanding of water quality in Lower Animas. Future updates to this watershed based plan should assess the feasibility of designing and funding studies to address these data gaps. All of these data gaps should be viewed as potential future projects.

1) Although we do have an understanding of the bacteria and nutrient loads of inflows (e.g., irrigation ditches and arroyos) along the Lower Animas during low flow, we do not know the contribution of these inflows during storm events. Storm event sampling is difficult due to the unpredictable timing of storms, and the safety hazards associated with high flows and flash floods. An existing network of SJWG water sampling volunteers could help with this type of effort in the future.

2) Water quality in the Animas River does not degrade in direct response to measured inflow sources, which would be expected if point sources were the primary contributor of nutrient and bacterial pollutants, or if major non-point sources were concentrated in smaller geographic areas. Figures 3, 5, and 7 demonstrate that nutrient and bacterial loads measured in the Animas River on the same day may increase and then decrease quite dramatically just a short distance downstream. The processes that are at work within the river corridor that are causing these spikes (inputs/release from storage) and valleys (assimilation) in load are currently unknown.

These patterns could be driven by channel storage and/or remobilization of nutrients and bacteria, but these processes have not been measured directly in the Animas River. The orange-tinted sediment released in the Gold King Mine spill in August 2015 did provide a fortuitous tracer study regarding the transport and fate of sediments entering the river, and it is possible that spikes in pollutants from storm events may remain in the channel longer than previously assumed. An intensive cross-channel, high frequency sampling and a geomorphic and vegetative assessment, for example, could help understand why the “spikes” and “valleys” occur (e.g., what about that reach is increasing/decreasing its assimilative capacity, etc.).

3) Soils and sedimentary rock within the Animas River watershed could naturally contribute high levels of phosphorus and other constituents that could affect water quality. Currently it is unknown how much of the phosphorous in the Animas River can be attributed to natural, non-anthropogenic sources. Some formations like the Mancos shale are said to be high in nutrients, but justification is difficult to find. This could be explored through a reference watershed study, or through research via the Four Corners Geologic Society.

4) There is much to be learned about temperature and turbidity, which are listed impairments on the Lower Animas. Inexpensive data loggers could be deployed at intervals along the Lower Animas to identify spatial and temporal patterns of water temperature. New USGS Sondes installed at Cedar Hill and Aztec stream gages in March 2016 will

provide a new source of temperature, turbidity, specific conductance, and pH data that was not previously available on the Animas River. Additional sites upstream in CO and downstream on the San Juan will be deployed later in 2016.
(http://waterdata.usgs.gov/nm/nwis/uv/?site_no=09363500&PARAmeter_cd=00065,00060 and http://waterdata.usgs.gov/nm/nwis/uv/?site_no=09364010&PARAmeter_cd=00065,00060)

5) There is an abundance of water quality data that has been collected along the Lower Animas over the past couple of decades. It does not appear that robust statistical analysis has been conducted on these datasets. Improving data availability via www.coloradowaterdata.org will increase the ease of analyzing multiple datasets in the future. Partnership with a university math department may be a way to analyze these data at low cost.

6) The causal relationships of nuisance algae blooms and nutrient concentrations are not well understood. There were times in the MST study where the lowest concentrations of ambient nutrients were observed during the largest algae blooms, which could mean algal growth affects ambient nutrients as well as vice versa. Nutrient limitation studies using enzyme assays or investigating N:P ratios could shed further light on this issue. The Southern Ute water quality program has done extensive study of dissolved oxygen, pH, and temperature swings using Sondes, to see how algal blooms are actually affecting the health of the aquatic life in the Animas. This data was collected upstream of the Lower Animas study area, and has not been released yet, but these results may inform the nutrient-algae bloom-aquatic health relationship and help to plan future studies.

7) Benthic macroinvertebrate and chlorophyll-a data exist for the Lower Animas and could serve as a baseline to compare with current and future conditions. Future sampling should focus on the same locations and follow the same protocols that were used for the historical data. Updated chlorophyll-a sampling could provide a better understanding of how nutrients are affecting habitat for aquatic life in the Lower Animas. Benthic macroinvertebrate communities are excellent indicators of water quality. Determining if the health of benthic macroinvertebrate communities has improved or degraded over time can provide a greater understanding of the general health of the watershed. Local contractors like Ecosphere or Mountain Studies Institute could be tapped to do this kind of work, or larger national firms like TetraTech.

8) The human bacteria sources coming from upstream in Colorado are currently unknown, but appear to be fairly consistent. There is a contrast between the Human Bacteroides data, which indicates a high concentration of human bacteria, and the *E.coli* data, which do not exceed water quality standards. Future academic studies should look at the connection between *E.coli* and *Bacteroides* as fecal pollution indicators, as well as their connection to the presence of disease-causing organisms. On-the-ground studies should look at the potential landscape sources of human bacteria in the Colorado reaches of the Animas, including WWTP discharges, both permitted and accidental.

Other impairments and threats to watershed health

Although this WBP focuses on nutrients and bacteria, other impairments within the watershed are concerning as well. Some of the topics described in this section fall somewhere between pollutant sources and impairments, and it may be worthwhile to revisit this section after reading the Pollutant Sources in Section 4.

Loss of Assimilative Capacity

Gale (2010) defines assimilative capacity as “the ability of the environment or a portion of the environment to carry waste material without adverse effects on the environment or on users of its resources. Pollution occurs only when assimilative capacity is exceeded.”

In the context of this watershed plan, it refers to the ability of the river and associated river corridor to absorb, store, filter, and recycle pollutants including nutrients, sediment, and bacteria (See B.U.G.S. 2011, Appendix 1). Research has shown (e.g. Klapproth et al. 2000) that there is a strong relationship between the concentration of pollutants in the river and the strength of the hydrological connection between the river and the riparian community. When there is a strong, subsurface, hydrological connection between the river and the riparian community, pollutants are filtered out through a series of biological, chemical and mechanical means.

Riparian areas are essential transition zones between land and water bodies, helping prevent scouring and erosion, filtering pollutants out of stormwater, and increasing the filtering capacity of ground water/surface water exchange. The roots of riparian vegetation can stabilize stream banks, the canopy of riparian trees and shrubs shades the water, and riparian vegetation can intercept sheet flow and pollutants from overland sources (USDA NRCS 1996). These areas also function as floodplains during high flow, and may connect to riverine wetlands which further increase the filtering capacity.

Conversely however, the loss of riparian areas due to clearing and channelization not only means the loss of these treatment functions, but may also lead to the disturbance of nutrient and sediment sinks, resulting in a mobilization of pollutants that had previously been assimilated into the system (Riley 2009).

Riparian areas along the Animas River have been lost due to erosion, direct removal of vegetation, and other anthropogenic causes such as channelization, artificial hardening of banks, and overgrazing. There are numerous places where the river has incised significantly, reducing or eliminating the filtering capacity of the riparian system.

Anaerobic muck and assimilative capacity

Comments by Neal Schaeffer, New Mexico Environment Department:

I've surveyed many streams in New Mexico, but I think that if you blindfolded me and plopped me in a river, I could tell whether it was the Animas: This channel stores an unusually large volume of anaerobic muck. I'm talking about the foot or more of black, greasy sediments that smell like sewage or rotten eggs. I've encountered these sediments throughout the New Mexico reach of the Animas. Floods scour these sediments away, but they seem to form again as the flood recedes.

I've never really understood what this means. It suggests upstream sources of both fine-grained sediments (or turbidity in floodwater) and nutrients: excessive nutrients could lead to excessive algal growth, like green slime on the rocks or the seaweed-like filamentous algae so common in the Animas. I suspect that floods scour these algae into the turbid water; and as the flood recedes, this mixture settles to the bottom. Muck.

These sediments apparently impede circulation of oxygenated river water. As the high concentration of organic matter decays, the sediments become anaerobic. After a scour event, fresh sediments regain the rotten egg odor within about three weeks. I've gotten complaints from the public about "sewage in the Animas" that didn't turn out to be raw sewage at all. These sediments also contain concentrations of ammonia that are high enough to kill fish. (Ammonia can form under anaerobic decomposition like this, and fish are very sensitive to unionized ammonia.)

Perennial rivers in alluvial channels, like the Animas in New Mexico, usually exchange water with the adjacent floodplains and wetlands -- "river" waters flow through shallow soils near and along the river. These hyporheic waters become exposed to biological and chemical processes that affect the water chemistry. One well-known process that occurs in riparian wetlands converts nitrates into nitrogen gas. The Animas is impaired with excessive nitrate, perhaps in part because this natural process to attenuate nitrates doesn't function right.

Finally, the Animas River's tendency to store large volumes of anaerobic muck could affect other aspects of the water chemistry. Chemically reducing conditions like this can increase the solubility of most metals. Dissolved metals are much more toxic than insoluble metal precipitates. This is part of the reason NMED is concerned about lingering effects from the Gold King spill: insoluble metal sediments might begin to dissolve in these sediments, liberating toxic metal ions into the water column, even if those sediments weren't toxic when they flowed into New Mexico. NMED and others are monitoring the river, in part to look for toxic dissolved metals.

I'm optimistic that future generations will understand these aspects of the Animas River better.

The 2008 Source ID and BMP Report produced for the San Juan Watershed Group collected GPS data on bank armoring structures and actively eroding channel areas on the Animas River. These locations are shown in appendix C of that report, available on the San Juan SWCD website: http://sanjuanswcd.com/sjwg/phase-i-source-id-report

Results of this mapping showed that at least 8% of the 38.7 mile length of the study reach is in poor condition, with over 1 mile of actively incising channel and over 2 miles of rip-rapped bank with materials such as boulders, automobiles, scrap concrete, gabions, scrap metal, and other refuse (BUGS 2008).

Figure 16. Picture of inappropriate bank stabilization (L) and actively eroding bank (R).

Invasive Trees

The invasive phreatophytes Russian olive and tamarisk (salt cedar) were introduced to provide bank stabilization on Western rivers, but many consider that they have done their job too well. These trees can mimic armored banks, increasing sedimentation and channelization of the river, which contributes to downcutting and reduces the ability of the river to access its floodplain, furthering the detriment to native riparian vegetation (Tamarisk Coalition 2009). Riparian systems that are dominated by Russian olive may also act as a source of nitrogen (Mineau et al. 2011). Russian olive is a nitrogen fixer, and Mineau's study showed that reaches dominated by Russian olive had higher organic N concentrations as well as reduced N limitation in stream algae. Previous studies by NMED SWQB have showed evidence of N limitation as well as co-limitation by N and P (Personal communication with NMED staff). In this scenario, the riparian area loses its ability to assimilate nitrogen and instead becomes a source.

Wildfire Risk

The 2011 San Juan Basin Community Wildfire Protection Plan identified 1,582 acres along the Animas corridor that are at high risk of wildfire due to dense infestations of Russian olive and salt cedar. Wildfires within these areas put the whole riparian vegetation community at risk, as well as people and structures located within the riparian corridor. Post-fire runoff can be extremely detrimental to river water quality and aquatic life.

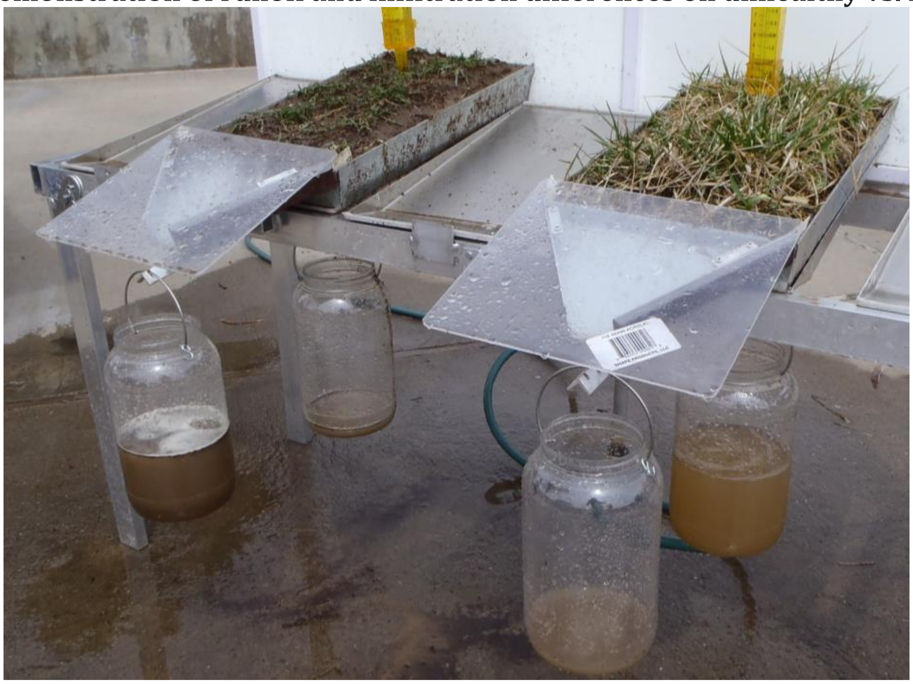
Fire is also a risk in the alpine headwaters of the Animas in Colorado and in the Pinon-Juniper uplands of the focal subwatersheds discussed in this plan. The State Line fire in 2012 burned 350 acres of pinon juniper within 1 mile of the river, and there have been numerous recent fires in the riparian areas of the San Juan and Animas Rivers.
See Vegetation and Forest sections for additional discussion about these dynamics.

Poor Soil Health

Healthy soils are critical to any healthy landscape. Soils that are managed to keep biota healthy and maintain high levels of organic matter exhibit higher water holding capacity and faster infiltration rates. These components are key to keeping water where it falls on the landscape, reducing runoff, and improving base flows (USDA NRCS 2016). With the limited water available as natural precipitation, it is crucial to keep it on the land as a resource as opposed to a detriment that runs off carrying valuable nutrients and topsoil.

The following image is from a 2015 Soil Health Workshop held in the Animas watershed. The soil on the left is characteristic of many areas within the Lower Animas. It is compacted, overgrazed, and has a high percentage of bare soil. The buckets below each soil show how much water ended up as runoff (front bucket) versus infiltration (back bucket) after a simulated one-inch rainfall. The increased infiltration rates associated with healthy soils lead to the attenuation of flood peaks, and increased flows to the river via groundwater during dry conditions. Promoting management for soil health will move more land in the watershed from the condition of the left soil to the one on the right.

Figure 17. Demonstration of runoff and infiltration differences on unhealthy vs. healthy soils



Aging Irrigation Infrastructure

Irrigation infrastructure (diversions, canals, ditches, laterals) affects the hydrology and can affect the local channel hydraulics and stability of the Animas River. Much of the infrastructure is decades old and in need of upgrades in order to efficiently provide irrigation and drinking water, as well as to minimize its impacts on the river system. Improvements can be broken down into several categories, each with different benefits.

Irrigation diversions influence the flow rate and hydraulics of the river and can seriously impact functioning capacity. Several diversions are in need of repair to reduce sediment inputs to the river caused by annual maintenance. These ditches must continually maintain their grade control by pushing up bed material (usually with a bulldozer in the channel) that then gets washed away during high flow events, increasing turbidity and sediment transport. The ditches in most need of repair for this reason are:

- Kello-Blancett
- Ranchmans-Terrell
- Farmington Echo

Other diversions are maintained using "improvised grade control" such as car bodies, rebar, and scrap concrete slabs. These can seriously impact functioning capacity, and are a hazard to fish, recreation, and people doing maintenance.

- Cedar Ditch
- Kello-Blancett
- North Farmington

Because all diversions represent a departure from the natural hydrology of the river, opportunities for improvements that meet multiple goals (reduced maintenance, improved head, better fish habitat, ease of passage for boats, etc.) are abundant.

Temperature

Temperature impairment on the Animas River is not directly addressed by this document, as a Use Attainability Analysis is still underway by NMED. The draft document can be found here: https://www.env.nm.gov/swqb/UAA/Animas/AnimasRiverUAA-FinalDRAFT07-07-2014.pdf with technical support here https://www.env.nm.gov/swqb/UAA/Animas/EPATechnicalSupportDocument-Animas.pdf
A TMDL for temperature is currently in place for the reach of the Animas River between the San Juan River and Estes Arroyo: https://www.env.nm.gov/swqb/SanJuan/Animas/index.html

Some best management practices proposed in this plan (e.g., buffer strips, erosion control) will also improve temperature conditions along the Lower Animas. Additional impairments, including temperature and turbidity, will be incorporated in future versions of this document.

Heavy Metals

While not directly addressed by this plan, heavy metals are still pollutants of concern in the Animas River watershed. The August 2015 Gold King Mine spill in Cement Creek impacted the Animas and San Juan Rivers, and stirred up region-wide concern over the impacts of historic mining. Before the spill, chronic mine drainage impacted the upper reaches of the Animas; and as far downstream as Bakers Bridge, levels of copper, lead, and zinc often exceeded EPA standards for chronic exposure to aquatic organisms, with cadmium and iron close to the threshold.

The Animas River Stakeholders Group (ARSG) has done an extensive amount of work toward mitigating contributions associated with mining and mine waste, though the expansive nature of mining in the area and spectrum of mine size makes addressing all contributors difficult. A watershed plan has been developed by ARSG specifically to address metal impairments in the Upper Animas (ARSG 2013). A multi-agency task force headed by NMED will conduct an extensive sampling and monitoring program that will monitor how the Gold King Mine spill may have impacted heavy metal levels in New Mexico.

An additional area of concern is the historic smelter location in Durango, CO. Ore was brought to Durango from Silverton and other mine locations because of the availability of water and coal. Up until 1961 a smelter operated at what is now the cross-roads of Highways 550 and 160. Originally, the smelter was used to process silver, lead, gold and copper. After World War II the smelter was modified into a uranium mill. The site is currently a Uranium Mill Tailings Remedial Action (UMTRA) site. At one time the smelter was discharging over 2 tons of material into the river per day. There is concern that material from this operation remains in the stream sediments and if disturbed may affect water quality.

Water Quality Improvement Goals

TMDL Load Reduction Goals

Load reduction goals were calculated in NMED's TMDL documents by comparing the TMDL, which is equivalent to a target load, to a calculated load (referred to in the TMDL document as a "measured load" but changed here to distinguish this method from an observation of a load on a single sampling date; See caption of Table 7). The 2010 calculated load was determined by NMED using a critical flow condition (73.5 cfs for San Juan River to Estes Arroyo; 86.5 cfs for Estes Arroyo to Southern Ute Indian Tribe bnd; NMED 2013) and the arithmetic mean of monthly samples; this same method was used on the 2014 MST data to see whether conditions had changed since 2010. Table 7 compares the target loads, 2010 calculated loads, and 2014 calculated loads to determine the percent reduction required to achieve the TMDL for each impairment (NMED 2013).

While one might be tempted to draw conclusions about loads improving or worsening from 2010 to 2014, the final column in Table 7 provides some necessary perspective. Within the single sampling year of 2014, observed loads varied by over four orders of magnitude. This extreme variation makes it difficult to compare datasets without including the large caveat that any changes may be within the normal range of variation.

To quote the 2013 TMDL document:

> "It is important to remember that the TMDL itself is a value calculated at a defined critical condition as part of a planning process designed to achieve water quality standards. Since flows vary throughout the year in these systems, the actual load at any given time will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained. Meeting the calculated TMDL at a given time may be a difficult objective," (NMED 2013, pg. 17).

Table 7. Target load, calculated loads, and percent reductions required.

Assessment Unit	Impairment	Target Load	Calculated Load in 2010[a]	% Reduction Required	Calculated load in 2014[b]	% Reduction Required[c]	Range of Loads Observed in 2014[d]
Animas River Estes Arroyo to So. Ute Indian Tribe land (NM-2404_00)	*E. coli*	**2.7 x 10^{11}** cfu/day	10 x 10^{11} cfu/day	73%	**6.7 x10^{11}** cfu /day	**60%**	3.5 x 10^{11} to 1.4 x 10^{14} cfu/day
	Total Phosphorus	**46.6** lbs/day	111.9 lbs/day	58%	**121.5** lbs/day	**62%**	<7.0 to 16,185 lbs/day
Animas River San Juan River to Estes Arroyo (NM-2403_A_00)	*E. coli*	**2.3** x 10^{11} cfu/day	3.4 x 10^{11} cfu/day	32%	**15 x10^{11}** cfu /day	**85%**	4.5 x 10^{11} to 4.3 x 10^{14} cfu/day
	Nutrients-Phosphorus	**33.5** lbs/day	-		**131.0** lbs/day	**74%**	<6.4 to 24,317 lbs/day
	Nutrients-Nitrogen	**201** lbs/day	-		**385.2** lbs/day	**48%**	<11.2 to 64,997 lbs/day

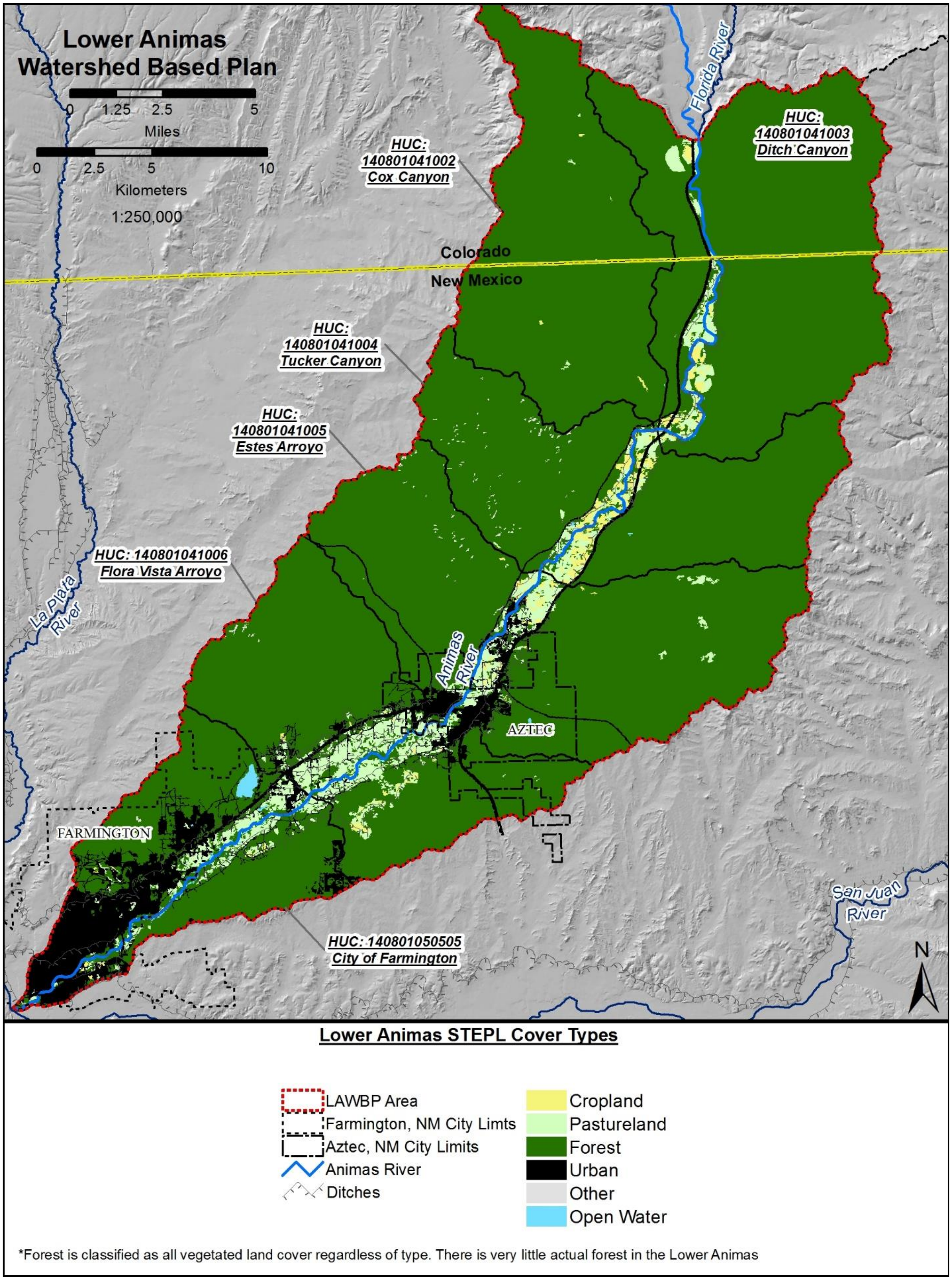
[a] Calculated using a critical flow condition and the arithmetic mean of monthly data from March to November of 2010 (NMED 2013).
[b] Calculated using the same critical flow condition as 2010, and the arithmetic mean of data from April to October of 2014 (MST 604B study 2014).
[c] Percent reduction required to go from 2014 calculated load to target load.
[d] Calculated using measured concentration and flow from the nearest USGS gage for each sampling date during the 2014 Microbial Source Tracking study. Where sample concentrations were below detection, one half of the minimum detection limit was multiplied by the flow to get the lower bound of a load estimate.

STEPL (Spreadsheet Tool for Estimating Pollutant Loads)

The section above discussed the observed loads of nitrogen, phosphorus, and *E.coli*, and how they were used to calculate the necessary load reductions to meet the TMDL. Another tool for discussing pollutant loads is the EPA developed STEPL model: Spreadsheet Tool for Estimating Pollutant Loads. The STEPL model uses simple algorithms to estimate nitrogen, phosphorus, and sediment loads from the landscape at a watershed scale. STEPL's pollutant load estimates are based on input data including land use type (urban, cropland, pastureland, feedlot, forest), pollutant sources (farm animals, feedlots, and failing septic systems), and climate data. Nutrient loading calculations in STEPL are a function of runoff volume and the concentration of nutrients in runoff water (Tetra Tech 2011).

We used STEPL to calculate the nutrient and sediment load expected to be produced by different land use types in each of the six HUC12 subwatersheds. The pollutant load estimates reflect processes occurring within each subwatershed separately and do not include pollutant sources from outside of the subwatershed, such as pollutant loads traveling down river from one subwatershed to another. Therefore, our objective with STEPL is not to accurately predict the exact amount of pollutant load that should be observed in the Animas River, but rather to be able to compare the relative differences in pollutant loads that can be expected from subwatersheds with varying proportions of land uses.

The land uses used in the STEPL model are shown in Map 20, and their estimated nutrient loading contributions by subwatershed are shown in Figures 19 and 20.



Map 20 – Lower Animas land cover categorized in STEPL cover classes.

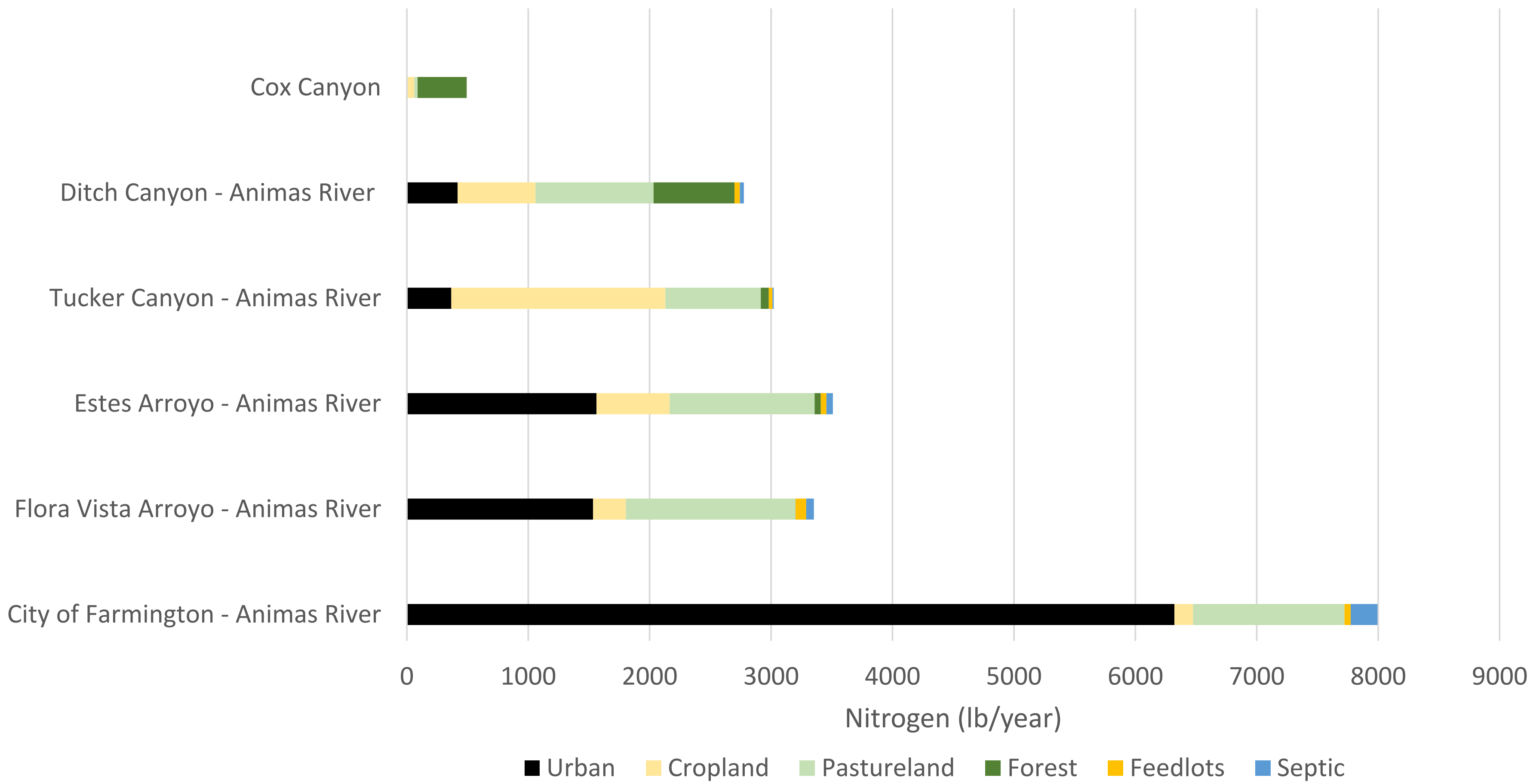


Figure 19. STEPL – Modeled total nitrogen load (lb/year) by land use for each HUC12 subwatershed.

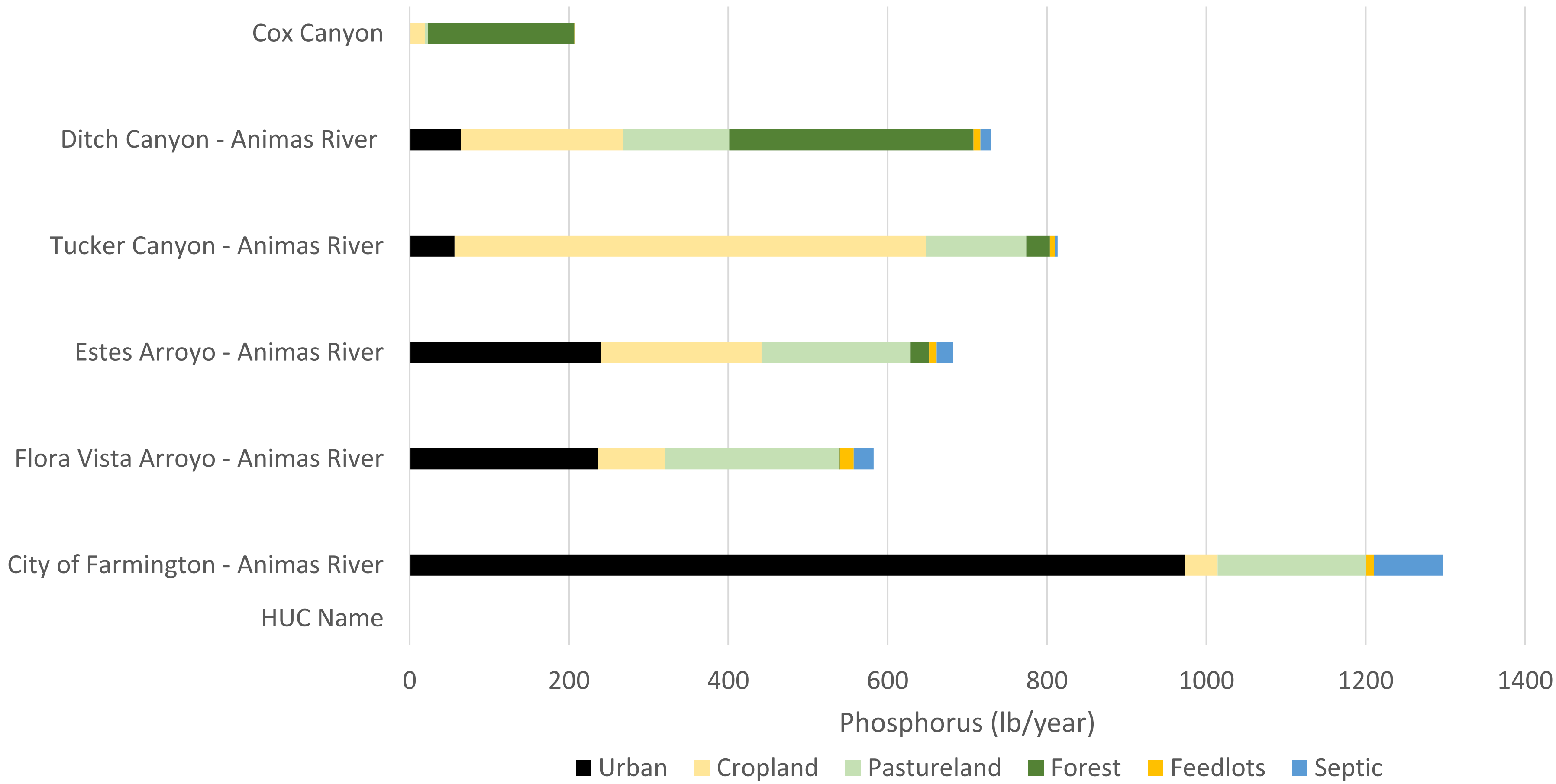


Figure 20. STEPL – Modeled total phosphorus load (lb/year) by land use for each HUC12 subwatershed.

STEPL estimates the contribution of pollutant loads by land uses, with the major sources of nitrogen and phosphorus loading differing among subwatersheds. For example, the pollutant load from the Farmington subwatershed is largely attributable to urban land use while the pollutant load in the Tucker Canyon subwatershed originates mostly from cropland (Figures 19 and 20). Details of land use-level pollutant sources and how they relate to the assumptions in the STEPL model are discussed in detail in Section 4.

Figure 21 shows that the highest modeled nitrogen and phosphorus loads originate in the Farmington subwatershed, while the greatest sediment load enters the river from the Tucker Canyon subwatershed. According to STEPL, the Cox Canyon subwatershed contributes substantially less nitrogen, phosphorus, and sediment than other subwatersheds along the Animas.

It is important to note that these pollutant load estimates do not include the pollutant load contribution to the Animas River from subwatersheds upstream in Colorado. Figure 22 illustrates that the 38 Animas River HUC12 subwatersheds in Colorado contribute a substantial load of pollutants to the Animas River.

STEPL also calculates estimated pollutant load reductions from implementing best management practices (BMPs). BMPs can be prioritized based on their documented efficiency value for removing pollutants. Specific modeled load reductions are discussed by land use in Section 5 and in final summary tables in Section XX.

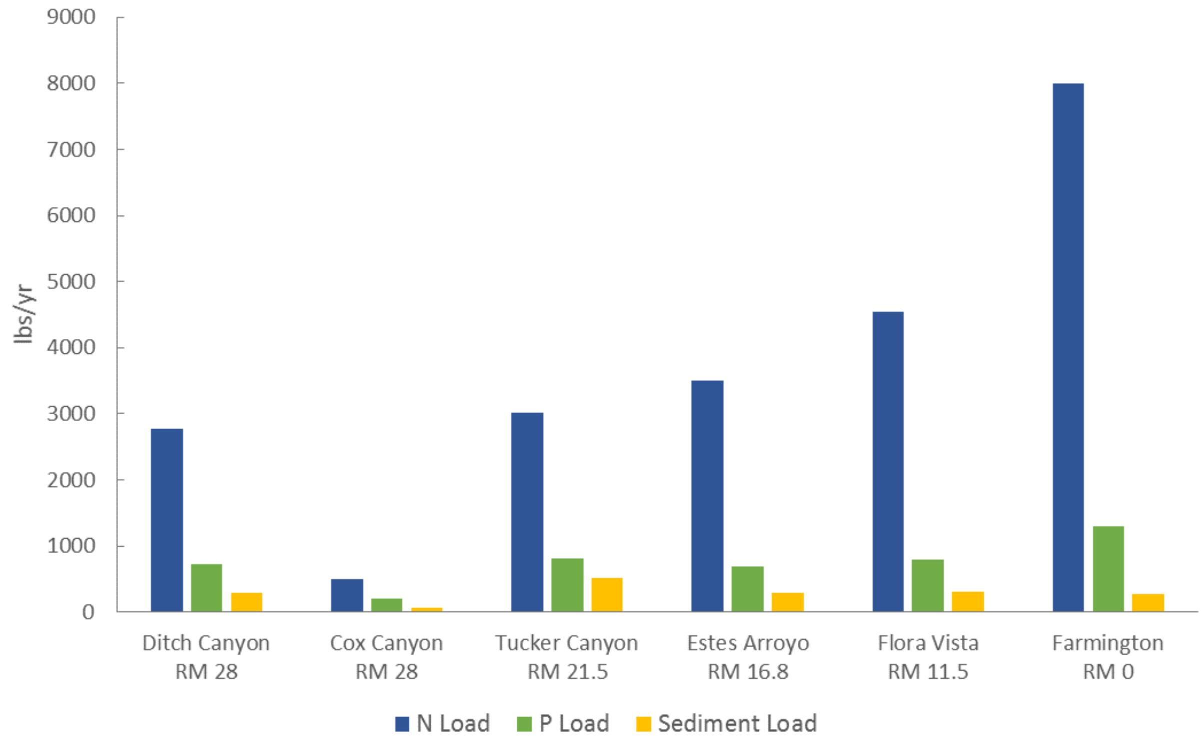


Figure 21. STEPL modeled nitrogen, phosphorus, and sediment load by the lower Animas River HUC12 subwatersheds.

*Y-axis units for sediment are in tons/yr, N and P are in lbs/yr

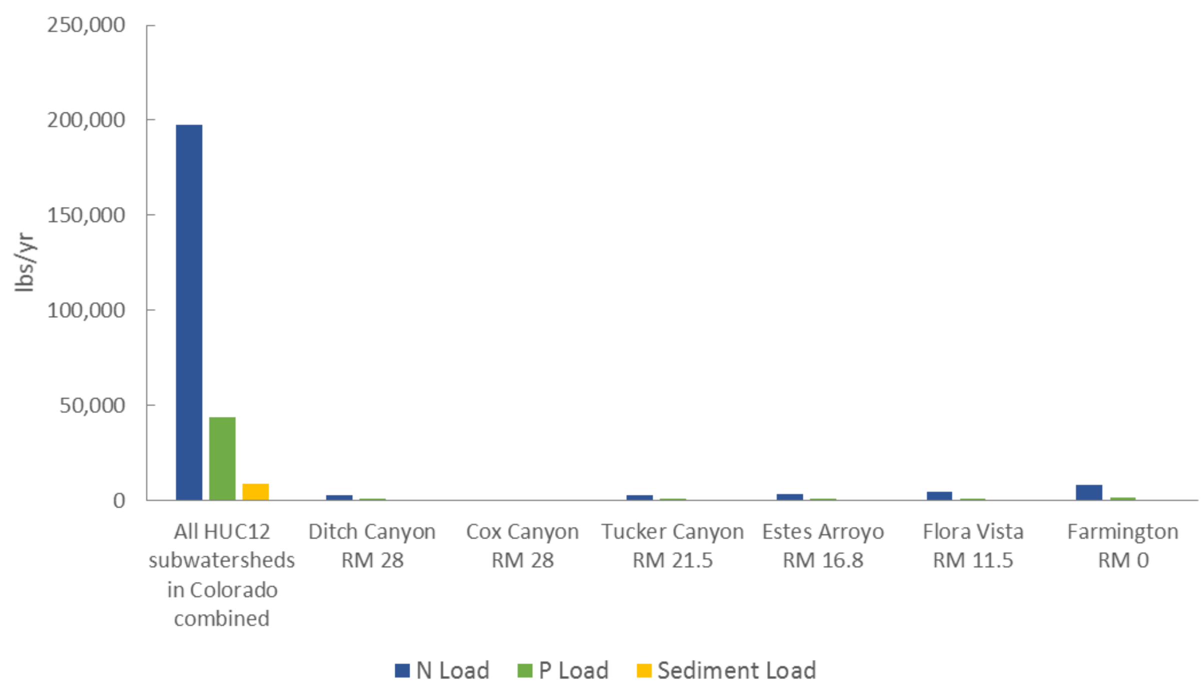


Figure 22. STEPL modeled nitrogen, phosphorus, and sediment load by the lower Animas River HUC12 subwatersheds and all HUC12 subwatersheds in Colorado combined.

4. Pollutant Sources

The TMDLs for the Animas River in New Mexico (NMED 2006 and 2013) list many potential pollutant sources that contribute to the impairments discussed above. This section expands on these sources in more detail, and discusses which sources across the Lower Animas Watershed are contributing the most bacteria, nutrients, and sediment and thus are most important to remediate.

Briefly, any sources of bacteria pollution are also sources of nutrients, and are a top priority to address.

Human Sewage

The results of the Microbial Source Tracking study were very surprising, in that human source bacteria was not initially suspected to be a primary source of bacterial contamination in the river. While the Animas River had a less persistent human bacteria problem than sites downstream on the San Juan River (see Section 3), concerns about recreation and the possible increased risk of illness from ingesting human-hosted pathogens make sources of human fecal pollution a primary concern.

Nearly all homes and businesses in the Aztec and Farmington city limits are connected to the municipal sewer systems and wastewater treatment plants for wastewater disposal. All homes and businesses not connected to city sewers use on-site liquid waste disposal (LWD) systems, commonly referred to as septic systems, for domestic wastewater disposal. Table 10 shows the possible sources of human bacteria to the Animas River, which loosely fall into the categories of: On-site liquid waste systems, illegal dumping, municipal wastewater infrastructure, and outdoor defecation. The prevalence of each of these sources is discussed in the following sections.

On-site liquid waste systems

On-site liquid waste systems for domestic wastewater disposal typically consist of a septic tank for primary treatment connected to a soil absorption field or drainfield. These systems can be a source of bacteria and nutrients in several ways. Failing systems with surfacing sewage can discharge directly to a channel system, or flow overland during storm events. Properly functioning systems installed in course sandy and/or gravelly soils that don't effectively filter bacteria can impact the river via subsurface flow. Illegal, improperly installed, or missing septic systems may reach the river through any of these pathways.

The current minimum lot size for a standard septic tank/absorption field system is 0.75 acre for a three bedroom home (with larger systems regulated by the NMED Liquid Waste Program or Groundwater Bureau). Prior to 1990, the New Mexico Liquid Waste Regulations permitted smaller lot sizes that varied from 0.33 to 0.5 acre during the 1970's – 1980's. There were no minimum lot size requirements prior to the 1973 Liquid Waste

Disposal Regulations and many subdivisions from the 1950's had 0.25 acre lots. Lots not in subdivisions had no minimum lot size requirement and some are as small as 0.1 acre (NMED LWP 2014 https://www.env.nm.gov/fod/LiquidWaste/laws.regs.pol.html).

These minimum lot size regulations are necessary to protect groundwater from nitrogen contamination. The established lot size is based on a rate of 58 lbs total nitrogen per acre per year, which is necessary to prevent groundwater from exceeding 10 mg/l nitrate and 1 mg/l nitrite (McQuillan et al. 2004). Application rates for total nitrogen increase with the decrease in lot size and those rates are: 0.5 acre – 116 lbs/acre/year; 0.33 acre - 174 lbs/acre/year; and 0.25 acre – 232 lbs/acre/year (McQuillan et al. 2004)[1].

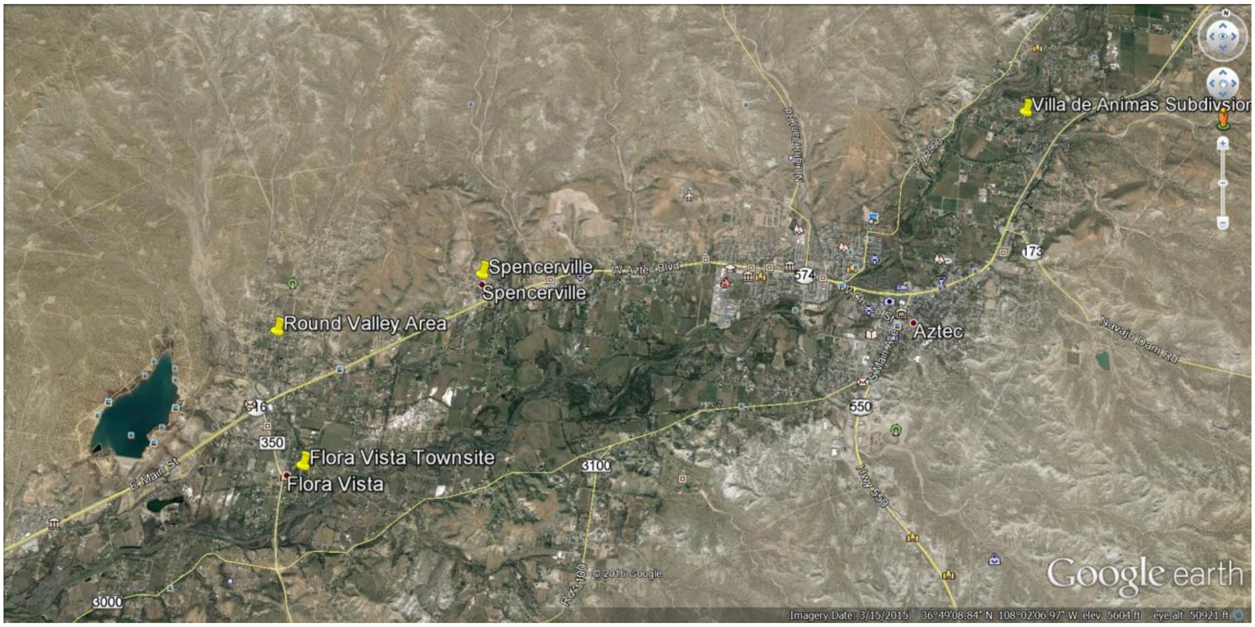
The river valley between Aztec and Farmington has several older subdivisions with a high density of on-site liquid waste systems that would not meet current lot-size regulations if designed today. The Round Valley area and old Flora Vista town site both have variable lot sizes that range from 0.15 acre to 0.5 acre in concentrated areas, and drain to the Flora Vista Arroyo, which had elevated nutrient and bacteria concentrations in both the 2006 and 2014 inflow studies (See Sampling Summary in Appendix B).

In addition to small lot size, the Flora Vista community has extensive areas with heavy clay soils and shallow depth to groundwater, which can cause liquid waste systems to fail prematurely. A 2006 study found 14% of septic tanks in the Animas corridor near Farmington to be failing (3 out of 22 systems inspected) and it is suspected that the failure rate is higher in the Flora Vista area (SMA 2009; personal communication with septic inspectors).

This is exacerbated by subsurface flow from unlined irrigation ditches up-gradient from these septic systems (see irrigation ditch network on Maps 7 and 8), and leaking ditches and/or excessive flood irrigation may raise the water table between April and October, increasing transport of nutrients and bacteria to the river through groundwater. High nitrogen concentrations in groundwater are common (McQuillan et al. 2004, NMED sewage report 2006).

[1]Report includes following equation and details on regulated constituents of liquid waste:
Q gal/day X 365 days/yr X 3.78L/Gal X C mg/L X2.2 lbs/10^6 mg/L X A/LS = lbs N/acre/year where
A = percent of total area consisting of platted lots/100,
C = total nitrogen concentration (mg/l),
LS = lot size (acre), and
Q = wastewater flow (gpd)

Domestic liquid waste should not exceed 300 mg/l BOD, 300 mg/l TSS, and 80 mg/l total nitrogen (NMED LWD Section 7.D.(6) 20.7.3 NMAC) and an average of 19 mg/l total phosphorus (Lusk et al. 2011). Septic tank effluent should not exceed 200 mg/l BOD, 100 mg/l TSS, 60 mg/l total nitrogen (NMED LWDR Section 7.O.(7) 20.7.3.NMAC) and an average of 10 mg/l total phosphorus (Lusk et al. 2011).



Map 21. Problem areas for on-site liquid waste disposal near Flora Vista, NM

Surfacing sewage has been enough of a problem in the Flora Vista area that in 2006, San Juan County commissioned a Preliminary Engineering Review to investigate community sewerage system options (SMA 2008). These remediation options are discussed in greater detail in the management measures section of this document.

STEPL estimates that only a small proportion of the nutrient load in the Animas River is from septic systems (Figure 19 and 20). However, the STEPL estimate is based on properly functioning systems and does not account for the local conditions described above. This likely results in an underestimation of the contribution of pollutants to the Animas River from septic systems.

Illegal dumping

The contents of a septic tank must be removed periodically to prevent overflow of grease or sludge to the drainfield. This septage has a very high concentration of *E. coli* bacteria (10,000 to >1,000,000 cfu/100ml) in addition to high concentrations of BOD, TSS and total nitrogen (See footnote on previous page). The only legal septage disposal facility in San Juan County is the Farmington Wastewater Treatment Plant (WWTP). Illegal dumping of septage and portable toilet waste by commercial septage haulers has been documented in San Juan County, and due to the remote nature of much of the landscape, there are numerous available locations to dump without being seen. Direct discharge of septage to the Animas River, an irrigation canal, or uplands near watercourses would be a substantial source of bacteria and nutrients, though it is impossible to quantify exactly how much loading comes from this source.

Upon discovery of the human bacteria problem in 2014, the San Juan Watershed Group initiated an outreach effort with the NMED Liquid Waste Program (LWP), the City of Farmington, and San Juan County. As of early spring 2015, there were 19 septage hauling companies listed in the phone book, but only two of these had their employees certified through NMED's Liquid Waste Program. Inspection of Farmington WWTP records indicated that some of the operating companies had not recorded waste deliveries to the plant, lending credibility to the anecdotal evidence of possible illegal dumping practices. After an enforcement effort by the LWP, all 19 companies were certified by the end of 2015, and brochures about reporting illegal dumping were distributed to all San Juan County residents in utility bills – an important first step towards addressing this problem.

The utility bill inserts also included information on reporting illegal dumping by users of recreational vehicles (RVs). Tourism is popular in the area, with RVs frequently visiting Aztec Ruins National Monument and stopping en route to other national parks in the region. Anecdotal evidence suggests that RVs may discharge waste into irrigation canals on a fairly regular basis (Personal communication with ditch riders). It is unknown how much RV waste dumping contributes to bacteria and nutrient loading, but like septage, the concentrated nature of the waste makes it a priority to prevent.

Wastewater Infrastructure

As discussed in the Discharge Permits section, the Aztec WWTP is the only permitted discharger of treated sewage effluent to the section of the Animas River focused on in this plan. The 2006 plan documented the WWTP as a significant source of both nitrogen and phosphorus, but these are covered in the plant's NPDES permit. Leaking sewage pipes are a possible source of both human bacteria and nutrients, but there have been no direct reports of this in either Aztec or Farmington, and the contribution of pollutants from deteriorating sewer infrastructure remains a data gap.

Upstream in Colorado, the Durango WWTP was documented as the number one single source of nutrients to the Animas River in 2010 (BUGS 2011). Colorado is in the process of updating its nutrient regulations (https://www.colorado.gov/pacific/sites/default/files/WQ_nonpoint_source-Regulation-85.pdf), and the City of Durango has plans in the works to do major renovations to its WWTP in order to meet these regulations.

The finding of a constant source of human bacteria at the CO/NM state line sampling site in 2014 was a very surprising result (SJWG 2014), but the exact source of this bacteria remains a data gap. Some NPDES permits do allow a certain amount of bacteria to remain in treatment plant effluent, and this could shed some light on whether the human sources are in fact from legal discharges under NPDES permits. An investigation into the other WWTP discharge permits in Colorado may yield additional information about human sources of bacteria entering New Mexico from the north.

Outdoor Defacation

The contribution of human bacteria that comes from people defacating outdoors in the Lower Animas watershed is unknown. Farmington has a fairly constant homeless problem, and makeshift camps without bathroom facilities are often found tucked into the riparian areas along the river corridor between Flora Vista and Farmington. Any efforts to provide more suitable housing to the homeless population would address this issue, and would be more important for social reasons than for water quality concerns.

Camping for recreation on public lands is scattered sparsely throughout the uplands in the watershed (hunting camps, etc.) but is not likely to be a major contributor of bacteria.

Table 8. Possible sources of human and ruminant bacteria to the Animas River.

Biological Source	Source Activity Pathway to River:	Ground water	Direct Discharge	Irrigation Returns	Storm water
Human	Faulty septic tanks	X			X
	Illegal septic (straight pipes, cess pits, etc.)	X	X	X	X
	Illegal dumping – waste disposal companies		X		X
	Illegal dumping – recreational vehicles		X		X
	Leaking sewer pipes	X	X		
	Wastewater treatment plants		X		
	Outdoor defecation				X
Ruminant –	**(includes cattle, deer, elk, sheep, goats)**				
	Animals with direct access to river		X		X
	Grazing on irrigated fields			X	X
	Grazing in uplands and riparian areas				X
	Improper manure disposal		X	X	X

Irrigated Pasture

As shown in Map 18, pasture is the most prevalent land use in the bottomlands and riparian corridor of the Animas River valley, which includes all of the focus subwatersheds except Cox Canyon. Because of its proximity throughout the river corridor, STEPL estimates that pasturelands contribute fairly similar loads of N and P in each subwatershed (Figures 19 and 20), leading to a combined contribution of 5,623 pounds of nitrogen and 854 pounds of phosphorus to the Lower Animas each year. STEPL estimates that pasture is the second largest contributor of nitrogen to the Lower Animas.

Of all the land uses included in the STEPL model however, pastures have the fairly unique ability to be an asset to water quality and watershed health when properly managed, and should not be looked at as a negative land use overall. A pasture with good grass coverage, deep root systems, high infiltration capacity, high soil organic matter, and good biodiversity has the ability to filter out and recycle nutrients from manure, slow runoff, and build topsoil. By contrast however, a poorly managed or overgrazed pasture often has bare ground, low infiltration capacity, and high rates of runoff, is susceptible to wind and water erosion, and can be a major source of bacteria, nutrients and sediment to the river.

The Lower Animas watershed has pastures that fall all across this spectrum. The biggest problem areas are properties where livestock are kept in close proximity to riparian areas, with direct access to the Animas River. Ruminant bacteria was present in nearly 100% of samples taken on the Animas in 2013 and 2014. While bacteria from ruminants includes a combination of cattle, sheep, and goats as well as wildlife sources (deer and elk), areas where livestock high-use areas are concentrated near the river are the easiest of these sources to identify and address.

The Paseo del Norte Rio Grande WBP calculated *E. coli* loading from livestock as follows: One horse is estimated to produce 2.1×10^8 cfu *E. coli* per day (EPA 2001; Doyle and Erickson 2006). The *E. coli* load was estimated using a conservative assumption that 0.2 percent of the *E. coli* from the horses in the watershed was discharged to the river each day. One dairy cow is estimated to produce 5.0×10^{10} cfu *E. coli*/day (EPA 2001, Doyle and Erickson 2006), with a conservative assumption that 0.01 percent of the cattle-source *E. coli* is transmitted to a drain daily (PdNWC 2014). Because cows in the Lower Animas are free roaming in pastures (like horses) instead of in confined dairies, the 0.2 % estimate is more appropriate.

An inventory of winter livestock pastures in January 2016 identified 216 cattle and 50 horses in pastures near the river in the Animas-Flora Vista subwatershed; 110 cattle, 60 sheep, and 10 horses in the Animas-Estes Arroyo subwatershed; and 160 cows in the Animas-Tucker watershed. Using the assumptions from PdNWC WBP mentioned above, this amounts to:

Animas-Tucker: 1.6×10^{10} cfu/day from cattle
Animas-Estes: 1.68×10^7 from horses and sheep, and 1.1×10^{10} cfu/day from cattle
Animas-Flora Vista: 2.1×10^7 cfu/day from horses, and 2.16×10^{10} cfu/day from cattle

While these appear as daily loading rates, it’s likely that more manure (and thus *E.coli*) is mobilized during flood irrigation, and especially after storm events, than on dry days when manure being deposited directly into the river is the primary pathway for bacteria pollution from pasture.

Riparian grazing by livestock and resident wildlife are also sources of *E.coli* along the length of the Lower Animas. The 2006 Shumway and Stevens Arroyo Sampling report documented that manure from fields serving as year-round or winter pasture generate *E. coli* bacteria that reach rivers and streams during the summer irrigation season (SJWG 2008 Phase I). Even dried manure contains viable bacteria that can be transported to waterways via runoff.

Irrigated Cropland

The STEPL model predicts that croplands contribute 3,487 pounds per year of nitrogen and 1,140 pounds per year of phosphorus to the Lower Animas. The majority of cropland in the Lower Animas watershed is concentrated between the State Line and Center Point, in the Ditch Canyon and Tucker Canyon subwatersheds (See Maps 3 and 5). STEPL estimates that cropland contributes 204 lbs phosphorus/year and 641 lbs nitrogen/year from the Ditch Canyon subwatershed, while 592 lbs P/ year and 1764 lbs N / year originate from the Tucker canyon reach.

Similar to pasture land, the cropland is nestled along the river bottom below the network of irrigation ditches. Irrigation practices vary, but flood irrigation, gated pipe, and side roll sprinkler are the most common. Based on conversations with staff at the Natural Resources Conservation Service (NRCS), most people irrigate based solely on water availability and not on actual crop needs. Over-watering is common, leading to nitrogen leaching into groundwater, tailwater runoff at the edge of fields, and increased salts at the soil surface. High nutrient concentrations were observed in irrigation ditches in the 2014 study (Sampling Appendix B), so inefficient irrigation methods will lead to these leaching back to the river.

Most cropland is tilled annually, and the subsequent bare ground is vulnerable to erosion, contributing both sediment and nutrients to the river, degrading soil structure, and leading to reduced infiltration rates and water holding capacity.

Hobby farms

During the January 2016 reconnaissance effort to document livestock feeding sites in the Animas valley, numerous properties with a small number of horses, sheep and goats were observed, with horses being the most common. Most of these properties were relatively small (1 – 2 acres or less), and some may fall into residential rather than pasture land use under STEPL. These small hobby farms far outnumbered the larger ranching operations.

Discussions with managers of the major irrigation ditch companies indicate an ongoing concern about manure from these properties being stockpiled adjacent to the irrigation canals were stormwater events would flush the manure into the ditch and even instances where property owners dump manure directly into the flowing ditches.

The level of proper manure management practices on these properties is highly variable dependent on the efforts of the animals' owners. Some properties were observed to be very well maintained with minimal residual manure and others had many months of accumulated manure.

"Forest"

The forest land use shown in the STEPL model in Map 18 encompasses almost the entire uplands of the watershed outside the river corridor. However, the "forest" of the Lower Animas likely differs greatly from the landscapes STEPL was originally designed for. The Lower Animas pinyon-juniper forest is often sparsely vegetated and occurs on erosive soils. The upland forest in the Lower Animas watershed is also highly disturbed by oil and gas development (Map 14) and grazing. Due to these conditions, STEPL may underestimate the nutrient and sediment contribution to the Lower Animas from forest land. The next two sections detail the pollutant sources originating from "forest" uplands.

Oil & Gas Development

Oil and gas development within the watershed produces substantial sediment through well pad construction, road building, pipelines, and associated infrastructure. Again, Map 14 shows the extent to which well pads and access roads spider web the landscape; to put the magnitude of development in perspective: San Juan County, NM has the same amount of acreage in well pads and roads as it does the total privately owned land. Matherne (2006) determined that road construction and well pads in the nearby Largo Canyon add to sediment loads from runoff across and along slopes and berms. The infiltration capacity of compacted areas (i.e. roads and well pads) is low compared to the surrounding areas and results in an increase in surface runoff and transportation of sediments. Surface runoff from across the landscape is then collected by borrow ditches along roads and concentrated into large outlets at an increased discharge rate, eroding down-slope channels (Montgomery 1994; Matherne 2006). This can drop the water table in upland areas, favoring deep rooted trees and shrubs in lieu of sod-forming native grasses which capture water and reduce erosion. (BUGS 2011). Matherne's research found that roads facilitate erosion by cutting across existing drainages and by providing focal points for erosion. Well pads were identified to increase erosion rates in a similar manner by providing areas for head-cut erosion and focusing flow.

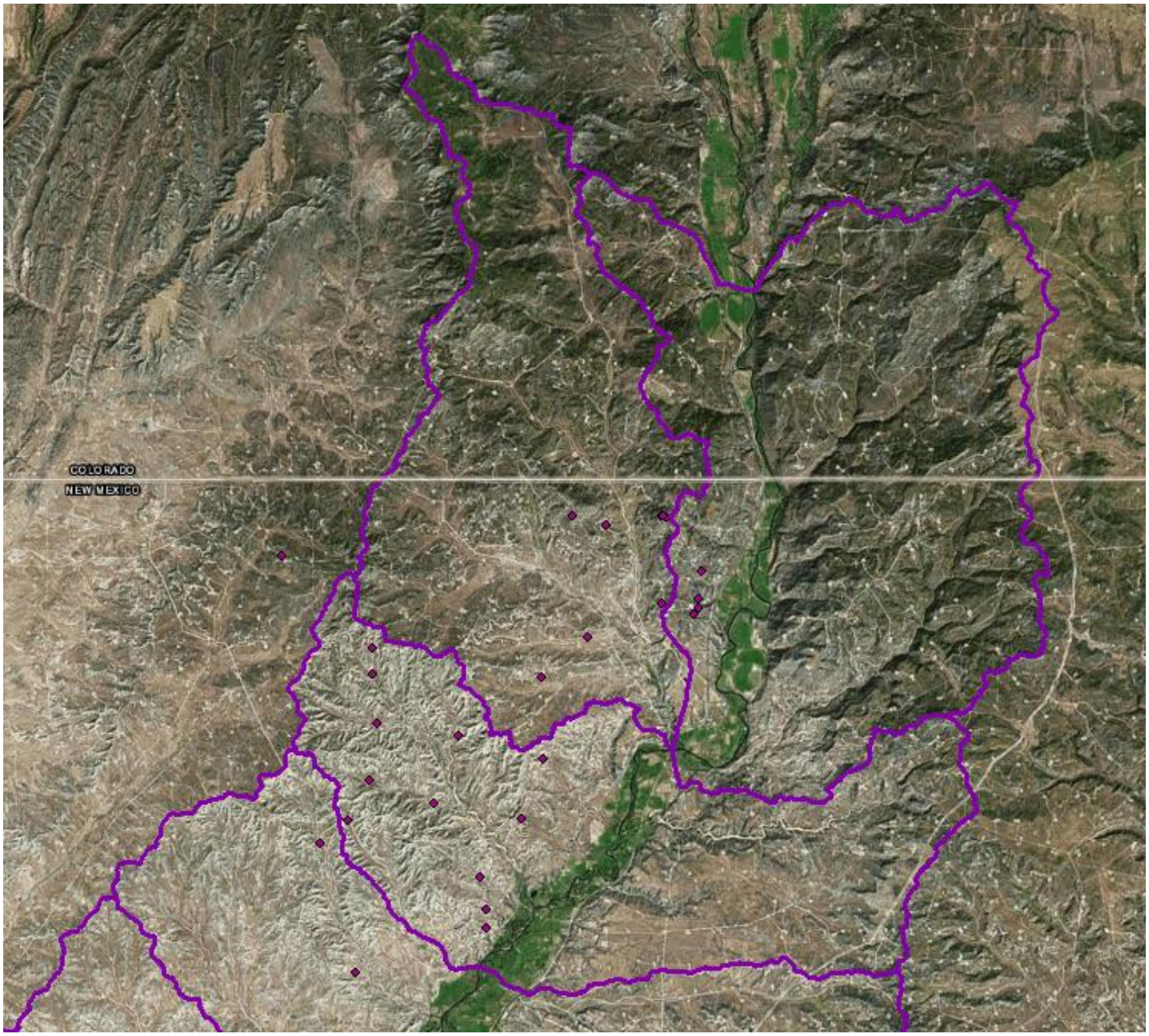
The San Juan Basin Roads committee is charged with management of the extensive road network, and includes members from all oil & gas producing companies, pipeline companies, and the Bureau of Land Management (BLM). While all road maintenance, grading, and construction is supposed to be done according to "The Gold Book" (BLM

2007), there are real barriers that prevent road graders from keeping roads up to standards. These include:

- Hundreds (probably thousands) of miles of old roads that were not engineered or designed to meet any erosion control standards
- Heavy road use in inclement and muddy weather and lax enforcement of "rut rules" leads to flow pathways down center of roads, shortcutting water turn-outs
- Pipeline right-of-ways on edge of roads that prevent proper crowning and water turn-outs
- "Tragedy of the commons" on maintenance – no one wants to front money for repairs when they can't prevent others from doing damage (this has improved greatly since forming the Roads Committee but is still an ongoing issue)

All six subwatersheds are influenced by oil and gas development, and the "forest" land use is greatly disturbed from its natural state as a result. Map 22 on the next page shows pipeline inspection points that were listed as non-compliant for erosion issues in a 2013 survey. These were largely concentrated in the Cox Canyon and Tucker Canyon subwatersheds, and also overlap with areas of highly erodible soils (See Soils Map 18 and 19).

Soil sampling in the large ephemeral drainage of Kiffen Canyon (tributary in the Tucker Canyon subwatershed; See Map 11) found very high nutrient concentrations in the sediments of the arroyo – 35 mg/kg Total Nitrogen, and 119 mg/kg Total Phosphorus (SJWG 2014). Note that soil characteristics in Kiffen Canyon are classified as "Badland" and do not have values for the erodibility index or cation exchange capacity. We know from local knowledge that these areas are highly erodible and likely low when it comes to cation exchange capacity. The Mancos shale is known to be a nutrient rich formation, but specifics on the nutrient content of the soils or geology from individual drainages remains a data gap. However, data from Kiffen lends evidence that any efforts to reduce sediment loading from upland disturbances could result in large reductions to nutrient loading as well.



Map 22. Pipeline right-of-way inspection points in non-compliance for erosion

Upland Grazing

Livestock grazing on BLM allotments is common throughout the upland areas in the Animas River Watershed, and includes the Kiffen Canyon, Hart Canyon, Knickerbocker Ranch, Lonetree Mountain, Animas Community, Tank Mountain Community, and Mt. Nebo AMP Allotments. Stocking rates and range improvements are managed by BLM range staff out of the Farmington Field Office.

Cox Canyon, Kiffen Creek and Flora Vista Arroyo are large ephemeral tributaries to the Animas which all have extensive upland areas available for grazing. While it is possible that these areas contribute bacteria to the river during very large storm events, the ruminant bacteria is persistent enough throughout the year that it is more likely influenced by animals residing in the river valley.

It is more likely that past over-grazing has influenced the uplands, and pushed it towards a transition from grass and shrub dominated landscape to a shrub and tree dominated landscape. Encroachment of sage, pinon, and juniper (for example) into grass environments means deeper root systems taking up the available water, displacing sod-forming grasses, and increasing the prevalence of bare ground and gully erosion between trees, which lowers the water table and gives further advantage to the deep rooted trees and shrubs (BLM Restore NM 2015).

By targeting the remaining grasses, grazing animals like cattle may be furthering this cycle. They also trample the fragile cryptobiotic soils of the desert, which can be the only defense against wind and water erosion on otherwise bare ground.

Urban

Stormwater runoff from urban and suburban areas contribute contaminants to river ecosystems including sediment, residual pesticides, herbicides, fertilizers, pet waste, petroleum products, and other toxins.

STEPL predicts that urban land use is the largest contributor of nitrogen and phosphorus from the six subwatersheds analyzed in this study. While it's possible this is an overestimate due to the lower number of fertilized lawns in the arid West, it is best estimate available using the chosen model. STEPL attributes the majority of this load to the City of Farmington – Animas River subwatershed, but estimates that urban land use in the Flora Vista and Estes Arroyo subwatersheds is an important source of nutrients as well.

These three subwatersheds fall within the MS4 Farmington urbanized area. The City of Farmington, City of Aztec, San Juan County, San Juan College, and NM DOT all participate in the MS4 program in the Animas Watershed, and are in the process of updating their MS4 plans in 2016. Because this process was ongoing at the time this document was written, some details about the urban sources and BMPs will be added in greater detail in future iterations of this Watershed Based Plan.

Regardless of what contaminants are present in urban stormwater, one of the easiest ways to prevent them from reaching the river is by addressing drainage and water retention from the impervious urban environment. Though an urban environment is unlikely to ever be looked at as "natural", the flashiness of the hydrograph should be attenuated as much as possible to mimic a "natural" drainage pattern back to the river. In short, keep water where it lands in the urban environment for as long as possible instead of giving it the shortest path to the river. This is discussed in greater detail in the Stormwater and Management Measures sections.

Stormwater Runoff

While not a pollutant source that is specific to a given land use, addressing stormwater runoff on all land uses will certainly result in pollutant load reductions to the Lower Animas River.

Stormwater runoff results from rainfall events that exceed infiltration rates. In the Lower Animas watershed, this occurs most often from late July through September during the Southwest's "Monsoon Season". Non-irrigated areas in San Juan County are sparsely vegetated and have highly erodible soils. These events mobilize animal waste and large quantities of sediment that flow down arroyos into the Animas River. Stormwater runoff can deliver nutrients, sediment, and bacteria to waterbodies from almost all land use types including urban, industrial, agricultural, suburban, and in an undisturbed landscape. Inadequate management of soil disturbances, vegetation, and riparian areas may exacerbate stormwater impacts.

As mentioned in the Recent Water Quality Trends section, several studies conducted by the SJWG suggest that stormwater runoff may be the most substantial source of pollutant loading to the Animas River (SJSWCD 2015). The highest nutrient and *E. coli* loadings observed in 2014 occurred during fall storm events (Figures 8 and 9 in Section 3). NMED data from 2005 demonstrated increases in nutrient concentrations and loadings during a fall storm (SWQB 2005). In the 2013-14 MST study, the highest concentrations of *Bacteroides* and *E. coli* were observed immediately following storm events.

Upstream Sources

As shown in the Water Quality Trends section of this plan (ie: Figures 3, 5, and 7) and from the STEPL model (Figure 22), significant loads of nitrogen, phosphorus, and *E.coli* are already present in the Animas River when it reaches the Colorado/New Mexico state line. The Animas Watershed Partnership and others are actively working on addressing several known pollutant sources upstream of the Lower Animas focus reaches addressed in this plan. Many of these were identified in the 2011 Animas Watershed Plan (BUGS 2011) and all of these upstream efforts should be supported as beneficial to reducing loading in the NM reach of the river:

- Durango Wastewater Treatment Plant upgrades for nutrient treatment
- Agricultural pollutant sources in the Florida River drainage
- Sediment inputs from Lightner Creek in Durango
- Impacts to riparian buffers and functioning capacity in the Animas Valley north of Durango

Summary of Causes & Sources of Impairment

While the water quality impairments and pollutant sources discussed in the previous two sections may seem overwhelming to address, there is also a great deal of overlap, where a single source activity is contributing to multiple impairments. There are also instances where addressing one problem (ie: barriers to assimilative capacity) will mitigate for other source activities. In summary, there are numerous opportunities to plan projects which will have multiple benefits to water quality in the Animas River.

Table 9. Summary of source activities and the water quality impairments they contribute to.

Source Activity: / Impairments that Source Activity Contributes to:	Nutrients	Bacteria	Sediment	Barrier to Assimilative Capacity
Faulty/illegal septic tanks	X	X		
Illegal dumping – septage waste/RVs	X	X		
Wastewater treatment plants	X	(X)		
Livestock with direct access to river/waterways	X	X	X	(X)
Pastures without buffers to manure runoff	X	X	X	
Improper manure disposal	X	X		
Poor soil health on cropland/pastureland	X	(X)	X	
Overwatering/over-fertilization of crops & pasture	X		X	
Erosion from well pads, pipeline, & dirt road network	X		X	(X)
Fertilizer runoff from urban/suburban areas	X			
Urban stormwater	X	X	X	
Infestations of invasive phreatophytes and weeds	(X)		(X)	X
Lack of vegetation in riparian areas	(X)		X	X
Inappropriate rip-rap, bank stabilization, or diversion grade control	(X)		(X)	X
Irrigation diversions with bed material grade control	X		X	X
Tree and shrub encroachment in uplands	X		X	

(X) indicates a pollutant that could be contributed in certain instances but not all.

Watershed Restoration Goals

Watershed restoration goals were discussed at San Juan Watershed Group public meetings in order to make sure the direction of the Lower Animas Watershed Based Plan was compatible with the needs and values of the community. The list is based on the goals from the 2011 Animas Watershed Plan, and was updated to incorporate the new body of information collected for this plan.

- Remediate all sources of human waste in river
- Ruminant bacteria reduced by half
- Storm flow bacteria and nutrient concentrations reduced by >10%
- Soil health improved on range, crop, and pasturelands
- Native grass, shrub, and tree buffers along river in all subwatersheds
- Riparian areas free from invasive phreatophytes
- Reduce loading of fine sediment originating from roads and disturbed areas
- Barriers to assimilative capacity removed
- Floodplains reconnected in reaches compatible with current land use
- Invasive weeds replaced with native grasses

5. Projects (Management Measures & Implementation)

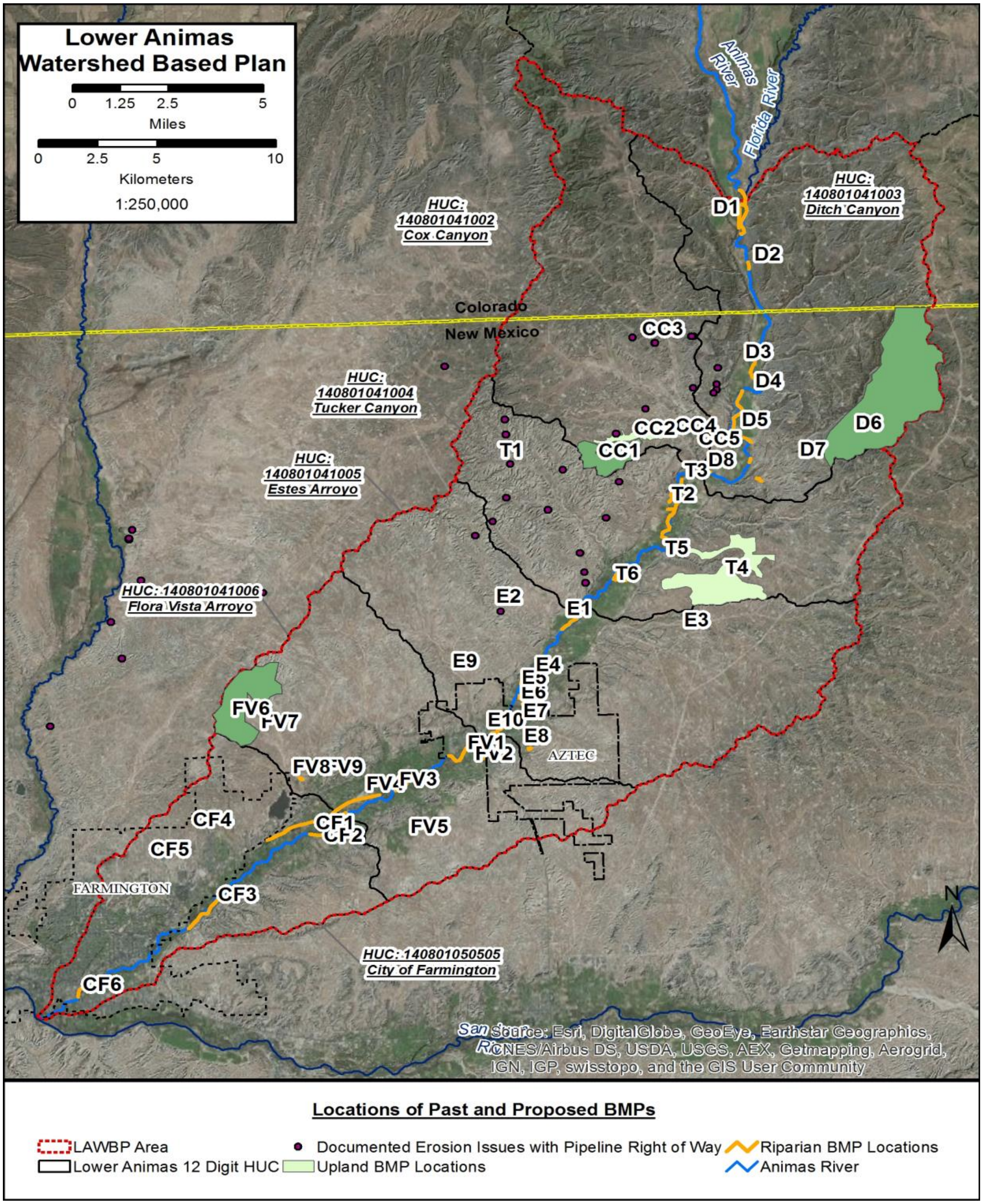
The following section presents a menu of on-the-ground projects and outreach efforts that address the pollutant sources, impairments, and threats to watershed health discussed above. This section is organized based on project types specific to a given land use or pollutant source category:

- Septic, sewer, and wastewater treatment
- Agricultural best management practices (BMPs)
- Upland restoration and best management practices
- Urban stormwater projects
- Riparian restoration
- Streambank, wetland, and floodplain restoration
- Irrigation infrastructure improvements

Stormwater best management practices are discussed in greater detail in Appendix C, since management measures for stormwater apply to multiple land uses, and are proposed for many locations throughout the watershed.

The project types within this section include general descriptions of the management measures involved, implementation strategies and possible funding sources, and summaries of specific project locations, costs, and load reductions. As this WBP is updated through adaptive management over time, the management measures and implementation strategies should stay relatively the same, while specific project areas and costs will be updated as original projects are completed.

The map on the following page provides a summary of the locations of on-the-ground projects currently proposed within each subwatershed. These project numbers are referenced within the detailed project implementation section that follows, providing an easy reference to the geographic location of proposed on-the-ground work.



Map: Locations of proposed BMP projects

Map 23. List of projects for each subwatershed, on a map of the river from up to downstream.

Map Key #s are listed for reference, and are referred to in the project summaries that follow.

Ditch Canyon-Animas HUC
D1. State line riparian pasture management
D2, D3, D5, D8. Riparian planting and restoration
D4. Cedar Ditch diversion improvement
D6. East Ditch canyon pinon/juniper thinning
D7. Ditch Canyon arroyo salt cedar removal/habitat restoration

Cox Canyon HUC
CC1. South-central Cox Canyon pinon/juniper thinning
CC2. South-central Cox aerial sagebrush treatment
CC3. Cox Canyon Pipeline erosion control
CC4. Cox Canyon riparian restoration & erosion control
CC5. Cox Canyon sediment fences

Tucker Canyon-Animas HUC
T1. Upper Kiffen pipeline erosion control
T2. Multi-property riparian buffer initiative
T3. Future floodplain/wetland enhancement
T4. Arch Rock Canyon aerial sagebrush treatment
T5. Arch Rock Canyon salt cedar removal
T6. Riparian pasture improvements

Estes Arroyo-Animas HUC
E1, E5, E6, E8. Riparian pasture improvement projects
E2. Bohanon Canyon salt cedar removal
E3. Hart Canyon road unit erosion control
E4. On-site treatment utility for Villa de Animas failing septic
E7. Lower Animas Ditch Siphon erosion control structure
E9. Upper Estes Arroyo sediment fences
E10. Aztec Ruins floodplain and riparian restoration + Eledge Ditch diversion

Flora Vista Arroyo-Animas HUC
FV1. Riverside-Townsend floodplain and riparian restoration
FV2. Kello-Blancett diversion
FV3, FV8, FV9. Riparian pasture improvement projects
FV4. Flora Vista sewer line extension
FV5. Siphon erosion control/sediment fence
FV6. Pinon/juniper removal
FV7. Flora Vista Arroyo dry sediment basin

City of Farmington-Animas HUC
CF1. Ranchmans-Terrell diversion
CF2. Flora Vista river and riparian restoration
CF3. Farmington Anesi Park river and riparian restoration
CF4, CF5. Farmington stormwater detention ponds
CF6. Farmington Animas Rock garden

Outreach and Education projects without a specific location
OE1. Septic care and management
OE2. Illegal septage dumping education and prevention
OE3. RV waste signage and outreach
OE4. Riparian pasture management
OE5. Soil health workshops
OE6. Low impact development workshops
OE7. San Juan Basin Roads Committee outreach and planning
OE8. General San Juan Watershed Group stakeholder engagement process

Septic, Sewer, and Wastewater Treatment

Public Outreach and Education

Sewer infrastructure projects are expensive, long-term solutions to the problems related to human waste reaching our rivers. The cheapest, short term solutions involve outreach and education to the general public and specific stakeholder groups, in order to change individual behaviors that may be contributing to pollution. While the results of these efforts can be difficult to quantify in terms of load reductions, they are still worthwhile.

It should also be noted that these outreach efforts are likely to also benefit the nearby San Juan River, which has human waste pollution issues even more serious than those on the Animas River.

On-site Liquid Waste System Education

On-site liquid waste systems (commonly referred to as septic systems) are the responsibility of individual landowners, and can either abate or contribute to non-point source pollution, depending on how they are managed. While soil type, lot size, and depth to groundwater are mainly out of the landowner's control, maintenance and regular pumping of the tank can be managed.

Due to the significant number of on-site liquid waste disposal systems in the area, specialized informational campaigns will be directed towards this stakeholder group. These campaigns will be focused around proper system care, as well as the acknowledgement that their system should be permitted and on record at the NMED Farmington field office for everyone's safety.

This outreach effort will build on the recent successes of the San Juan Watershed Group's Liquid Waste Subcommittee to notify the public on proper liquid waste system maintenance, permitting requirements, and septage disposal to enable individuals to take proper action and report illegal systems and septage dumping.

STEPL estimates that a failing septic tank that serves a household of three individuals contributes 38.4 lb/yr of nitrogen and 15 lb/yr of phosphorus (Techlaw 2011). This estimation assumes that a failing septic tank produces 200 gallons/day at concentrations of 60 mg/L of nitrogen and 23.5 mg/L of phosphorus. Assuming 10% of the waste reaches the river, an outreach campaign that leads to repair of failing tanks will have the following result:

Costs to mail utility bill insert to everyone in San Juan County	
$2,500	
Estimated change in behavior	
10 septic tanks maintained per mailing	
Estimated pollutant load reduction to Animas	
Nitrogen	38 lb / year (10 tanks)
Phosphorus	15 lb / year (10 tanks)

Targeting and preventing illegal dumping

The outreach and enforcement campaign started by the Liquid Waste Subcommittee in 2015 will continue to follow up on licensing and monitoring of septage pumping companies to curb possible illegal dumping. If each of 19 pumping/hauling companies hauls 1.5 loads each business day on average, that totals nearly 7,500 loads per year. If even 1% of these loads are illegally dumped and can be prevented from reaching the river via an outreach campaign, it will have a significant load reduction of human sourced *E.coli* as well as nutrients.

To keep the septage hauling industry a part of the conversation, a focus group should be held to discuss concerns about lack of legal places to dump (Farmington WWTP is currently the only legal location) and discuss possible need for additional transfer stations.

We have estimated that an average illegal septic dump could contain 1.0 lb of N and 0.17 lb of P and 2.0×10^{11} cfu of fecal coliform bacteria. This calculation is based on assumptions that a septic tank pump truck is carrying 2,000 gallons of wastewater at concentrations of

60 mg/l of nitrogen, 10.4 mg/l of phosphorus, and 1,580,000 cfu of fecal coliform bacteria (Lowe et al. 2009).

Costs of NMED Liquid Waste Program staff time	
$5,000	
Estimated change in behavior	
75 septage loads not dumped per year	
Estimated pollutant load reduction to Animas	
Nitrogen	75.1 lb / year (75 loads)
Phosphorus	13.0 lb / year (75 loads)
Fecal coliform bacteria	8.98×10^{12} cfu (75 loads)

RV waste signage and outreach

Improve signage at all local RV parks, campsites, and popular tourist recreational sites (ie: Aztec Ruins) to identify legal dump stations for RV waste. Develop, print, and distribute a map of legal dump stations at all visitors' centers and tourist sites. Include in the brochure information on the human waste problem in the rivers, and encourage visitors to the area to be part of the solution, not part of the problem.

We have estimated that an average illegal RV waste dump could contain 1.0 lb of N and 0.17 lb of P and 1.8×10^9 cfu of fecal coliform bacteria. This calculation assumes that an average RV holding tank contains 30 gallons of waste water at concentrations of 60 mg/l of nitrogen, 10.4 mg/l of phosphorus, and 1,580,000 cfu of fecal coliform bacteria (Lowe et al. 2009).

Costs of signage and brochure/map development	
$5,000	
Estimated change in behavior	
75 RV waste loads not dumped per year	
Estimated pollutant load reduction to Animas	
Nitrogen	1.1 lb / year (75 loads)
Phosphorus	0.2 lb / year (75 loads)
Fecal coliform bacteria	1.35×10^{11} cfu (75 loads)

Septic Tank Improvements

The SJWG and City of Farmington undertook a septic tank inspection and repair campaign in 2008. A follow up to this study could pump people's tanks, determine failure rate, and suggest or offer funding assistance or regulatory amnesty for repair or replacement.

The currently unfunded Liquid Waste Indigent Fund could also assist landowners who have failing septic tanks and are out of compliance with liquid waste disposal regulations. This could be used to fund or cost-share individuals getting their tanks pumped out. In depressed economic times, any financial incentive could increase the likelihood that individuals will take action.

STEPL estimates that a failing septic tank that serves a household of three individuals contributes 38.4 lb/yr of nitrogen and 15 lb/yr of phosphorus (Techlaw 2011). This estimation is based on an assumption that a failing septic tank produces 200 gallons/day at concentrations of 60 mg/L of nitrogen and 23.5 mg/L of phosphorus. Assuming 10% of the waste from a failing tank reaches the river, this campaign will have the following result:

Costs to fix failing septic tank	
Pump - $175 Repair - $500-$900 Replace - $2,100-$2,800	
Estimated change in behavior	
5 septic tanks replaced per year	
Estimated pollutant load reduction to Animas	
Nitrogen	19 lb / year (5 tanks)
Phosphorus	7.5 lb / year (5 tanks)

Sewage Management Projects

Regionalization with Farmington Wastewater System

FV4. A sewer extension is the best long-term solution to the human sewage issue in Flora Vista, and will also provide auxiliary benefits in terms of economic opportunity in this area of the County. A Preliminary Engineering Report for extending Farmington's wastewater collection system to the Flora Vista area was completed in 2008 (SMA 2008). The study area included areas with high water table, tight clay soils with poor absorption capabilities and small lot sizes. As of fall 2015, this was San Juan County's number one priority infrastructure improvement project, and San Juan County state legislators were promoting it for capital outlay funding in 2016. $3 million in appropriations was set aside for this project as of April 1, 2016.

As proposed, the trunk line for the sewer would be laid down the former railroad grade from Flora Vista to Farmington, which would give approximately 250 homes access to sewer. The main area with high rates of failing septic systems is bounded by County Roads 3333 and 3334 in Flora Vista. Funds for individual sewer connections would need to be sought separately, through the NM Finance Authority, Rural Loan Program, Water Trust Board, or other sources.

STEPL estimates that 1,343 lbs /year of nitrogen and 526 lb/year of phosphorus would be contributed by 250 houses in Flora Vista if we assume a septic failure rate of 14% (SMA 2009).

Cost to install trunk line for sewer	
$9,000,000	
Estimated change in behavior	
250 homes no longer discharging to groundwater and surface water	
Estimated pollutant load reduction to Animas	
Nitrogen	1,343 lb / year (250 houses)
Phosphorus	526 lb / year (250 houses)

San Juan County received $3 million in general appropriations from the 2016 legislative session for the sewer extension project. The remaining $6 million may come from the NM Water/Wastewater Revolving Loan Fund and other sources as they become available.

If enough funding does not become available to execute the full sewer expansion project however, either of the following options could address the sewerage problem:

On-site Treatment Utility

An option to address impacts of improperly managed septic systems in the floodplain would be to create a wastewater utility district that manages scheduled inspections, maintenance, and proper operation of the on-site wastewater management systems within the district boundaries. The wastewater utility would conduct a program of active oversight of the installed systems, including assistance with selecting a preferred on-site wastewater management system based upon local knowledge of soil and water table conditions at the location where the installation is to be completed, periodic inspection and maintenance, performance evaluation, and unscheduled maintenance. The wastewater utility would provide a certified operator to perform and oversee these activities.

E4. The Villa de Animas Subdivision north of Aztec would benefit from the creation of an On-site Treatment Utility. Many of the homes in the 77 lot subdivision have Advanced Treatment Units instead of septic tanks to overcome limitations from a high water table (less than four feet in many areas). The NM Liquid Waste Disposal Regulations in effect at the time the homes were constructed (1999 – 2004) required a separation of four feet from the bottom on the absorption field trench to the seasonal high groundwater table. Advanced Treatment Units that aerated the liquid waste to secondary treatment standards were used instead of septic tanks. The aerated liquid waste could then be disinfected with chlorination before discharge to the absorption field and this reduction in fecal coliform bacteria reduced the separation from the absorption field trench bottom to high water table from four feet to one foot. Those systems were granted a variance from the NM LWDR which required that a valid service contract be in effect with an individual certified by the Advanced Treatment Unit manufacturer who would perform quarterly inspections and sampling to confirm proper operation of the treatment unit and chlorination of the unit's effluent. The systems were issued permits with conditions that required compliance with the variance. Failure to have a certified representative inspect, sample and repair the treatment unit would void the permit and a system that provided a four foot separation would need to be installed to replace the Advanced Treatment Unit (See sidebar by David Tomko on next page).

The reason for the four foot separation requirement is to provide adequate removal of fecal bacteria and *E. coli* bacteria before the wastewater enters the groundwater table. Secondary treatment and disinfection should also provide adequate removal of bacteria. Continued use of a nonfunctioning Advanced Treatment Unit and no disinfection actually produces an effluent that fails to meet the NM LWD Regulations definition of primary treatment due to higher nitrogen and fecal bacteria levels. This subdivision is located close to the Animas River with lots that have river frontage. The effluent contains E coli levels exceeding 10^6 E. coli/100 ml and discharge rates from 375 – 525 gallons per day discharging to the shallow aquifer. The soil column is will not adequately remove the bacteria and this would allow a plume of groundwater containing very high concentrations of E. coli bacteria to enter the nearby Animas River during seasons when the river is a gaining stream.

In this case, the homeowners association, or perhaps Northstar Water could be the manager of the utility, and collect the fees along with regular dues or water bills. Costs for this type of treatment utility are unknown at this time and should be calculated in future updates of this watershed plan.

Cost to develop on-site treatment utility	
Unknown	
Estimated change in behavior	
77 homes no longer discharging to groundwater and surface water	
Estimated pollutant load reduction to Animas	
Nitrogen	414 lb / year (77 houses)
Phosphorus	162 lb / year (77 houses)

Liquid waste variances for Villa De Animas subdivision

By David Tomko

I worked for the New Mexico Environment Department's Farmington Field Office from 1978 and was the Program Manager/Staff Manager from 1985 until my retirement in 2004. As Program Manager, I was delegated the authority to grant variances from the New Mexico Liquid Waste Disposal Regulations (LWDR), and granted these variances for lots within the Villa De Animas Subdivision that used Advanced Treatment Units (ATUs) to overcome limitations due to the high water table present in parts of the development.

The subdivision's developer applied for the Liquid Waste Permits and variances either in the name of the homeowner or in the corporation's name, Villa de Animas LLC. The developer also owned the company that installed the ATU and was certified by the ATU's manufacturer to maintain and service the system.

The variances were granted subject to specific conditions, and failure to comply with the conditions would require removal of the ATU and replacement with a system that complied with the LWD regulations by maintaining a four foot clearance to seasonal high groundwater. The conditions required the homeowner to: maintain a valid service contract with a service provider certified by the ATU's manufacturer; maintain a measureable chlorine residual at the outlet of the ATU at all times; and to submit records of the chlorine residual measurements to the NMED Farmington Field Office annually. In addition, the variances were valid only for the current property owner/applicant and were not transferable to a subsequent owner. The buyer of the property would have to apply for a new variance in order to maintain use of the ATU system. The current LWD regulations contain design and treatment standards for ATUs without the need for a variance, but the ATU must still be maintained by a service provider to assure proper operation.

According to the current staff at NMED's Farmington Field Office, the original certified service provider is no longer maintaining those systems and no records are being submitted as required. Technically, all the properties in Villa de Animas Subdivision that use ATUs are in violation of the variance conditions and are violating the LWDR. Property transfers should not occur due to the invalid LWDR permit for not meeting conditions for granting the variance and granting the permit.

Cluster Systems

These are regional systems that would include multiple properties using a single small to moderate sized liquid waste treatment and disposal system operated by certified operators. These would be most beneficial in high density subdivisions and areas with soils with poor absorption characteristics. No specific projects of this type have been identified in this draft of the plan, but it could be an option in future updates should sewer line upgrades not come through.

Wastewater Treatment Plant Upgrades

As mentioned in the Wastewater Infrastructure and Upstream Sources sections above, Durango's planned WWTP upgrade is expected to provide major nutrient load reductions to the Animas River. The plant was documented as the single largest source of nutrient loading to the Animas from Durango to Farmington (BUGS 2011), and even though it's not in NM, the reductions will help reduce upstream sources. Repairs and updates to the Aztec WWTP should be considered in future revisions of this plan.

Estimated cost to upgrade the City of Durango (Colorado) wastewater treatment plant	
$20,000,000	
Estimated pollutant load reduction to Animas	
Nitrogen	High
Phosphorus	High
Fecal coliform bacteria	Low

Agricultural BMPs

Riparian Pasture Management

Direct deposits of livestock manure into waterways are one of the most straightforward pollutant sources to address, and will lead to reductions in ruminant source bacteria and nutrient loading. In areas where livestock use is also eroding streambanks, remediating this will reduce sediment load and improve assimilative capacity as well. As discussed in Chapter 4, pastures have the ability to make a significant swing from pollutant source to a filter of pollutants, and were thus selected as a focus for BMP implementation. Priority areas for implementation were selected through driving tours of the watershed and inspection of aerial photos, as well as discussions with local landowners, NRCS staff, and irrigation ditch contacts. The selected priority areas will be targeted for implementation of BMPs with the following tiered approach:

Tier 1: Low cost/short time scale solutions

- Locate mineral and supplemental feed away from water sources to discourage high-use areas and reduce manure build up near waterways.
- Dispose of manure from pens and corrals away from ditches, arroyos, and waterways.

In chapter 4 (Pollutant Sources, Irrigated Pasture), we estimate that a total of 4.86×10^{10} cfu/day are contributed by cattle, horse, and sheep in the Tucker Canyon, Estes Arroyo, and Flora Vista subwatersheds. If even 5% of this *E.coli* load to the Animas River is happening via direct deposits to the river, removing this source through riparian pasture management will result in a reduction of 8.9×10^{11} cfu/year.

Cost	
Free; Behavior change only	
Estimated pollutant load reduction to Animas	
E.coli	8.9×10^{11} cfu / year

Tier 2: Low-Moderate cost/time scale solutions

- Develop alternative livestock water sources to keep animal manure further from waterways.
- Install riparian fencing along pastures to limit livestock access to the river (and to ditches or waterways draining to the river) for periods of time long enough to allow vegetative buffers to recover.
- Develop additional pasture fencing as needed to manage for proper grazing timing, duration, and intensity to maintain higher grass height/density on entire pasture and to reduce bare ground.
- Plant vegetative filter strips at downstream edges of fields to filter irrigation and storm runoff.

STEPL estimates that one acre of pastureland in the Lower Animas River contributes approximately 0.89 lbs/year of nitrogen, 0.14 lbs/year of phosphorus, and 0.07 tons/year of sediment (TetraTech 2011). We use STEPL provided BMP efficiency values to estimate the effectiveness of Tier 2 and Tier 3 BMPs.

Cost	
Barbed wire fence	$2/linear foot
Water development (pipeline, floats, trough)	$2,000-$4,000
Native grass seed mix	$150-$250/acre
Estimated effectiveness (STEPL BMP efficiency)	
Riparian fencing	75% (TetraTech 2011)
Estimated pollutant load reduction to Animas	
Nitrogen	0.67 lb / yr / acre
Phosphorus	0.10 lb / yr / acre
Sediment	0.05 tons / yr / acre

Tier 3: Moderate-High cost/time scale solutions

- Plant and maintain riparian buffer zone with grasses, willows, & cottonwoods.
- Upgrade from flood irrigation to more efficient sprinkler irrigation.

Cost	
Native grass seed mix	$150-$250/acre
Willow planting	$3.50/tree
Cottonwood planting	$40/tree
Willow/cottonwood/grass planting	$1.70/linear ft of riverbank
Sideroll sprinkler	Site specific
Estimated effectiveness (STEPL BMP efficiency)	
Vegetated filter strip	70% for N, 75% for P, 65% for Sediment
Estimated pollutant load reduction to Animas	
Nitrogen	0.63 lb / yr / acre
Phosphorus	0.10 lb / yr / acre
Sediment	0.05 tons / yr / acre

Properties that currently have high concentrations of livestock, bare soil, and no buffers fall into the highest priority. Acreage and linear feet of river frontage were also used to prioritize projects, since working with a single landowner to address a large area leads to easier implementation.

D1, T2, E1: These are the top three riparian pasture properties that meet the criteria listed above. While some have better management or ground cover than others, they all have large river frontage that is unbuffered. Adding riparian fencing, revegetation, and alternative water sources to these properties is estimated to cost $88,518 and lead to high pollutant load reductions as well as improvements in assimilative capacity. See Map 23 for project locations.

D2, D3, D5, D8, T6: In addition to the properties identified as top priorities above, five more projects were identified in Ditch and Tucker Canyon HUCs that would address bacteria sources from livestock, as well as nutrient and sediment runoff. Based on the linear ft of fence and riverbank, it would take $116,488 to address these five properties.

E5, E6, FV3: Additional properties were identified in the Estes and Flora Vista HUCs for similar reasons to these other properties. Note that GIS data with proposed linear feet and structures is included in Map 23 and will be used to plan all of these proposed projects.

E8, FV8, FV9: Vegetated Filter Strips to protect drinking water sources
Three sites were identified were a visible livestock bacteria source is in very close proximity to ditches that deliver drinking water to Aztec and Farmington. At one site, a 150 foot long by 5 foot wide filter strip is needed between property used to raise up to 200 fowl (chickens, guinea fowl, turkeys and ducks) and the Aztec Ditch in Aztec. The pens for the fowl are located uphill from the Ditch and all runoff from the property flows directly into the main irrigation canal for the Aztec Ditch. In Flora Vista, two cattle and horse corrals back up directly to the Farmers Ditch with delivers water to Farmington Lake.

<u>Implementation strategy:</u>

The first goal of this project will be to get Tier 1 BMPs implemented at all of the priority sites. San Juan Watershed Group will collaborate with San Juan SWCD, NRCS, and NMSU Ag Extension to develop a “pasture BMPs” flyer to distribute via mail including a description of the ruminant bacteria problem and how landowners can help. In the same mailing, priority landowners will be notified of the NRCS EQIP sign up and the 2015-2016 Animas River Watershed Initiative, which includes funding for projects that improve water quality along the Animas. NRCS will provide landowners with technical assistance in developing individual conservation plans, with certain projects possibly eligible for reimbursement cost-share funding through the EQIP program. Up to $100,000 per year is available to ranking projects through 2016.

The BHP Billiton Microbial Source Tracking BMP grant administered through San Juan SWCD will be used as additional cost-share funding to incentivize the most efficient Tier 2 and 3 livestock related BMPs (riparian fencing, filter strips). Up to $140,000 is available for BMP implementation, with $10,000 additional available for sampling and monitoring to determine project effectiveness.

The above funding sources could be used as match to leverage additional funding from a Clean Water Act Section 319 grant, administered by the New Mexico Environment Department Surface Water Quality Bureau.

Irrigated Cropland

There are a wide variety of agricultural conservation practices that can be applied and that are currently being applied in the project area. The USDA Natural Resources Conservation Service (NRCS) is instrumental in local efforts and provides a wealth of knowledge and support for designing and implementing conservation practices. The NMSU Ag Extension Office and Farmington Field Office of the Bureau of Land Management are other local resources for conservation practices in relation to livestock and land management.

Forms of agricultural conservation practices include:

- Soil conservation BMPs.
- Vegetated buffers and edge-of-field runoff control.
- Fertilizer management.
- Manure management.
- Riparian access management for livestock.
- Soil moisture monitoring to avoid over-irrigating.
- Conversion to efficient irrigation systems.

Due to the lack of "hotspots" that could be traced directly to cropland sources, specific priority BMP sites have not been singled out for this land use. However, some of the largest cropland tracts within the watershed also fall within the priority areas for "riparian pasture" BMPs above, due to their use for winter grazing (**D3, D5**). STEPL calculated high load reductions for these properties.

The outreach described in the next section should continue on a regular basis, and be used to identify specific project needs that will reduce the water quality impacts of cropland in the Animas Valley. These projects should be incorporated into future iterations of the watershed plan.

Outreach to Agricultural Producers

Agricultural producers are some of the most valuable stakeholders to engage for implementation of this plan. As active land managers, this group has a wealth of knowledge about the land, and has an opportunity to make a substantial impact to water quality. Additionally, the social connections made through irrigation ditch associations, livestock boards, county fair, and other organizations mean information on BMPs, funding opportunities, and successful (or unsuccessful) projects can be easily shared throughout the community at a grassroots level. Agricultural producers will be one of the main audiences solicited for the implementation of BMPs on their land, given the potential for nutrient, bacteria, and sediment load reductions.

Values commonly associated with agriculture include:

- Water quantity, with a substantial focus on water rights
- Infrastructure/technology for efficient irrigation water delivery and management
- Maximizing yields
- Livestock health
- Reducing inputs, costs, and labor
- Water quality, mainly as it affects crop yields (e.g., salinity) and required inputs (nutrients)
- Soil health characteristics, including organic matter, drainage, water holding capacity, compaction
- Control of invasive weeds
- Land stewardship for future generations
- Private property rights

Outreach events, such as soil health workshops, are crucial for advocating conservation practices that are beneficial for both landowners and other stakeholders in the watershed. Agricultural workshops have been held in the past for minimal costs. Staff from NM and CO NRCS are usually able to present free of charge. Facility rental is less than $200 (often free for government or non-profits), with only additional costs being food, amenities for participants (books, soil samples, etc.), or bus rental for field tours.

These workshops should be held annually, in conjunction with NRCS, NMSU Ag Extension, the NMSU Ag Science Center, Farm Bureau, 4H, Cattleman's Association, National Young Farmers Coalition, San Juan Agricultural Water Users Association, and the ditch associations where possible.

Upland BMPs

Upland Vegetation Management Projects

Uplands dominated by pinon/juniper and/or sagebrush make up the majority of the land area of the Lower Animas watershed, and managing these lands for optimal water storage and runoff control will be essential to overall watershed health. BLM, NRCS and others have had success in restoring grasses and reducing erosion by thinning these trees and shrubs. Manual thinning is the primary method for reduction of pinon/juniper. Sagebrush can be mowed or mulched on small areas, but is more effectively treated with an aerial application of tebuthiuron. Anecdotally, this type of project has led to increased water infiltration rates in upper watersheds, to the extent that water runoff during storms went down enough to reduce the amount of water reaching detention structures, or "dirt tanks" set up to trap water for livestock and wildlife (BLM staff, personal communication).

These projects are often combined with pasture fence infrastructure to allow revegetation and to implement grazing rotation (fencing projects and water sources development), as well as replanting with native grasses. These projects have the additional benefit of abating fire hazards at the top of the watershed.

Costs and estimated load reductions:

Cost	
Pinon/juniper thinning	$1,000-$2,000/acre
Sage and brush mowing/mulching	$200-$350/acre
Salt cedar/Russian olive mulching	$1,000-$2,000/acre
Sage brush aerial spraying	$13-$19/acre
Native grass seeding	$100-$250/acre
Estimated effectiveness (STEPL BMP efficiency)	
Revegetation, erosion control, mulching, seeding	70% for N, 75% for P, 65% for Sediment
Estimated pollutant load reduction to Animas	
Nitrogen	0.63 lb / yr / acre
Phosphorus	0.10 lb / yr / acre
Sediment	0.05 tons / yr / acre

Three pinon and juniper thinning projects and two sage brush treatments were identified in meetings with State Land Office and BLM employees:

D6 East Side of Ditch Canyon HUC: This area falls within the Tank Mountain Community BLM grazing allotment, and has 3,500 acres of very thick pinon/juniper across a rugged landscape. Costs for thinning on other projects around the state of NM are running $500 to $1,000 on flat ground. This region is not flat but has an expanse of roads making access easier. Selective thinning within this area would bring estimated costs for the project between $1,750,000 and $3,500,000, though it could easily be split up into smaller projects based on available funds.

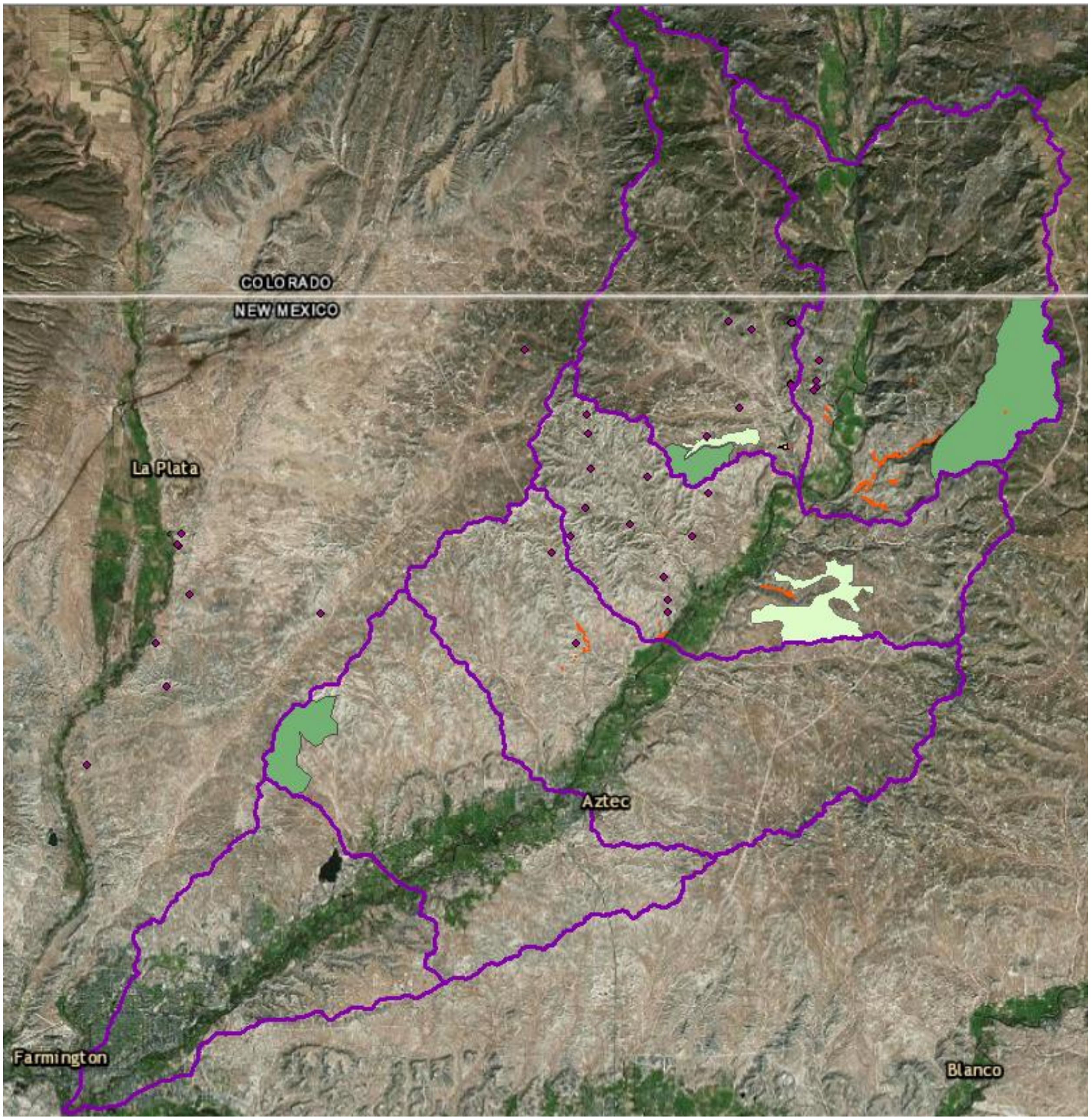
CC1, CC2 South central portion of Cox Canyon HUC: This area includes 700 acres of thick pinon/juniper costing between $500,000 and $1,050,000 for thinning. This project area is immediately adjacent to 250 acres of sage brush which could be targeted for aerial treatment for approximately $4,000.

T4 Arch Rock Canyon in Tucker Canyon HUC: 1500 acres of sagebrush aerial treatment.

FV6 Northwest portion of Flora Vista HUC: 1500 acres of thick pinon/juniper thinning.

These projects will be executed primarily through the Restore NM partnership, which is a collaboration between the BLM, the NM Association of Conservation Districts (NMACD), BLM grazing permittees, and the local San Juan SWCD. This program performs aerial tebuthiron treatment of sagebrush annually, and has included Animas River parcels in its San Juan Watershed priority area through 2017. All of the above sagebrush treatments would qualify, and some pinon juniper treatments may also be eligible to be treated under this program, creating significant cost savings over hand-thinning.

Pinon/juniper areas that cannot be treated aerially will be targeted for other funding. Possible funding sources include the watershed restoration category of the Water Trust Board grant, or NRCS-EQIP funding to the BLM grazing permittees. In the case of NRCS funds being used for thinning on federal lands, a Coordinated Resource Management Plan will first need to be completed. NMACD has provided funds and staffing for CRMP completion 2011-2016, and should be able to fund these plans going forward as well.



Map 24: Pinon-Juniper, sagebrush, & salt cedar treatments, with pipeline erosion control points

Pinon-juniper treatments in green, sagebrush in light green, salt cedar in orange, pipeline points in purple.

BLM Riparian restoration

The majority of the arroyos in the watershed fall on BLM land, and many of these are infested with invasive phreatophytes and other noxious weeds (See Map 24). Salt cedar and Russian olive take up water and increase surface salts in these important habitat areas, which are often the only water sources in the arid uplands. The areas highlighted on Map

24 include 53 acres of removal in Ditch Canyon, 17.56 acres in Arch Rock Canyon, 10.03 acres in Bohanan Canyon, and 3.82 acres near the outlet of Tucker Canyon. These areas should be restored via removal of the invasives, retreatment of resprouts, and replanting with native species. In a restored state, these parcels (especially Ditch Canyon) will provide important habitat for wildlife.

BLM has funds in their annual budget for riparian area management, as well as funds from the Colorado River Salinity Control Fund that could be applied to these projects.

Oil & Gas Field Projects

BMPs in this land use mainly focus on minimizing erosion from roads, well pads and pipelines. These practices and goals include:

- Properly aligned, graded, constructed, drained gas field roads
- Alleviate the impact of borrow ditches, which intercept sheet flow and mainline it to the river - the exact opposite of infiltration basins
- Stabilize and revegetate erosional features and disturbed lands using features such as: dry seeding, hydromulch, straw, net, grade control structures, zuni bowls, one rock dams, or silt traps (BLM 2007).

These goals will be addressed through a combination of outreach and specific projects.

Outreach to San Juan Basin Roads Committee

Work with BLM, oil and gas companies, ranchers, road graders and all members of the San Juan Basin Roads Committee to promote best practices to reduce sediment and erosion impacts from oil and gas infrastructure, in a way that also reduces road maintenance and improves oil and gas field operations.

- Change road specs to prevent use of fine-grained sediment cleaned out from ponds for road base (erodes at a higher rate)
- Enforce BLM surface use requirements for silt fences during construction
- Hold a workshop on proper road design, grading, and maintenance (use Zeedyk principals where possible; model after 319 workshop held in 2008)
- Have a booth or presentation at the NM Oil & Gas Association (NMOGA) meeting to promote best practices for roads, pipelines, and well pads.
- Encourage installation of simple, low cost, small-scale erosion structures (ie: one-rock dams, zuni bowls, etc.) in degrading or unstable channels, especially upstream from areas prone to washouts
- Encourage/fund revegetation and recontouring of old roads and well pads
- Open lines of communication for identifying priority areas, project needs, and additional funding sources

- Develop GPS enabled form for field crews to easily record and photograph locations with active erosion problems.
- Plan a future monitoring project evaluating the effectiveness of various road and well pad BMPs in reducing runoff and erosion.

The San Juan Basin Roads Committee operates on road units, and the units that overlap with the Lower Animas Watershed are: Crouch Mesa (Enterprise, Chad Timmerman), Hart Canyon (ConocoPhillips, Chris Neuenschwander), and La Plata (ConocoPhillips, Billy Schaapok).

Portions of the Hart Canyon Road unit drain to Hart Canyon arroyo and other drainages which flow into the Animas River on the east side of the Estes Arroyo-Animas River and Tucker Canyon-Animas River HUCs. This was road unit was identified as a current priority area in conversations with field crews, and will be a good place to start in investigating the success of the above erosion control measures.

Erosion control on actively eroding roads and pipelines

While there are thousands of miles of road and pipeline in the San Juan Basin that would benefit from erosion control measures, one has to start somewhere. Pipelines can be actively damaged by erosion when exposed, and BLM requires that pipelines comply with regulations for minimizing erosion. Therefore it is in the pipeline companies' best interest to address these concerns before their infrastructure gets damaged or BLM takes regulatory action. For this project, outreach will be conducted to pipeline companies to encourage them to improve maintenance on pipelines identified to have a current erosion problem.

Map 24 identifies problem erosion areas where sediment is eroding from around pipeline infrastructure and being transported downstream. These points were identified in a survey of right-of-way compliance conducted by San Juan SWCD staff for BLM, and were all non-compliant for erosion concerns, gullying, or exposed pipeline. Most of these fall within areas of highly erodible soils, within the following two subwatershed priority areas:

- Tucker Canyon HUC – Kiffen Canyon Allotment
- Cox Canyon HUC – Lonetree Mountain Allotment

Costs and exact load reductions are currently unknown for the pipeline erosion project and the San Juan Basin Roads Committee outreach project. Dedication of some San Juan SWCD and BLM staff time should be enough to encourage oil and gas companies to direct some of their annual maintenance budgets to address issues within these specific watersheds.

While not specifically calculated since they will vary greatly by project, estimated sediment load reduction (and associated nutrient loads) to the Animas River is expected to be very high. Multiple tons of sediment load could be abated for each problem area fixed. The

WEPP road model should be used to calculate load reductions on these projects in the future. http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/wr/wepproad.pl

Sediment Fences & Detention Basins

While it is difficult to plan individual erosion control projects for the immense road and well pad network in the uplands of the Lower Animas Watershed, sediment fences are a way to address sediment transport at a point further downstream but before it reaches the Animas.

Sediment fences are a series of parallel wire-mesh fences that extend from the channel bank out into the channel a short distance, angled downstream, that reduce water velocities in the near-bank region and promote the deposition of sediment between and downstream of the fences. The fences help stabilize eroding sand-bed wash and arroyo banks, capture sediment from upland flows, allow for vegetation establishment, and reduce sediment and associated nutrient loads to the receiving stream. This technique was developed by local BLM staff to address the challenges of sand-bed arroyos in the San Juan Basin, and have been used successfully by the BLM in several watersheds including Largo Canyon. The sediment fence installed in Kiffen Creek under the Section 319 Phase III Grant has proven effective at retaining 4,000 tons of sediment per year. Additional sediment fences in Cox Canyon, Kiffen Creek, Flora Vista Arroyo and other drainage basins can produce similar results.

Costs to design and install	
$38,000 for sediment fence similar to Kiffen Canyon 319 Project	
$400,000 for 20 acre-foot dry retention basin	
$30,000 for 5 acres of mixed erosion control structures	
Estimated pollutant load reduction to Animas	
Sediment	4,000 tons/year

FV7 Dry Retention Basin in Flora Vista Wash: A 20 to 30 acre foot basin in the upper reaches of Flora Vista arroyo will capture sediment and reduce flood runoff. An available location on State land (legal description 32N 11W, Section 16, NW ¼) was recommended by NM SLO staff. Funds from BLM Salinity Control, NM SLO, or Restore NM could be used for this project.

CC4 Riparian Restoration project in Cox Canyon: An area of NM State Land and BLM land (32N 10W, Section 32, ¼) was recommended for a mixed-practice erosion control project, just downstream from the vegetation management projects discussed in the previous section. This one would entail 10 to 12 acres of non-native removal with native planting, approximately 150 feet of silt fences, and 5 to 6 acres of erosion control on upland arroyos.

CC5, E9 Sediment Fences in other arroyos: There are numerous opportunities to control erosion, improve habitat, and reduce sediment loads from arroyos to the Animas River. The upper reaches of Cox Canyon off CR 2300 near the Colorado border would be an excellent collaborative project between the Animas Watershed Partnership and SJWG. Estes Arroyo presents another good opportunity, as downstream sediment transport is a constant maintenance issue for the City of Aztec.

E7. The Lower Animas irrigation ditch is siphoned under the ephemeral, sand bed Knowlton Canyon Arroyo approximately 1000 ft. directly west of Hwy 550 at the south end of Rd2930 just north of Aztec. The Lower Animas Ditch Company is concerned about channel bed scour that jeopardizes the siphon structure. Numerous types of channel and bank stabilization materials (e.g., rock, concrete, car bodies, etc.) have been placed at this siphon to address vertical and horizontal channel instability. Large concrete blocks have been placed across the channel just downstream of the siphon to provide bed grade control but some of the concrete blocks washed out resulting in an overly steep reach at the siphon. In addition to siphon concerns, a large flood-transported cottonwood was recently deposited mid-channel approximately 150 ft. upstream of the siphon that resulted in significant erosion and loss of the west bank.

To stabilize the channel at the siphon crossing, two cross vane-type structures using channel sediment fences are proposed to address vertical and horizontal instability. The upstream structure should be placed at the downstream face of the existing large concrete blocks and set to match the top-of-the-block elevations. Prior to fence installation, additional concrete blocks (top and footer) should be installed to tie into the existing blocks. A second fence structure should be located approximately 10 feet downstream (and approximately 1 foot lower than the upstream fence) to step the channel bed elevation down. Both fences must be sufficiently keyed into both channel banks; have a 4 foot wide (min.) fabric secured to the upstream side of each fence (to retain sediment) extending from the top elevation of the fence downward. Each sediment fence should be constructed using standard sediment fence material (e.g., 4 inch diameter by 10 foot long steel posts, 48 inch +/- galvanized horse fencing) and techniques except they should have a cross vane shape and slopes but with no posts or fencing visible. Two 60 foot long sediment fences are proposed to accommodate the channel width and ensure adequate bank key-in distances. Minor bank shaping and debris removal will be required to allow fence installation and create a more uniform bankfull channel through the reach.

Upstream of the siphon, the actively eroding south bank will require the installation of two rows of sediment fencing (30 ft. and 40 ft.) and the removal of the mid-channel cottonwood stump. The sediment fences would ideally be installed with a slight radius to match that of the channel's meander at this location.

Figure 23 shows the areas and types of treatments identified with this reach. A brief survey will be required prior to construction to determine the appropriate “flowline” elevations and widths and how the banks will need to be regraded to provide a smooth transition through the reach. Benefits of this project include the prevention of significant sediment displacement as a result of a newly exposed channel knickpoint and ongoing bank erosion and potential complete channel realignment upstream of the siphon.

Partners: Lower Animas Ditch, approximately 4 private landowners (see San Juan County Assessor’s parcel data for details)

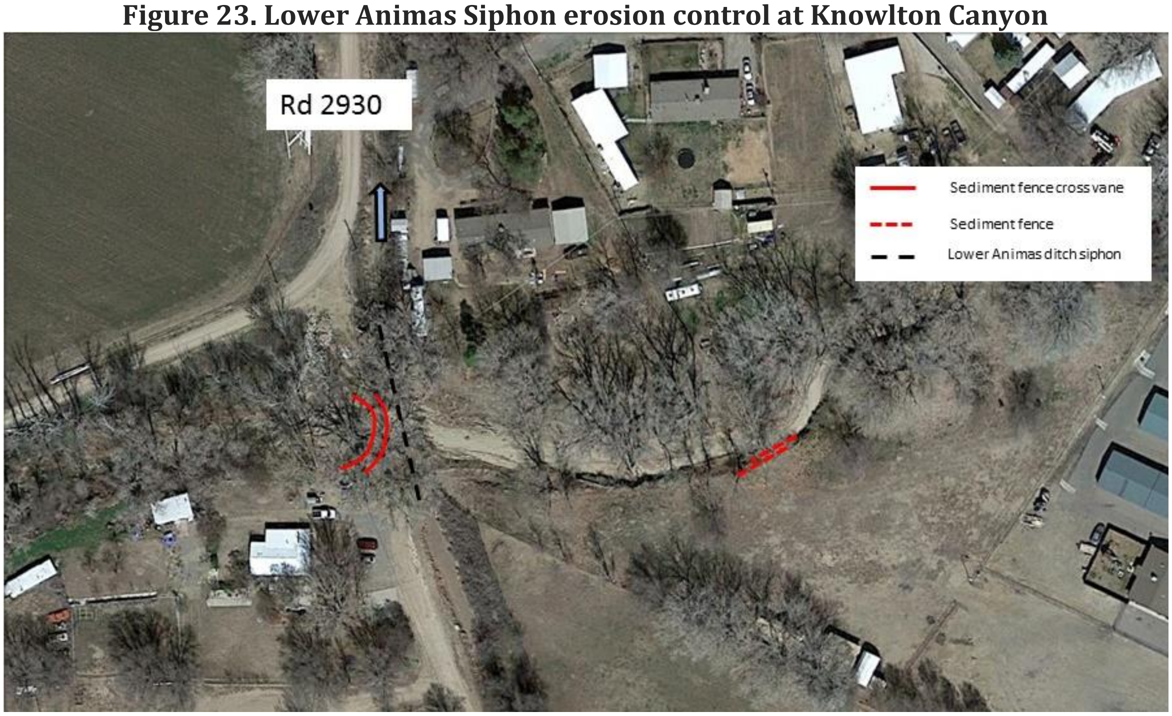
Potential Sources of Technical and Financial Assistance: Army Corps 404 program, ISC 90/10 ditch improvement program, Pilot System Water Conservation Program, NMED River Stewardship program, in-kind/cash match from partners

Implementation Strategy:

Seek funding for design study; engage adjacent private landowners to solicit input on project implementation; engage 1 ditch company, Bureau of Reclamation, Interstate Streams Commission, and the NM Office of the State Engineer to fund siphon improvements that are compatible with natural processes.

Nutrient and Sediment Load Reductions based on the following activities:
Bank stabilization (100 ft. of eroding bank and 200 ft. of bed): 325 tons/yr sediment, 520 lbs/yr N, 195 lbs/P year

Figure 23. Lower Animas Siphon erosion control at Knowlton Canyon



FV5. The Lower Animas irrigation ditch is siphoned under the ephemeral, sand bed Hart Valley Arroyo approximately 700 ft. downstream of CR3100. The Lower Animas Ditch Company is concerned about continual channel bed scour that exposes and jeopardizes the siphon structure and the conveyance of ditch water west beyond this arroyo. Ongoing headcutting within the arroyo system is lowering the channel bed in this reach which is also exacerbated by a large headcut on the downstream side of CR3100 and the ditch company excavating the arroyo between the siphon and CR3100 to generate fill material for use over the siphon.

To stabilize the channel at the siphon crossing, three cross vane-type structures using channel sediment fences are proposed to address vertical and horizontal instability. The upstream structure should be placed just a few feet downstream of the siphon structure with the fencing's top elevation set to match the natural channel bed elevation a short distance upstream of the siphon location. A second fence structure should be located approximately 10 feet downstream (and approximately 1 foot lower than the upstream fence) and a third fence structure installed approximately 10 feet downstream of the second fence structure (and approximately 1 foot lower than the second fence). The second and third fence structures are required to step the channel bed elevation down as there is two to three feet of elevation difference from just upstream of the siphon to a point 20 feet downstream of the siphon. All three fences must be sufficiently keyed into both channel banks; have a 4 foot wide <min.> filter fabric secured to the upstream side of each fence <to retain sediment> extending from the top elevation of the fence downward. Each sediment fence should be constructed using standard sediment fence material (e.g., 4 inch diameter by 10 foot long steel posts, 48 inch +/- galvanized horse fencing) and techniques except they should have a cross vane shape and slopes but with no posts or fencing visible. Three 50 foot long fences are proposed to accommodate the channel width and ensure adequate bank key-in distances. Minor bank shaping will be required after the fence installation to create a more uniform bankfull channel and flood plain that tie in within existing upstream and downstream reaches.

Figure 24 shows the areas and types of treatments identified with this reach. A brief survey will be required prior to construction to determine the appropriate "flowline" elevations and widths and how the banks will need to be regraded to provide a smooth transition through the reach. Benefits of this project include significant reductions in sediment displaced by a continually downcutting channel and related regrading efforts following flood events that scour the project area.

Partners: Lower Animas Ditch, approximately 3 private landowners (see San Juan County Assessor's parcel data for details)

Potential Sources of Technical and Financial Assistance: Army Corps 404 program, ISC 90/10 ditch improvement program, Pilot System Water Conservation Program, NMED 319 grant, in-kind/cash match from partners

Implementation Strategy:

Seek funding for design study
Engage adjacent private landowners to solicit input on project implementation
Engage 1 ditch company, Bureau of Reclamation, Interstate Streams Commission, and the NM Office of the State Engineer to fund siphon improvements that are compatible with natural processes.

Figure 24. Lower Animas Siphon erosion control at Hart Valley

Urban Stormwater Projects

This section primarily discusses projects already underway by the City of Farmington, City of Aztec, San Juan County, and NM DOT as part of their Stormwater Management Plans required by the MS4 program. As urban sources were predicted by STEPL to contribute high loads of nutrients (See Section 3), efforts to attenuate storm runoff from urban areas in the Lower Animas watershed are expected to have significant nutrient load reductions to the river. The above entities were in the midst of updating their stormwater management plans at the time this plan was written (March 2016), so load reductions for specific projects will be added in future iterations of this watershed plan.

Farmington and San Juan County MS4 Projects

The City of Farmington has implemented a number of urban stormwater BMPs. Farmington's 2007 Stormwater Management Plan (set for update in 2016) includes a list of proposed projects, many of which have now been completed. These include creating a river corridor park and riparian protective buffer along a segment of the Animas River in Farmington; building storm water detention ponds in the Foothills residential area; encouraging drainage swales to be installed at all construction areas; implementing a street sweeping program; and building an infiltration pond adjacent to the Miller Street Bridge (AES 2007). More recently, the City of Farmington has constructed two additional detention systems to alleviate storm water flooding: Porter Arroyo Detention Pond (27.3 acre-feet) and Lakewood Detention Pond (7.6 acre-feet). See Farmington's stormwater website for additional details: http://fmtn.org/index.aspx?NID=306

The City of Farmington has several basins planned (**CF4, CF5**) that are primarily intended to prevent flood damage to public infrastructure and private property, but will also result in pollutant load reductions to the river.

The City of Aztec is conducting flood control studies on several arroyos that have jumped their banks and flowed through town in the last few years, causing significant damage to buildings and private property. Detention basins and repair of the decades old flood control structures (built in the 1960s) in the headwaters of these arroyos could be viable options. The study is currently underway as of April 2016, and will identify projects that will help Aztec's arroyo flooding problem and reduce sediment and nutrient transport to the river.

The draft 2015 NPDES Stormwater Permit will require Farmington, Aztec and San Juan County to identify and implement BMPs from urban areas 16 months after the date of issuance. Farmington may require installation of subsurface detention/retention basins/ponds for large parking areas and developed areas (Personal Communication with staff).

All of the MS4 participants in San Juan County have expressed concern about the lack of funds in their general budgets to address stormwater issues. Discussions on ways to collaborate and maximize resources while reducing duplication of efforts have already occurred. San Juan Watershed Group or San Juan Water Commission may end up assisting with the water quality sampling and outreach for all four entities.

Other grants that may help fund future stormwater projects include the EPA Urban Waters Grant (https://www.epa.gov/urbanwaters/urban-waters-small-grants), and the Surdna Foundation Sustainable Environment Urban Water Management Grant (http://www.surdna.org/what-we-fund/sustainable-environments/4-what-we-fund-/what-we-fund-/482-urban-water-management.html. This grant supports innovative stormwater run-off practices that capture and slowly release water into existing drains, pipes and sewers, or reuse rain water where it falls (sometimes called "green infrastructure") instead of building expensive pipes and sewer tunnels.

General Stormwater & LID Outreach

Because stormwater was found to be a main pathway for pollutants in urban areas, ag lands, and upland environments, it opens an opportunity to conduct outreach that spans multiple land uses.

In conjunction with the MS4 entities discussed above, the San Juan Watershed Group will execute a "When It Rains, It Drains" marketing campaign. The goal will be to sell the idea that pollution from stormwater is everyone's problem and everyone can be part of the solution. It will promote that with smart management, water should be a resource (growing food, healthy rivers), not a problem (causing flooding and erosion). The more water stays where it falls instead of running off, the better.

- Minimize impervious surface
- Maintain natural drainage patterns
- Filter strips on edges of roads, driveways, pastures, corrals, cropland
- Promote soil health and water holding capacity by planting cover crops
- Reduce bare ground wherever possible (helps control weeds too)
- Minimize transport of pollutants (proper septic care, manure management, containment of construction materials, disposal of hazardous wastes)

A stormwater BMP workshop that incorporates Low Impact Development techniques will also be incorporated into the outreach campaign. Speakers with experience in stormwater BMP design will be invited to share their success stories. The Paseo Del Norte watershed plan and subsequent workshops held in Las Cruces by Stream Dynamics is an excellent example and possible speaker. The workshop will include hands on work to implement a demonstration project. See the Paseo Del Norte WBP for additional details:
https://www.env.nm.gov/swqb/wps/WBP/Accepted/PasoDelNorte/PasoDelNorteWBP.pdf

Riparian Restoration

Riparian vegetation is a crucial part of the river ecosystem, and has the potential to either improve functioning capacity and water quality, or in its current disturbed state (e.g., dominated by nitrogen-fixing Russian olive) it can disrupt these functions. Native vegetation can sequester nutrients, filter runoff, and provide habitat for wildlife. Where riparian vegetation is entirely absent (e.g., mowed or grazed up to river's edge), there is a high potential for bank erosion.

This WBP has identified numerous properties within the Animas River corridor that are in varying states of riparian disturbance. Many have already removed invasive Russian olive as part of San Juan SWCD's ongoing Wildland Urban Interface firebreak program through NM State Forestry (CWPP 2014), but have not gone the next step to revegetate these buffer areas.

Example management plan with BMPs for riverside landowners:

1. Remove N-fixing invasive Russian olive from along waterways
2. Treat weeds and invasive re-sprouts for 1-2 growing seasons
3. Install fencing to keep livestock out of revegetation zone
4. Revegetate buffer zone with native grass, willows, native shrubs, and cottonwoods

San Juan SWCD has shapefiles of all properties along the Animas that have already completed either of the first two steps above, totaling 922 acres within the river corridor. Landowner contacts have already been made for all of these properties, streamlining implementation of revegetation projects.

As discussed under Riparian Pasture Management, the priority areas for revegetation are those where livestock currently have direct access to the river. Second priority would be cropland properties with no filter or buffer strips between them and the river. These properties have the potential to make the greatest swing from pollutant source, to a healthy buffer and streambank with improved assimilative capacity.

In the long run, however, a contiguous native riparian buffer corridor along the Animas River will be a crucial asset to overall watershed health and especially wildlife habitat. Many rural residents enjoy seeing wildlife on their properties, and this represents a window to create win-win management scenarios. Either as an independent project, or in conjunction with other outreach activities, the following strategy will be undertaken to promote improvements in the Animas River riparian corridor.

<u>Implementation strategy:</u>

- Develop riparian buffer management flyer/guide to distribute via mail to landowners that border the Animas River.
- Target mailings to contiguous landowners along the Animas river corridor. Highest potential is on the Animas mainstem in the Tucker Canyon subwatershed (Map Key # **T2**), and Ditch Canyon subwatershed (**D1, D2, D3, D5**) due to larger parcel size.
- Conduct site visits assessing the current state of a landowner's riparian area in comparison to a reference site. Discuss restoration options that fit landowner's management goals.
- Match landowners with funding sources to assist with invasive removal, fence building, purchase of native seed, and purchase and planting of native trees.

Source of Financial & Technical Assistance:

- Partner with agencies that have overlapping restoration goals, such as NM State Forestry and San Juan County (fire breaks and hazardous fuel removal), NM Game and Fish (wildlife and fish habitat), Xerces society (pollinator habitat), etc.

- Wildland Urban Interface (WUI) grants fund removal of woody invasives for hazardous fuel reduction on private lands.
- San Juan County Non-Native Phreatophyte Fund is available annually through San Juan County and administered by San Juan SWCD, and could fund invasive tree removal or revegetation with native riparian species.
- BHP Billiton Microbial Source Tracking BMP grant administered through San Juan SWCD can fund livestock fencing.
- NRCS can provide landowners with technical assistance, as well as reimbursement funding through the EQIP program.

Overall, 13.3 miles of riparian restoration opportunities were identified (See Map 22). As calculated under Riparian Pasture Management, riparian fencing as well as revegetation with willows, cottonwoods, and native grasses can be completed for as little as $4/linear foot of riverbank. About half of this cost is fencing, meaning that all 13.3 miles could be revegetated for $140,587.

Wetland, streambank, and floodplain restoration

Restoring the functioning capacity of the river and adjacent flood plains is one of the best long-term solutions for abating nutrient pollution. Because these projects (especially wetlands) also require a good deal of land, engineering, planning, logistics, and money, it is important to identify projects that meet multiple land management goals. These projects can be designed to have additional social and ecological benefits, by enhancing recreation, riparian and aquatic habitat, and even irrigation infrastructure. City owned properties are especially attractive since they are least likely to undergo changes in ownership.

The projects described below identify opportunities to improve assimilative capacity along longer stretches of the Animas River. While the 2011 Animas Watershed Plan proposed numerous constructed wetlands without regard for actual project feasibility, these projects have all been vetted by stakeholders and represent real solutions to needs identified by multiple parties. Each project includes multiple practices which should be designed together to take a full river-reach approach, as opposed to addressing single issues. An example of this would be designing in-stream structures upstream of an eroding bank to divert water stress and improve aquatic habitat, as opposed to just installing gabion baskets at the point of erosion. With the exception of the City of Farmington Rock Garden project, all of these need to acquire funds for engineering, permitting, and design before finalizing exact costs for construction.

Aztec River and Riparian Restoration

There are several opportunities to reduce bank erosion (e.g., sediment sources), increase riparian vegetation reestablishment in direct contact with the Animas River, remove Russian olive and construct an improved irrigation diversion structure along this 2.3 mile reach divided by Aztec Boulevard (Highway 516). There are multiple landowners within this reach that include federal (i.e., National Park Service), City of Aztec, and private individuals. The City owns a large area on both sides of the river near City Park and the large vacant parcel on the north side of the river at the downstream end of the reach. It is understood that at least some of the private lands would consider these proposed stabilization and restoration measures.

Large cottonwoods are common along both sides of this reach with very limited development along the river, except for Aztec's City Park. Russian olive is also common except on City properties where removal has recently occurred. The Eledge irrigation diversion located at the upstream end of the reach is usually able to receive its share of water except during very low runoff years. Only minor river bank erosion segments associated with high vertical banks exist upstream of Aztec Blvd. Downstream of Aztec Blvd. a steep eroding bank exists along much of the north bank bordering the City Park and its sidewalk. A 200 ft. long sagging gabion basket wall defines the City Park's south river bank at the apex of a tight meander. Just downstream of the sagging gabion baskets bank, the south bank is stabilized with concrete, metal and other materials that minimize its assimilative capacity and creates a river-user hazard. The Kello-Blancett irrigation diversion is located at the downstream end of this bank where a channel-wide concrete weir is used for water level control. It is ineffective at diverting low river flows into the ditch and has contributed to an overly wide channel and associated sediment deposition. The ditch master has indicated the desire to replace the weir (this would be the third installed structure) and to add more concrete to the upstream bank. Opposite this diversion, the north river bank along the remainder of the City Park, the river bank is near-vertical and experiencing erosion and contains segments of gabion baskets and loose riprap. Downstream of City Park, much of the river has a stable form, limited bank erosion and two areas with thick Russian olive. Concrete riprap exists on the City's large undeveloped downstream parcel along and an almost property-long berm located at the top of the bank aimed at preventing flooding of the property.

An assessment of the reach was conducted to determine what appropriate measures could be applied to reduce bank erosion and improve bank stabilization methods while increasing assimilative capacity and in-channel fisheries habitat; increase over bank flooding; improve irrigation diversion facilities; and identify boater ingress-egress sites as well as increase river user accessibility.

Proposed measures include sloping and revegetating eroding banks, installing geomorphically-appropriate bank stabilization features (e.g., J-hooks); removing floodplain berms; removal of Russian olive to promote native riparian vegetation; and construction of a stable, and hydraulically effective diversion structure for the Kello-Blancett diversion. Figure 25 shows the areas and types of treatments identified with this reach.

Upstream of Aztec Blvd., proposed stabilization and enhancement measures include:

- Removal of 160 ft. of concrete riprap on the north bank just downstream from the new City pedestrian bridge and replace it with a sloping revegetated bank and a J-hook structure;
- A straight vane or J-hook structure at the Eledge irrigation diversion to facilitate low flow intakes; a boat ingress-egress ramp opposite the Eledge irrigation diversion;
- Removal of 5 acres of Russian olive just downstream of the Eledge diversion; bank sloping and revegetation of 600 ft. of south bank including 2 J-hook structures;
- Installation of 2 J-hooks on the south bank to move the thalweg away from the bank;
- 2 J-hooks just upstream of the Aztec Blvd. where the thalweg is eroding 350 ft. of the north bank and an irrigation ditch is immediately north of this bank;
- Removal of a 700 ft. long flood plain berm on the south side of the river roughly paralleling Aztec Blvd.

Downstream of Aztec Blvd., installation of a riparian fence on the south side of the river from the highway south to the City Park and removal of 1.5 acres of river-edge Russian olive:

- Install 4 to 5 J-hook structures along the 1000 ft. long, near-vertical bank segment on the north side of the river bordering City Park including relocation of the existing sidewalk to the north to allow sloping of the steep bank segment;
- Install 3 J-hooks on the north bank just downstream of the tight meander and relocate the existing sidewalk northward to allow bank sloping and revegetation;
- Install a boat ingress-egress on the north side of the river at the far west end of the City Park; replacing the sagging gabions on the south side of the river with a large-rock stepped feature and 3 J-hooks to provide a safe access to the river and move the thalweg away from the bank;
- Remove the riprap, regrade, revegetate and install 2 J-hooks on the 300 ft. long bank just upstream of the Kello-Blancett diversion;
- Remove the existing channel-wide concrete weir diversion structure and replace it with 2 J-hooks (or cross vanes) and the redistribute channel materials to narrow the bankfull channel width at this location;
- Remove the 7 acres of thick Russian olive on the south bank downstream of the Kello-Blancett diversion and the 6 acres on the opposite north side of the river;
- remove 300 ft. of concrete riprap, regrade, revegetate and install 3 J-hooks on the north bank at the east end of the City's large undeveloped downstream parcel;
- Install a boat ingress-egress feature near the eastern end of this City parcel; remove 2000 ft. of berm located at the top of the south bank to facilitate overbank flooding;
- Install 2 J-hooks after concrete riprap removal and bank sloping on 200 ft. and removal of 0.6 acres of Russian olive on south bank opposite the boat ramp site.

The City of Aztec has indicated they would like to install trails, picnic tables, a solar farm and potentially play fields on their large undeveloped parcel, such activities should be situated away from the river so that the above measures can be implemented to allow the overbank flooding without adversely affecting site improvements.

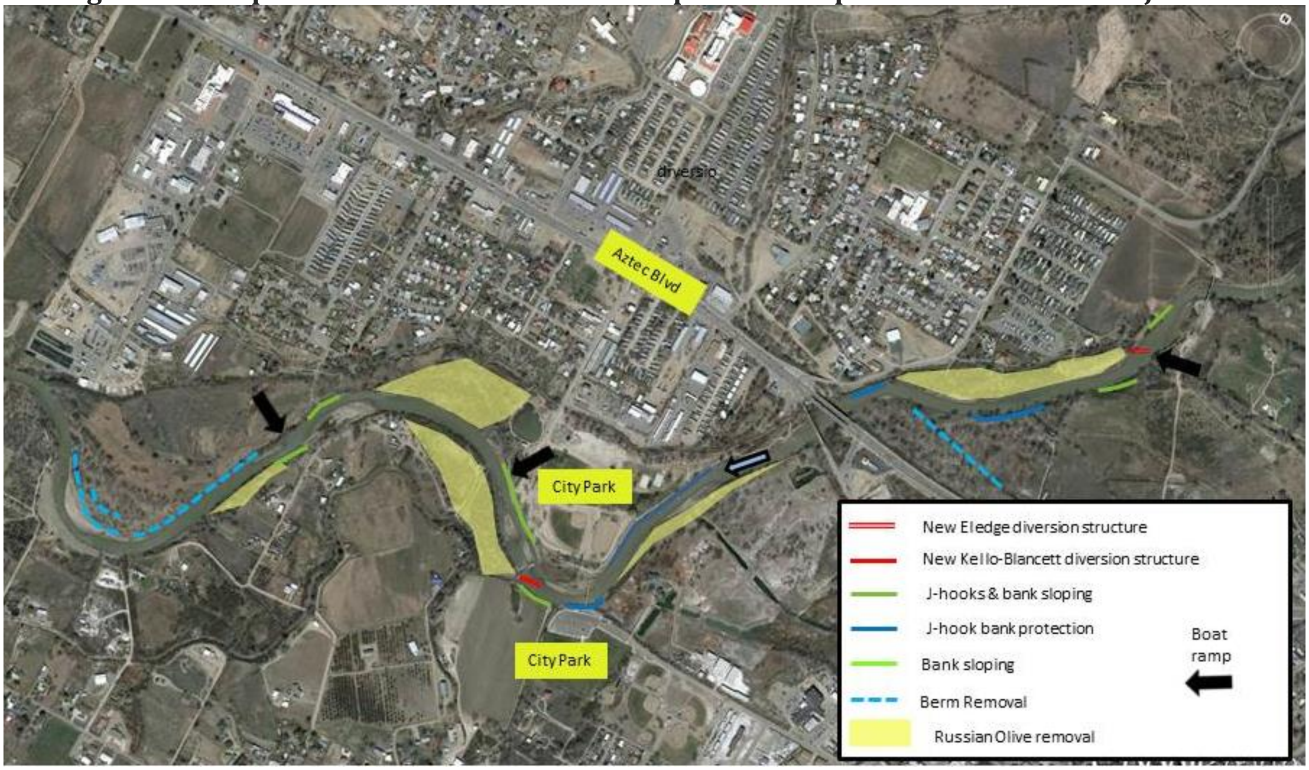
The City of Aztec has just built a pedestrian bridge connecting Aztec Ruins to the North Main St Extension, and plans to add a boat ramp and possible in-stream recreation features for boaters. These features will be installed in a way that minimizes erosion and improves fish habitat. They have also appropriated $100,000 to improve erosion control features that are currently failing on the river bank opposite Riverside Park.

Partners for this project include the City of Aztec, Aztec Ruins National Monument, Eledge-Mill Ditch, Kello-Blancett Ditch, Aztec Trails & Open Space, Four Corners Paddle Trails, and 18 private landowners (see San Juan County Asssessor's parcel data for details).

There are multiple funding sources that could apply to various pieces of this project, and include the Army Corps 404 program, Interstate Streams Commission 90/10 ditch improvement program, American Rivers grant, The Nature Conservancy, NMED River Stewardship program, Wildland Urban Interface & state severance tax Russian olive removal programs, and in-kind/cash match from partners.

The first step needed will be to acquire funding for the full engineering study and 404 permitting process. While the City of Aztec, Kello-Blancett Ditch, Eledge Ditch, and Aztec Ruins have all been contacted at this point, outreach to all adjacent private landowners has not yet occurred and will be needed before the project progresses.

Figure 25. Proposed BMPs for the Aztec Floodplain and Riparian Restoration Project



Flora Vista River and Riparian Restoration

There are several opportunities to reduce bank erosion (e.g., sediment sources), increase riparian vegetation reestablishment in direct contact with the Animas River, remove Russian olive and construct a stable irrigation diversion structure along this 0.5 mile reach immediately downstream of County Road 350. The north bank is owned by willing landowners that are interesting in preserving the natural floodplain character and improving the riparian vegetation along the river. The reach's north bank has just recently had its Russian olive removed to allow for reestablishment of native shrub and grass species. Large cottonwoods are common along both sides of this reach, especially on the north side of the river. The Ranchmans-Terrell irrigation diversion is located immediately downstream of the CR350 Bridge. This diversion requires in-channel reconstruction of a gravel-cobble push-up dam three to four times a year using a bulldozer in order for the ditch to receive its water. This activity has created an overly wide reach of river near the diversion and also negatively impacts the river's functioning capacity. Near the middle of the reach, a secondary channel is forming on the north bank that has the potential to capture the river resulting in several channel adjustments that would lead to loss of riparian and floodplain areas as the channel goes through its "adjustment" process.

An assessment of this reach was conducted to determine what appropriate measures could be applied to meet multiple goals. Figure 26 shows the areas and types of treatments identified with this reach.

- Eliminate annual channel disturbances associated with the diversion structure;
- Increase the assimilative capacity of the reach by sloping eroding banks and installing geomorphically appropriate bank stabilization features (J-hooks);
- Promote natural sediment and debris deposition in the forming side channel feature;
- Remove Russian olive on the south bank.

A formal survey and design would be required for the Ranchmans-Terrell diversion structure to ensure the ditch receives its 8.3 ft^3/second during low-flow conditions but also does not impede sediment transport, allows fish movement and is not a boater safety hazard. Due to the narrow width between the river bank and the high sandstone bluffs on the south side of the river where the irrigation ditch and access road are located, the river is jeopardizing the access road. To address this issue, a series of J-hook rock structures are proposed to reduce near-bank velocities and move the thalweg away from the south bank 20 to 30 ft.

Promoting sedimentation and debris trapping within the forming 500 foot long side channel on the north bank would be accomplished using a several large blow-down cottonwoods located on the property of the affected property owner. A series of check dams would be constructed using these large trees (root fans attached to 20 to 30 ft. of trunk) and securing while inter-tangling them into the side channel's bed, north bank and bar to the south. These large woody debris check dams would be inundated well below the annual flood elevation resulting in the capture of large amounts of sediment and organic debris. Over time, this area will become a functional vegetated flood plain with good assimilative capacity and prevent further bank erosion at this location.

Immediately downstream from the Ranchmans-Terrell diversion on the south bank is a 2.8 acre area between the river and the irrigation ditch that is dominated by Russian olive. Removal of the Russian olive would provide the opportunity for reestablishment of native shrub riparian species, similar to that on the north side of the river. Other minor areas of eroding bank were identified that would require simple bank regrading of its existing near-vertical shape to a more stable 3:1 slope (+/-) and reapplying salvaged topsoil and vegetation. Other areas require this measure in conjunction with the installation of a series (2 to 4) J-hook rock structures to move the thalweg away from the bank while providing reduced near-bank velocities that will allow regraded banks to revegetate quickly.

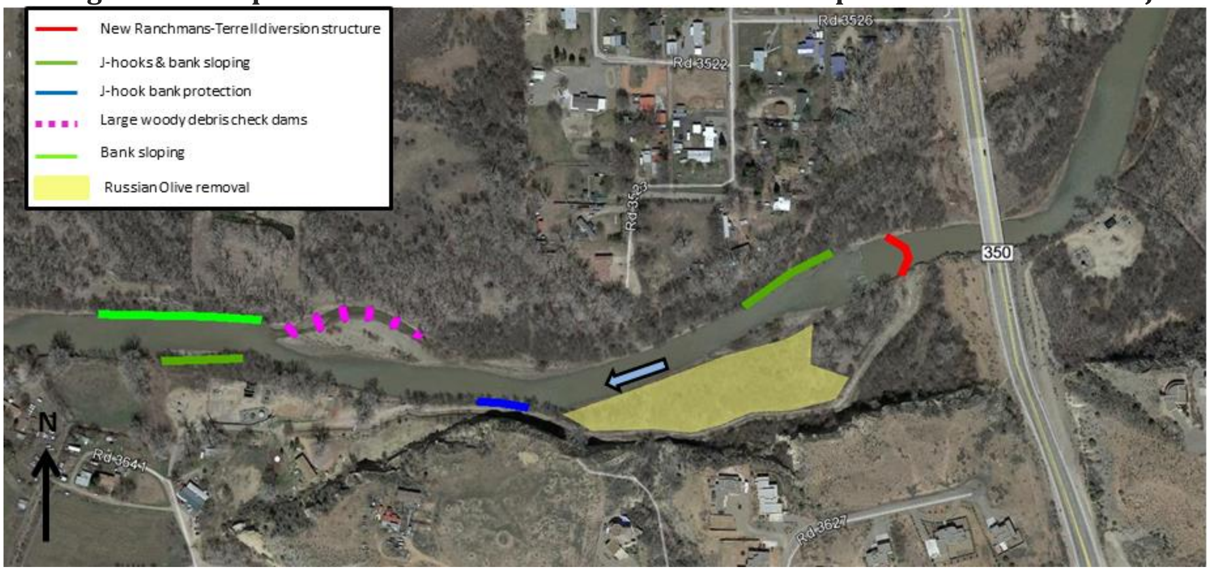
Potential Sources of Technical and Financial Assistance: Army Corps 404 program, Interstate Streams Commission 90/10 ditch improvement program, Pilot System Water Conservation Program, American Rivers grant, The Nature Conservancy, Wildland Urban

Interface & state severance tax Russian olive removal programs, in-kind/cash match from partners

Implementation Strategy:

Seek funding for design study and 404 permitting process
Engage adjacent private landowners to solicit input on project implementation
Remove Russian olive on identified properties (2.8 acres)
Engage 1 ditch company, Bureau of Reclamation, Interstate Streams Commission, and the NM Office of the State Engineer to fund in-channel diversion improvements that are compatible with natural processes desired for this reach of river.

Figure 26. Proposed BMPs for the Flora Vista River and Riparian Restoration Project

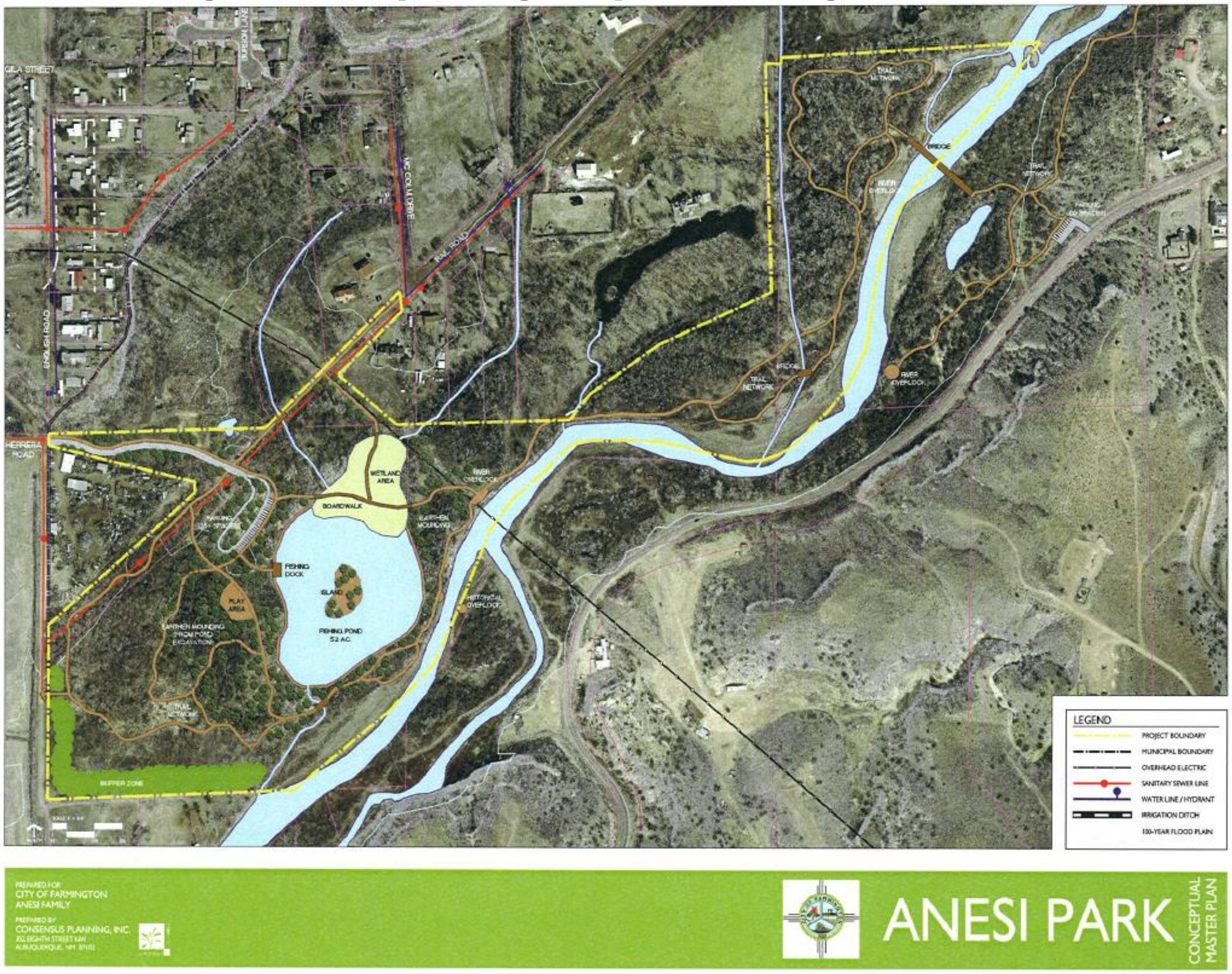


Farmington Anesi Park

This project includes multiple phases proposed by the City of Farmington in their parks master plan. Phase I is in progress, and involves the removal of invasive Russian olive and salt cedar on both sides of the river through San Juan SWCD's grants to clear fire breaks on public lands (NM State Forestry). Future plans include wetland enhancement, trail building, and revegetation with native plants. While no load reductions are calculated for this project in this iteration of the watershed plan, these activities are expected to improve functioning capacity of the river through an important urban reach.

Estimated total costs for the project are $515,283. Current sources of funding include $15,000 donated by the River Reach Foundation and City of Farmington Parks & Recreation annual budgets. Additional funding was sought by the City through both a NM DOT trails grant and Land and Water Conservation Fund (LWCF) grants. Results of funding requests are still pending.

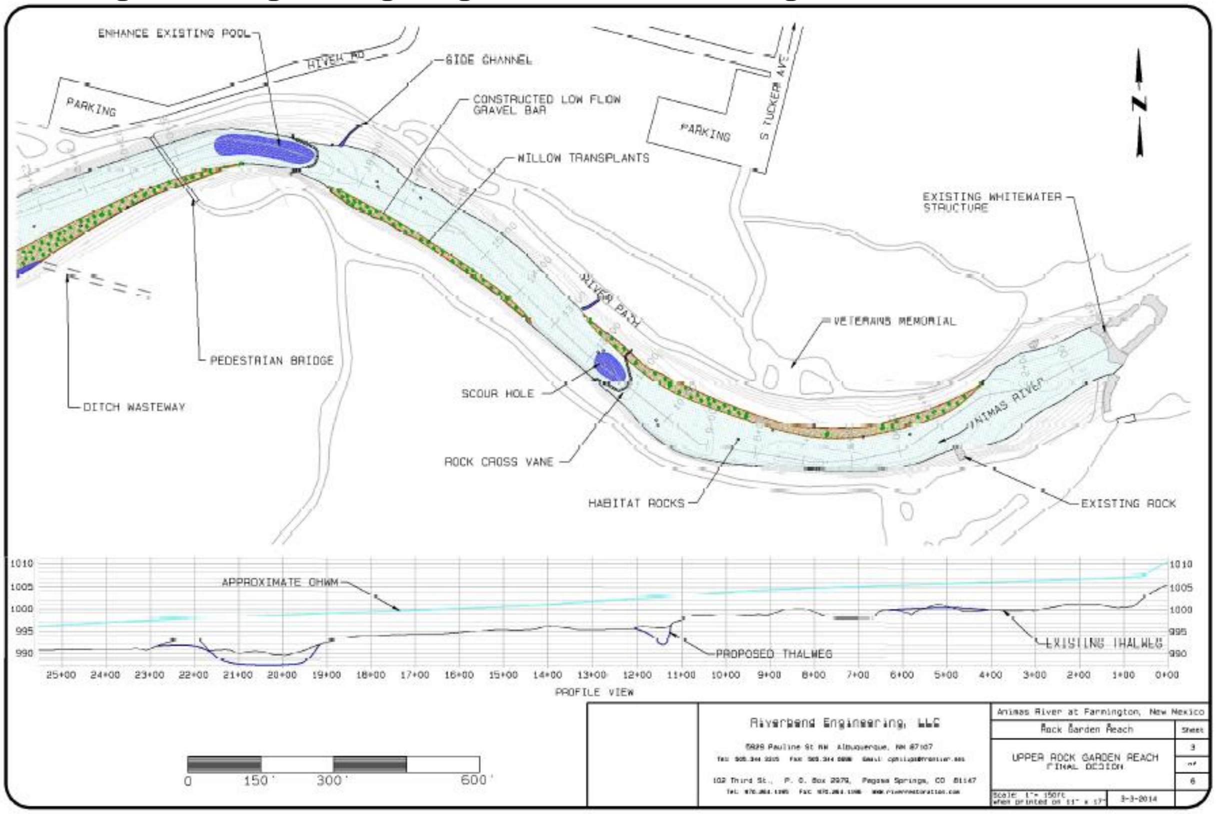
Figure 27. Conceptual long-term plan for Farmington's Anesi Park

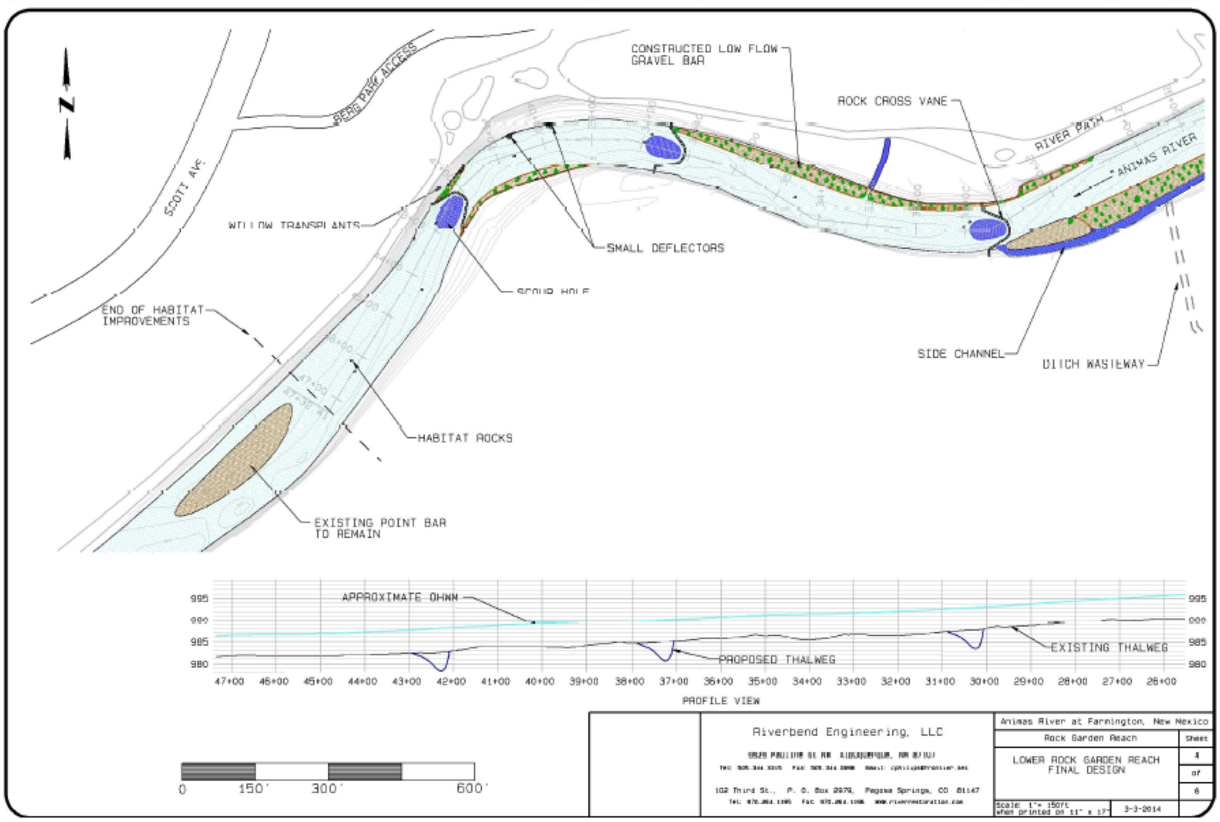


Farmington Animas Rock Garden

Unlike the projects listed above, this proposed project already has engineering designs and 404 permits completed and is "shovel ready." City of Farmington and the River Reach Foundation have collaborated on this project, which will improve in-stream fish habitat, while also enhancing recreation features, riparian areas, and assimilative capacity of the river. Project costs are unknown at the time of publication of this plan, but City of Farmington and River Reach are taking the lead on securing project funding.

Figure 28. Engineering design schematic for Farmington's Animas Rock Garden





Restoration via Army Corps Permitting

The U.S. Army Corps of Engineers (Corps) permits certain regulated activities that occur within Waters of the U.S. under Section 404 of the federal Clean Water Act. For projects that impact Waters, the Corps may require offsetting mitigation. The local Division of the Corps recently promulgated Regional Compensatory Mitigation and Monitoring Guidelines (http://www.spd.Corps.army.mil/Portals/13/docs/regulatory/mitigation/MitMon.pdf). This guideline and Corps regulations require the Corps to use a "watershed approach" when making mitigation decisions:

> 3.2. Watershed approach: The compensatory mitigation rule (33 C.F.R. part 332) requires the Corps to undertake a watershed approach for compensatory mitigation decisions to the extent appropriate and practicable (33 C.F.R. § 332.3(c)(1)). The ultimate goal of the watershed approach is "to maintain and improve the quality and quantity of aquatic resources within watersheds through strategic selection of compensatory mitigation sites." It is expected that the use of a watershed approach will result in ecologically successful compensatory mitigation that more effectively offsets losses of aquatic resource functions and services.

Corps regulations (33 CFR 332.4(c)) further describe using local watershed plans:

> Where a watershed plan is available, the district engineer will determine whether the plan is appropriate for use in the watershed approach for compensatory mitigation. In cases where the district engineer determines that an appropriate watershed plan is available, the watershed approach should be based on that plan. Where no such plan is available, the watershed approach should be based on information provided by the project sponsor or available from other sources.

The San Juan Watershed Group met with the Corps, NMED, San Juan Soil and Water Conservation District, industry representatives, and others to pursue using this WBP as a "watershed plan" within the context of permittee-responsible mitigation. The goal was to use this WBP to identify projects as watershed-based restoration goals that the Corps might implement through 404 mitigation. The WBP would list landowner contacts, available acres, recommended restoration, expected RAM score lift, and estimated cost of restoration. The Corps would evaluate this information for sufficiency, as described above. These estimates could guide later Corps decisions; but perhaps more importantly this public WBP would enable industry to plan activities that are subject to 404 mitigation, removing some regulatory uncertainty.

This WBP identifies the four projects listed above in this section (or subprojects within them) as priority restoration locations. However, adding the above information requires promulgation of the referenced RAM; and at the time of this writing, the RAM remains in development. It is hoped that the above list of mitigation opportunities can be added to a later revision of this WBP to fully mesh the needs of these two programs.

During the first (and, at the time of this writing, only) meeting to discuss this, the following topics seemed especially important:

- The public WBP would not include landowner contacts. Instead, it would say that prospective permittees could obtain that information from the District.
- This WBP focuses on water quality, but a watershed plan (and related Corps decisions) must contemplate broader issues including local ecology. This information would be added to the site descriptions.
- The Corps generally requires easements to ensure that mitigation projects have a long lifespan. While private landowners often are interested in similar conservation easements, this could be a significant obstacle to others.
- Municipalities appear to be the most promising landowners because they seem to have the most suitable land and these public entities could accommodate the easements.
- The SJWG may need support for the fairly intensive landowner contacts/outreach, collecting information and wordsmithing to expand the WBP as described above. This includes drafting the necessary ecological and other information and developing technical information (pre-mitigation RAM scores, and then identifying remedial actions, expected RAM lift, and estimated project cost). Local environmental consultants and others may contribute some of this work, such as through targeting future RAM trainings at proposed mitigation sites.

Irrigation Infrastructure Improvements

As mentioned under "Other impairments and threats to watershed health," properly designed and maintained diversion structures are key to avoiding reductions in the assimilative capacity of the river.

Properly designed diversion structures include the in-channel feature(s) that provide sufficient water elevation at the diversion heading during low flow conditions, and the heading itself (headwall, slide gates, etc.). These should not adversely alter channel hydraulics, channel stability or bank stability.

Appropriate water diversion BMP's include:

- Permanent in-channel grade control structure(s) that concentrate low flows near the center of the channel, maintain sediment transport competency, and reduce moderate and high flows velocities in the near-bank area.
- Construction of a sediment sluice gate at the diversion heading to minimize the accumulation of sediment upstream of grade control structure during high flows.
- Heading designed to divert only the water right amount with the least required head.
- Routine maintenance of in-channel structures and heading to prevent channel and bank erosion and instabilities.

Costs range widely for water diversion structures depending on current method of diversion (e.g., push-up dam vs hardened riffle), diversion rate, channel characteristics, design requirements and construction methods.

The ditches in most need of repair are:

- Cedar Ditch
- Eledge Ditch
- Kello-Blancett
- Ranchmans-Terrell
- Farmington Echo
- North Farmington

Because all diversions represent a departure from the natural hydrology of the river, opportunities for improvements that meet multiple goals (reduced maintenance, improved head, better fish habitat, ease of passage for boats, etc.) are abundant.

For instance, the Eledge Ditch diversion (discussed in Aztec Floodplain restoration above) is in a particularly wide part of the river on an outside bend, and is opposite an area of city land where they want to build a put-in for recreational boaters. It is also immediately downstream from a bank that is stabilized with scrap concrete slabs.

Other irrigation ditch infrastructure can also influence river health. Canal lining and installation of pipe conveyances are both ways to improve the delivery efficiency of irrigation water, as well as reducing seepage which can raise local water tables (bringing salts and nutrients to the surface) and increase the potential for delivering septic wastes towards the river via groundwater.

Acequias within the Aztec FO boundaries that are currently planning canal lining or piping:

- Graves Atteberry: $134,000 (2,680 ft Concrete ditch lining)
- Halford Ditch: $25,000 (175 ft. 48" diameter corrugated metal pipe)
- Kello Blancett Ditch: $561,000 (3,440 ft. of 5-ft. diameter pipe)
- Pioneer Ditch: $250,000 (2-mile of 15" diameter HDPE pipe)

The Bureau of Reclamation, San Juan SWCD, and NRCS are beginning a comprehensive evaluation of irrigation ditch infrastructure needs from April – December 2016. Future iterations of this WBP will include specific infrastructure improvements, design specs, and cost estimates for projects that influence water quality on the Lower Animas river. This needs assessment is being conducted with Colorado River Basin Fund grant monies, with administrative support provided by an AmeriCorps volunteer at San Juan SWCD from the OSMRE/VISTA program.

Summary of priority projects & estimated load reductions

The following tables summarize the load reductions expected following implementation of the projects proposed in this Watershed Based Plan. Where exact numerical calculations are not available, we indicate the potential for a "High", "Medium", or "Low" pollutant reduction. Future iterations of this watershed plan will update these tables with more accurate load reduction estimates for all projects. Improvements to Assimilative Capacity (AC) are indicated with a Y for Yes.

When tallied together, the proposed projects lead to estimated load reductions of 5080 lbs nitrogen/year, 1654 lbs phosphorus/year, and 1526 tons of sediment per year. This does not include any of the additional reductions that will be accomplished through urban BMPs under MS4 stormwater management plans, so final load reductions could be even higher.

Map Key	**Septic & Sewer Infrastructure Projects**	Pollutant Removal N (lb/y)	P (lb/y)	Sed (t/y)
E4	On-site treatment utility for Villa de Animas failing septic	414	162	
FV4	Flora Vista sewer line extension	1343	526	
	Subtotal Expected Load Reductions:	**1757**	**688**	**0**

Map Key	**Ag BMP Projects**	Acreage	Pollutant Removal N (lb/y)	P (lb/y)	Sed (t/y)	AC
D1	State line riparian pasture management	300	190	26	12	Y
D2	Riparian restoration w/ fencing	17	10.9	1.5	0.7	Y
D3	Riparian restoration w/ fencing	173	110	15	6.8	Y
D5	Riparian restoration w/ fencing	677	423	58	26	Y
D8	Riparian restoration w/ fencing	27	15	2	1	Y
T2	Multi-property riparian buffer initiative	256	177	28	15.1	Y
T6	Riparian pasture improvements	35.2	24	4	8	Y
E1	Riparian pasture improvement projects	226	152	24	13	Y
E5	Riparian pasture improvement projects	83	54	8	4	Y
E6	Riparian pasture improvement projects	11	7	1	0.6	Y
E8	Riparian pasture improvement projects	1.6	1.1	0.2	0.1	Y
FV3	Riparian pasture improvement projects	54	37	6	3	Y
FV8	Riparian pasture improvement projects	3	0.2	0.04	0.005	Y
FV9	Riparian pasture improvement projects	27	18	3	1.5	Y
	Subtotal Expected Load Reductions:		**1219.2**	**176.7**	**91.8**	

Map Key	Upland Revegetation & Erosion Control Projects	Acreage	Pollutant Removal			AC
			N (lb/y)	P (lb/y)	Sed (t/y)	
D6	East Ditch canyon pinon/juniper thinning	4388			12.3	
CC1	South-central Cox Canyon pinon/juniper thinning	693			2.3	
CC2	South-central Cox aerial sagebrush treatment	304			1	
CC3	Pipeline erosion control		Med	Med	High	
CC4	Cox Canyon riparian restoration & erosion control	9.8			0.03	Y
CC5	Cox Canyon sediment fences		Med	Med	Med	Y
T1	Upper Kiffen pipeline erosion control		Med	Med	High	
T4	Arch Rock Canyon aerial sagebrush treatment	1716			0.5	Y
T5	Arch Rock Canyon salt cedar removal					Y
E2	Bohanon Canyon salt cedar removal					Y
E3	Hart Canyon road unit erosion control					
E7	Lower Animas Ditch-Hart Valley Siphon erosion control structure		560	210	350	Y
E9	Upper Estes Arroyo sediment fences		Med	Med	High	Y
FV5	L. An. Ditch-Knowlton Canyon Siphon erosion control structure		520	195	325	Y
FV6	Pinon/juniper removal	1417			3.5	
FV7	Flora Vista Arroyo dry sediment basin		High	High	High	
	Subtotal Expected Load Reductions:		**1080**	**405**	**694.63**	

Map Key	Floodplain, streambank, & irrigation diversion projects	Acreage	Pollutant Removal			AC
			N (lb/y)	P (lb/y)	Sed (t/y)	
T3	Future floodplain/wetland enhancement					Y
E10 FV1	Aztec Ruins floodplain and riparian restoration	75	720	270	450	Y
CF2	Flora Vista river and riparian restoration	960ft.	304	114	190	Y
CF3	Farmington Anesi Park river and riparian restoration					Y
CF6	Farmington Animas Rock garden					Y
D4	Cedar Ditch diversion improvement					Y
FV2	Kello-Blancett diversion				Med	Y
CF1	Ranchmans-Terrell diversion				High	Y
	Subtotal Expected Load Reductions:		**1024**	**384**	**640**	

6. Implementation Plan

Implementation schedule

While the load reductions summarized on the previous page are important tools for prioritizing individual projects, many more factors are involved in making decisions on which projects to implement. Most of these factors are discussed in the project descriptions found throughout Chapter 5, and they are summarized on the next few pages. Projects with specific locations include their Map Key number shown on Map 23.

Though the parties responsible for implementation vary, it is likely that, whether listed in the table or not, San Juan Watershed Group and the San Juan Soil & Water Conservation District will act as "cheerleaders" for the projects laid out in this plan, and will be actively working with their partners to encourage project implementation. San Juan SWCD has worked hard to include the majority of its partners and current projects in this plan, and is in fact already beginning to move from planning to implementation on several projects.

San Juan Watershed Group will use this document as its guide in seeking new funding and working towards its goal of removing sources of water quality impairment in the San Juan Watershed, with the eventual goal of removing the Animas, San Juan, and La Plata Rivers from the 303(d) list of impaired waters. San Juan Watershed Group is in a state of transition at the moment, having just completed a four-year cycle (2011-2015) in which it had a full-time 40 hour per week AmeriCorps VISTA volunteer. Costs related to future staffing needs for the San Juan Watershed Group will be included in the group's strategic plan; due to the broad nature of this plan, and projects that involve implementation by many partners, costs specific to operations of the watershed group were not calculated or included at this time. Initial steps have been taken to form the group's first-ever steering committee, and it is hoped that completion of this watershed plan will launch the SJWG into a new chapter of project implementation.

Projects listed in the following tables with a 2016 start date have either already begun, or funding sources have been secured and projects are set to begin within the year.
The grant application process for projects with a 2017 start date will begin this year, 2016.
The planning and scoping process for projects with later start dates may begin earlier, but start dates are pushed back due to projected limitations in funding or staff time.

Project Costs, Responsible Parties & Timeline

Project Type	Map Key #	Project Description	Cost	Ease (1-Difficult, 5 Easy)	Projected Pollutant Load Reduction (1-5)	Responsible Party/Parties	Funding Sources	Timeline for completion
Septic, Sewer & Wastewater Treatment		Utility bill mailing - Outreach flier on proper septic care, permitting, and stopping illegal dumping	$2,500	5	2	SJWG, San Juan County, City utilities depts.	County budget, NMED Liquid Waste Program	Annually
		Illegal dumping outreach and enforcement campaign	$5,000	4	5	NMED Liquid Waste Program, SJWG	NMED Liquid Waste Program	Ongoing
		RV waste disposal signage and outreach campaign	$5,000	4	4	SJWG, San Juan County	San Juan County, SJWG BHP outreach fund	2016-2017
	FV4	Sewer line from Farmington to Flora Vista	$9,000,000	1	5	San Juan County, City of Farmington, NM State Legislature, Flora Vista Water Users Association	$3mil NM General Fund Appropriation already allocated, State Revolving Loan Fund negotiations in progress	2016-2020
		Updates to Durango Wastewater Treatment Plant	$20,000,000	1	5	City of Durango	City of Durango Sewer Bond passed 2015	2017-2021
	E4	On-site treatment utility for Villa de Animas subdivision (CR-2929)	Unknown	1	4	NMED Liquid Waste Program, Homeowners Association, Northstar Water Users	Resident User Fees, etc.	Pending NMED enforcement of liquid waste permit regs
		Septic tank inspection and repair campaign	$100,000	2	3	SJWG, City of Farmington, Aztec, San Juan County	319 grant	2018
		Cost-share funds for individual septic tank repair/replacement; Lobby state legislature to fund the Liquid Waste Indigent Fund	Unknown	1	3	NMED Liquid Waste Program, SJWG	Liquid Waste Indigent Fund	2019
Agricultural BMPs		Pasture BMPs education and outreach campaign	$500	5	3	SJ SWCD, SJWG, NRCS	BHP Billiton BMP grant, NRCS EQIP	2017, 2019, 2021
	D1 T2 E1	Installation of riparian fence, alternative water source, and filter strip at top 3 riparian pasture priority sites	$88,518	3	5	SJ SWCD, SJWG, NRCS, landowners	BHP Billiton BMP grant, NRCS EQIP Animas Watershed Initiative	2016-2019
	D2 D3 D5 D8 T6	Installation of riparian fence, alternative water source, and filter strip at Ditch & Tucker riparian pasture priority sites	$116,488	3	4	SJ SWCD, SJWG, NRCS, landowners	BHP Billiton BMP grant, NRCS EQIP, 319 grant	2018-2021

	Map Key #	Project Description	Cost	Ease (1-Difficult, 5 Easy)	Projected Pollutant Load Reduction (1-5)	Responsible Party/Parties	Funding Sources	Timeline for completion
Agricultural BMPs	E5 E6 E8 FV3 FV8 FV9	Installation of riparian fence, alternative water source, and filter strip at remaining Estes & Flora Vista riparian pasture priority sites	$36,652	3	4	SJ SWCD, SJWG, NRCS, landowners	NRCS EQIP, 319 grant	2018-2021
		Irrigated cropland BMPs within Animas Valley	Variable	3	4	NRCS	$100,000 in NRCS EQIP Animas Watershed Initiative	2016
		Soil health and Ag BMP workshops	$2,000	5	2	AWP, SJ SWCD, NRCS	BOR WaterSmart, NRCS	Annually 2016-2020
		Ongoing outreach to ag producers to identify needs and project opportunities	Variable	5	1	NRCS, SJ SWCD	BOR WaterSmart, NRCS	Ongoing
Upland Erosion Control & Re-vegetation	T4CC2	Sagebrush aerial treatment in Arch Rock Canyon & Cox Canyon	$28,000	4	3	BLM, NMSLO, SJ SWCD	BLM Restore NM grant, NM State Land Office	2016-2018
	CC4	Invasive removal, native planting, and small erosion control structures in Cox Canyon	$30,000	3	4	BLM, NMSLO, SJ SWCD	319 Grant	2019
	CC5	Sediment fences in Cox Canyon	$38,000	2	4	BLM, NMSLO, SJ SWCD	319 Grant	2019
	CC3 T1	Pipeline erosion control in Cox and Kiffen Canyons	Unknown	3	4	Enterprise/ other pipeline companies	Current pipeline maintenance budgets	Unknown; Outreach in 2017
	E3	Road unit erosion control in Hart Canyon	Unknown	3	4	San Juan Basin Roads Committee, SJ SWCD, BLM	Roads Committee Budget & Cost/share	Ongoing
	CC1	Pinon Juniper thinning in Cox Canyon	$500,000	2	1	BLM, NMSLO, SJ SWCD	Water Trust Board Watershed Restoration; NRCS EQIP	2020
	D6	Pinon Juniper thinning in Ditch Canyon	$1,750,000	1	2	BLM, NMSLO, SJ SWCD	Water Trust Board Watershed Restoration; NRCS EQIP	2020
	FV6	1500 acres Pinon Juniper thinning in Flora Vista HUC	$750,000	2	2	BLM, NMSLO, SJ SWCD	Water Trust Board Watershed Restoration; NRCS EQIP	2020

	Map Key #	Project Description	Cost	Ease (1-Difficult, 5 Easy)	Projected Pollutant Load Reduction (1-5)	Responsible Party/Parties	Funding Sources	Timeline for completion
Upland Erosion Control & Re-vegetation	**D7 T5 E2**	Salt cedar removal (84.4 acres)	$168,820	4	1	BLM, SJ SWCD	BLM Riparian,Salinity Control, & Invasive Weed Funds; SJ County Non-native Phreatophyte fund	2017
	E7	Lower Animas Ditch siphon erosion control at Knowlton Canyon crossing	$22,000	3	3	SJWG, Lower Animas Ditch	319 Grant, Water Trust Board	2019
	FV7	Lower Animas Ditch siphon erosion control at Hart Valley crossing	$12,000	3	3	SJWG, Lower Animas Ditch	320 Grant, Water Trust Board	2019
		Dry sediment basin in Flora Vista HUC		2	3	BLM, NMSLO, SJ SWCD	319 Grant	2021
Urban Stormwater		MS4 Stormwater Outreach Campaign	low	5	3	City of Farmington, Aztec, San Juan County, NMDOT, SJWG, SJSWCD, AWP	City MS4 budgets	Ongoing
	CF4 CF5	Current MS4 detention ponds - Porter Arroyo detention pond, Villa View detention pond	high	5	5	City of Farmington	City MS4 budgets, Capital Outlay	2016-2017
		Future MS4 detention ponds	med-high	2	5	City of Farmington	City MS4 budgets, Capital Outlay	2018-2020
		City of Aztec arroyo study & future stormwater infrastructure	med-high	2	3	City of Aztec	City MS4 budgets	2016-2017
		Green infrastructure/Low Impact Development workshop	$16,000	5	3	SJWG, SJ SWCD, MS4 participants	319, city MS4 budgets, registration fees	2018
Riparian Restoration	**T2**	Animas River Riparian Restoration (Tucker Canyon HUC)	$41,264 (overlap with ag BMPs)	3	3	SJSWCD, NRCS	319 grant, NRCS EQIP or CSP	2017-2020
	D7 T5 E2 etc	Revegetation of 13.3 miles of river, including pasture areas and areas cleared of Russian olive & salt cedar	$140,587 (overlap with ag BMPs)	4	2	SJSWCD, landowners	NM State Forestry grants, USFWS Partners for Wildlife, NMGF	Ongoing as RO/SC projects are completed

	Map Key #	Project Description	Cost	Ease (1-Difficult, 5 Easy)	Projected Pollutant Load Reduction (1-5)	Responsible Party/Parties	Funding Sources	Timeline for completion
Streambank, Floodplain & Wetland Restoration Projects	**E10 FV1**	City of Aztec streambank and river restoration	Unknown	1	4	City of Aztec, Aztec Ruins National Monument, Eledge Ditch, Kello-Blancett Ditch, landowners	River Stewardship grant, City of Aztec riverbank stabilization ($100k), The Nature Conservancy, BOR & ISC ditch funding	2016-2021
	CF2	Flora Vista river and riparian restoration	Unknown	2	5	Ranchmans-Terrell ditch, SJ SWCD, landowner, San Juan County	River Stewardship grant, The Nature Conservancy, BOR & ISC ditch funding	2017-2022
	CF6	Farmington Animas Rock Garden	Unknown	3	1	City of Farmington, River Reach Foundation	City of Farmington, River Reach Foundation	2017
	CF3	Farmington Anesi Park	$515,318	3	1	City of Farmington, River Reach Foundation	City of Farmington, DOT trails grant	2019-2022
Irrigation Infra-structure Improvemnt Projects		Irrigation ditch system needs assessment	Unknown	4	1	SJSWCD, Bureau of Rec, Individual ditch companies	OSMRE VISTA program, BOR	2016
	D4	Cedar Ditch diversion improvement	Unknown	2	2	Cedar Ditch, BOR, NRCS, SJ SWCD	BOR ISC ditch programs, NRCS, The Nature Conservancy	Unknown
	FV2	Kello-Blancett diversion improvement	Unknown	2	4	KB Ditch, BOR, NRCS, SJ SWCD	BOR ISC ditch programs, NRCS, The Nature Conservancy	Unknown
	CF1	Ranchmans-Terrell diversion improvement	Unknown	2	5	RT, BOR, NRCS, SJ SWCD	BOR ISC ditch programs, NRCS, The Nature Conservancy	Unknown

Achievement Criteria

The long-term goal of this plan is to restore the Animas River to an unimpaired condition such that it meets all of its designated uses. This means that bacteria concentrations are reduced to a point where they don't impact recreation, and nutrient concentrations, functioning capacity, and sediments are improved to where they support healthy aquatic life. Accomplishment of these goals will be determined in part by a delisting of the impaired reaches of the Animas River after sampling and assessment by the NMED SWQB.

Interim criteria are important in measuring progress towards these goals. The first criterion that will be used to measure the progress of this plan is *E.coli* concentration. Measured *E.coli* concentrations should decrease over time as projects are implemented, and will be compared to the following benchmarks:

- Exceedances of the single sample maximum criterion 410 cfu/100mL
- Exceedances of the monthly geometric mean 126 cfu/100mL
- Reductions in calculated *E.coli* load using the critical flow condition (See Table 7).
- Reductions in peak *E.coli* load and concentration during storm events

As bacteria sources are remediated, we expect to see reductions in nutrient loading as well. While a segment specific water quality criterion for total phosphorus exists for the Estes Arroyo to SUIT boundary segment of the Animas, the reach from the San Juan River to Estes Arroyo is impaired for the broader problem of nutrients and eutrophication. In this case, biological responses to nutrients are weighted equally to nitrogen and phosphorus concentrations, and should be taken into consideration for assessing the progress of this plan. These biotic indices will be more important over the long term, since stakeholders are primarily concerned with river health and not just nutrient concentrations.

- Exceedances of the total phosphorus concentration targets 0.1 and 0.07mg/L TP
- Exceedances of the total nitrogen concentration target 0.42 mg/L TN
- Reductions in calculated nutrient load using the critical flow condition (See Table 7).
- Reductions in peak TN and TP load and concentration during storm events
- Periphyton biomass reduced to less than 10ug/cm^2
- Macroinvertebrate community indices, ie: Hilsenhoff Biotic Index < 2.0

Sediment related criteria are difficult to measure due to the narrative nature of New Mexico's sediment and siltation criteria, which specifies: *"Surface waters of the state shall be free of water contaminants including fine sediment particles (less than two millimeters in diameter)…that have settled to form layers on or fill the interstices of the natural or dominant substrate in quantities that damage or impair the normal growth, function or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom."* SJWG will defer to the state for final assessment of sediment and turbidity related criteria.

Milestones

The milestones to measure the progress of this plan will be both programmatic and implementation based. Education and outreach activities will be included as programmatic milestones. The checklist below was designed as a tool for tracking progress, facilitating adaptive management, and quantitatively measuring project completion in a way that will be easy to calculate load reductions. The milestone table will be used in conjunction with the timeline in the Implementation Schedule and the Chapter 5 project descriptions to measure progress.

SJWG will review this checklist quarterly, and update the table with progress towards completing the plan. Progress reports including both quantitative and qualitative updates should be prepared annually. This adaptive approach should encourage frequent check-ins with the plan, as well as active communication with partners to track cumulative progress.

Task	This Quarter	Total
Programmatic Milestones		
San Juan Watershed Group meetings held – How many? # of attendees? # organizations present		
Grant applications submitted – Which ones? For which projects? How much $?		
Funding secured – What source? How much $?		
Literature/brochures created or purchased – Septic care & management, Pasture BMPs, Who Pooped in the River?, When It Rains It Drains, Riparian Buffer Management. How many distributed?		
Workshops organized – Soil health, Low Impact Development, Road BMPs, etc.		
Outreach/Education meetings with landowners regarding BMP implementation – How many? With who? For which projects?		
Presence in the media - # of newspaper articles, Facebook shares, etc.		
Booth/activities promoting watershed issues at public events - Beef Symposium-Feb, Invasive Weed Symposium-Mar, Aztec Ruins Earth Day-Apr, Fmtn River Fest-Memorial Day, Aztec Fiesta Days-Jun, Durango Animas River Days-June, Fmtn Freedom Days-July 4th, Farm Bureau meeting-Oct, SJSWCD meeting-Dec, Irrigation Ditch Meetings-Dec/Jan		
Permits and designs completed – 404 permits, engineering designs, CRMPs, NRCS conservation plans		

Implementation Milestones		
# Failing septic tanks pumped		
# Failing septic tanks repaired/replaced		
# Septic tanks hooked to sewer or treatment utility		
# of properties implementing pasture BMPs		
Linear feet of riparian areas fenced		
# of livestock removed from direct river access, # of corrals moved away from riparian areas		
Linear feet of riparian area planted with willows and cottonwoods		
Acres seeded with native grasses (riparian seeding, cover crops, filter strips, upland revegetation)		
Acres invasive phreatophytes removed		
Acres pinon/juniper thinned		
Acres of sagebrush aerially treated		
# Sediment fences installed		
# Detention basins installed		
# Ditch diversions repaired/replaced		
Linear feet of riverbank w/ rip-rap removed		
Linear feet of streambank stabilization		
# of in-stream structures installed in river		
Monitoring Milestones		
# of times completing this checklist (2x/year min.)		
# of monthly baseline water quality monitoring runs, # of sites, # of samples/constituents collected		
Data entered into Colorado Data Sharing Network		
# of BMP implementation projects with photo points, before and after water quality sampling		

Monitoring Plan

Follow-up monitoring will be crucial to achieve two objectives: 1) track the overall health of the Lower Animas over time; and 2) directly measure the effectiveness of remediation projects.

Overall Watershed Health

There is substantial baseline data available for the Lower Animas including multiple years of data on water quality, aquatic life, and chlorophyll-a. Water quality data is the easiest and cheapest to collect, though it still requires a significant ongoing investment to collect enough samples to distinguish trends over time from natural variability. Funding will be sought for a long-term water quality monitoring scheme, to collect samples monthly[1] at a minimum of four sample sites (see below for site suggestions). The cost to collect nutrients (Total Phosphorus, Nitrate-Nitrite, and Total Kjeldahl Nitrogen = $87), *E. coli* ($40) and turbidity plus staff time and gas ($81) for each sample site would be $208 per visit, for a total of just under $2,500 for one year of monthly monitoring at each sample site. This would bring the estimated cost to $10,000 for four reference sites.

Baseline chlorophyll-a and benthic macroinvertebrate data is available from 2003-04 along the Lower Animas at four locations: the NM/CO state line, Aztec, Flora Vista, and Farmington (BUGS 2007). In order for data to be as comparable as possible to historical data, future sampling should focus on the same locations and follow the same protocols that were used for the 2003-04 data. Therefore, these four locations should be targeted for collection of chlorophyll-a and benthic macroinvertebrate samples in early October and monthly water quality samples from April through October. Baseline data should be collected annually for at least a three year period to account for natural variability in the data. These monitoring costs will be calculated based on previous studies in the watershed.

Follow up Microbial Source Tracking (MST) sampling would also be beneficial to track the prevalence of different bacteria sources over time. This is an expensive undertaking ($500 per site per sampling day to test for five markers and quantify two), and should be coordinated with comprehensive upstream (Animas in Colorado) and downstream (San Juan River) sampling if conducted. A reduced cost way to monitor this would be to measure and quantify only the two most prevalent *Bacteroides* markers, human and ruminant, but bulk sample discounts may cancel out these savings. Lab details for previous studies are in the QAPP for the 2013-2014 MST and nutrient study http://sanjuanswcd.com/sjwg/mst/.

The other "data gaps" discussed in Chapter 3 under Water Quality Trends will all also be targeted for future monitoring projects. Costs and responsible parties have not been identified at this time, but these projects represent an opportunity for academics to get involved in the watershed and assist with water quality monitoring.

[1]Avoiding winter sampling could be a reasonable adjustment to this sampling scheme, however it would be beneficial if samples diverted from the 3 winter months (Dec-Feb) were moved to the monsoon season to increase the likelihood of catching at least one storm flow per year.

Remediation Project Monitoring

The direct load reduction effects of individual remediation projects are often very hard to measure, but are worth monitoring nonetheless.

Inflow locations monitored in the 2014 Lower Animas Targeted Sampling and BUGS 2011 watershed surveys will be used as baselines in the tributaries and drainage networks where on-the-ground projects are taking place. The following monitoring strategy will be used for measuring progress on projects:

- Identify the nearest baseline water quality monitoring point from previous studies
- Establish additional water quality monitoring locations immediately upstream and immediately downstream of the remediation project.
- Our goal will be to collect at least one season of monthly upstream/downstream water quality sample before project implementation and then sample in the same season for three years following completion of the remediation project.
- Establish GPS photo points at each site to monitor changes over time that may not show up in water quality data.

Due to the 2015 Gold King Mine spill that occurred in a high elevation tributary to the Animas River, NMED may conduct extensive sampling along the Lower Animas in the coming years. This monitoring plan will be actively adjusted based on NMED's efforts so that any redundancy of resources is avoided. For example, as part of this monitoring, USGS has installed permanent Sondes at 4 sites along the Animas which measure turbidity, pH, temperature, dissolved oxygen, and conductivity in addition to flow. This data should be incorporated into future monitoring plans and assessments.

All water quality data (baseline and project based) for this WBP will be collected in format compatible with entry to the Colorado Data Sharing Network. Visit their website http://coloradowaterdata.org frequently for the most up-to-date data entry templates. Both San Juan Watershed Group and Animas Watershed Partnership are members of CDSN, and share the goal of making high quality water quality data available to the public.

As mentioned under milestones above, San Juan Watershed Group will review the progress to this plan on a biannual basis, and will formally review the effectiveness of the Watershed Plan to determine whether we are achieving stated objectives and milestones. If milestones are not being achieved, we will use adaptive management to implement course correction measures. For example, if specific BMPs are found to not be effective, we will refocus efforts on BMPs that prove to be more effective in the region. The Watershed Based Planning process is ongoing and iterative, and it is expected that changes will need to be made as we learn from this process over time.

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8. Appendices

Appendix A. Load Reduction Efficiency of Best Management Practices

Cropland	Pastureland	Forest	Urban	Riparian	Best Management Practice (BMP)	Pollutant Reduction Efficiency (%)	Load Reduction Potential
			■		Septic - On-site Treatment Utility		
			■		Septic - Cluster Systems		
			■		Septic - Disposal/Maintenance Public Outreach and Education		
			■		Septic Improvement (elevated sand mounds, media filters, etc.)	20-69	MOD
			■		Regionalization with Aztec/Farmington Wastewater System		
■	■				Fertilizer Management		
■	■				Watering Facility		
■	■				Waste Management (manure)		
■	■				Grazing Management		
■	■				Reduced Tillage Systems	50	MOD
■	■				Cover Crop		
		■			Revegetation - erosion control - seeding/mulching	70	HIGH
		■			Sediment Fences		
			■		Porous Pavement	80	HIGH
			■		Concrete Grid Pavement	90	HIGH
■	■	■	■	■	Detention Basin (dry)	38	LOW
■	■	■	■	■	Infiltration Basin	67	MOD
■	■		■	■	Constructed Wetland	47	MOD
■	■	■	■	■	River Restoration		
■	■	■	■	■	Bank Stabilization	75	HIGH
■	■			■	Riparian Fencing	75	HIGH
■	■	■	■	■	Filter strip (along rivers, irrigation ditches, or roads)	70	HIGH
■	■				Irrigation - change from flood to gated pipe	20*	LOW
■	■				Irrigation - change from flood to sprinkler	30*	LOW
■	■				Irrigation - change from flood to surface drip	55	MOD

Note: Pollutant reduction efficiency represents an estimate of the average percentage of nitrogen, phosphorus, and sediment that could be expected to be removed by implementing a BMP. Pollutant reduction efficiency values in this table are pollutant reduction efficiency values are derived from STEPL (Tetra Tech 2011) except when indicated by asterisk (*), in which case the value was derived from Byelich et al. 2013.

Appendix B. 2014 Lower Animas Targeted Sampling Summary

Table. Site Locations for 2014 Microbial Source Tracking (MST) and Lower Animas Targeted Sampling

Site ID	Site Type	River Mile	Latitude	Longitude
			NAD 83	
MST_BoydPark	Mainstem	1.3	36.720746	-108.202436
92a	Input	2.2	36.726566	-108.189532
92b	Diversion	3.4	36.733584	-108.174574
89a	Input	3.9	36.737993	-108.168094
89c	Diversion	4.6	36.744260	-108.163444
73a	Input	10.1	36.787465	-108.092517
73b	Ditch	10.1	36.794676	-108.092016
72a	Input	10.4	36.786515	-108.086362
72c	Diversion	10.7	36.787641	-108.080818
70a	Input	10.9	36.788297	-108.078922
70b	Ditch	11	36.787623	-108.076925
70c	Ditch	11	36.787479	-108.076774
69a	Input	11.3	36.793327	-108.073398
69c	Ditch	11.3	36.788311	-108.067873
68a	Input	11.4	36.794543	-108.074000
68b	Ditch	11.4	36.803111	-108.084383
69b	Ditch	11.8	36.792569	-108.062043
55a	Input	16.3	36.818994	-108.007020
55b	Ditch	16.3	36.811846	-108.004482
55a1	Diversion	16.4	36.819721	-108.006782
MST_Aztec	Mainstem	17.2	36.829517	-107.997063
52a	Ditch/Input	18	36.839273	-107.991457
49a	Input	18.5	36.845459	-107.988103
52b	Ditch	18.5	36.842469	-107.976956
49b	Ditch	19.5	36.848279	-107.973589
49c	Ditch	19.6	36.852282	-107.966622
45a	Input	20.9	36.870215	-107.964830
45b	Diversion	21.2	36.872833	-107.960745
41b	Arroyo	23.2	36.895907	-107.944890
41c	Arroyo	23.3	36.903981	-107.946697
41e	Ditch	23.3	36.899313	-107.945540
41d	Ditch	23.6	36.899738	-107.938038
27c	Arroyo	27.8	36.947235	-107.902437
27c1	Arroyo	27.8	36.947235	-107.902437
29a	Ditch	27.8	36.934683	-107.903478

27a	Arroyo/Input	28.1	36.933624	-107.898042
27b	Input	28.1	36.936423	-107.898844
27d	Ditch	28.4	36.938836	-107.887362
25a	Input	28.5	36.931869	-107.890733
25b	Diversion	28.9	36.929203	-107.885691
25c	Ditch	29	36.931840	-107.884513
22a	Input	30.1	36.942478	-107.878044
27e	Ditch	30.1	36.943164	-107.880418
22b	Diversion	30.8	36.947402	-107.882308
20a	Ditch	31.4	36.955675	-107.883448
20b	Ditch	32.6	36.968349	-107.875110
MST_StateLine	Mainstem	37.5	37.024501	-107.874007

See www.sanjuanswcd.com/watershed/sjwg-projects/ for full 2014 Sampling Summary.

Introduction

The Lower Animas River, defined as the reach of the Animas River from just downstream of the confluence with the Florida River in Colorado, to the confluence with the San Juan River near Farmington, New Mexico, has been the focus of several studies aimed at determining contributions and loading of bacterial and nutrient pollutants. These studies have examined inflows to the river itself as well as ditches and storm water in the Lower Animas Watershed. Impairments to water quality are consistently found and indicate that various non-point source activities play a cumulative role in increasing bacteria and nutrient levels in the Animas River from the Colorado-New Mexico border to the confluence with the San Juan River (BUGS 2009).

One of the water quality studies, the 2006 Animas River Nutrient study, was the main driver for the 2014 Lower Animas Targeted Sampling study. In the 2006 study, samples were collected from each inflow to the Animas River and nutrient loads were determined for each of those inflows (BUGS 2007). Total Daily Maximum Loads (TMDL) were found to exceed New Mexico Environment Department (NMED) and EPA approved standards for portions of the Lower Animas River (NMED/SWQB 2013f).

While exceedances were found in the aforementioned studies, the studies did not focus on potential sources of loading to the Animas. The crucial data gap, then, was the extent to which different land uses throughout the Lower Animas River Watershed were affecting bacteria and nutrient loading. This missing data was essential for prioritizing implementation projects that would have the biggest impact on pollutant load reduction.

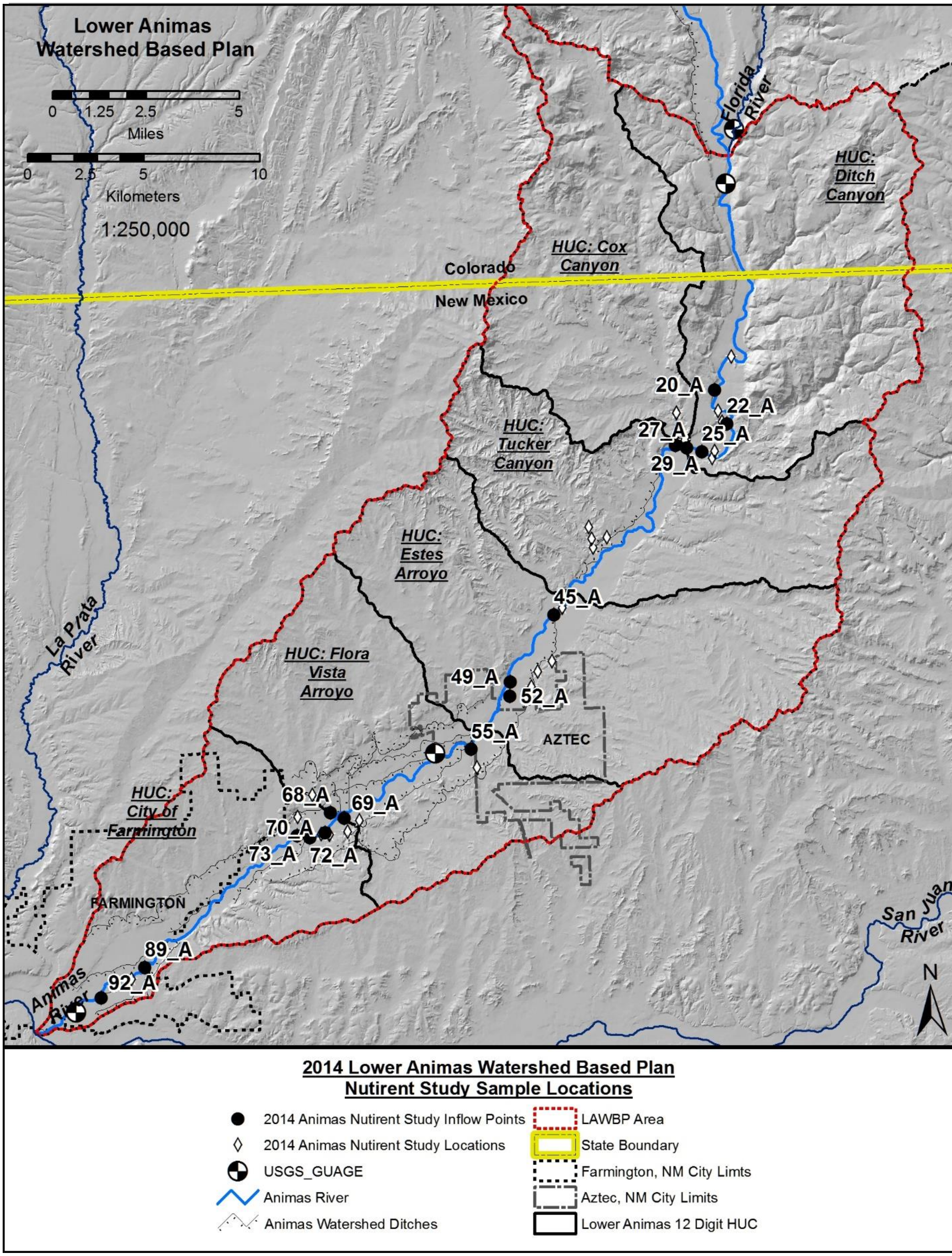
When the San Juan Watershed Group (SJWG) and the Mountain Studies Institute (MSI) began discussions to compose a watershed based plan for the Lower Animas River, it was determined that follow-up sampling, driven by the 2006 Animas River Nutrient Study, was a crucial course of action to identify load contributions of different land uses along the Animas. Over the course of several discussions among project partners including MSI, SJWG, SJ SWCD, Basin Hydrology, and the Animas Watershed Partnership (AWP) in late

2013 and early 2014, a subset of the 2006 inflow sample locations were defined as high loaders and selected for the 2014 study, Map A1 and Table A1.

The next step in the planning process was to define upland areas that contributed to each selected inflow and to select sampling locations from within those areas. This step proved to be a challenge due to numerous watershed features, including the vast network of irrigation ditches (LAWBP Map 11) in the riparian corridor of the Lower Animas River, often crossing one or two 12-digit HUC boundaries; 12-digit HUCs that cross the main stem of the Animas River rather than contributing a single point or confluence; a wide variety of land use types including pastureland, crop land, dense suburban developments using septic systems, and dense urban development in the cites of Farmington and Aztec, New Mexico (LAWBP Map 12); the high acreage of undeveloped uplands relative to the narrow but highly utilized riparian zone (LAWBP Map 13); and finally, upland disturbance resulting from energy extraction and summer monsoonal flash-flooding events (LAWBP Map 14).

Furthermore, access to sampling locations was limited by the lack of public lands along the Lower Animas (LAWBP Map 9). Taking all of the aforementioned features into consideration, the project team defined subwatersheds associated with each selected inflow. Sample locations were then bracketed within each subwatershed, Map A1.
A final relevant limitation of the 2006 study was that only one round of sampling occurred (in July)[1]. The project team decided that more rounds of data collection should occur in the 2014 study in order to better characterize pollutant sources. The July sampling round was retained for replication, and also because it is typically a time of base flow in the summer (pre-monsoon). In addition, it was determined that sampling pre-irrigation, when ditches were being flushed, as well as post irrigation/post monsoon, would provide insight into the timing of potential bacteria and nutrient contributions. Timing data might help determine if a loading source was upland or due to land use in the riparian corridor.

[1]. A second round of sampling also occurred in October 2006, but it appears this data was influenced by a storm event and was not fully analyzed in the subsequent sampling report and 2011 watershed planning effort.



Map A1 – 2014 Lower Animas Targeted Sampling sample locations. Inflow sample points are labeled.

Site #	Site Subsample IDs	Land Use Types
20	20_R_b_IS 20_R_a_ID	Agricultural Low density residential
22	22_R_a_IF 22_R_b_IS	Agricultural
25	25_R_a_IF 25_R_b_ID 25_R_c_ID 25_R_d_ID	Agricultural Low density residential
27 Lower	27_R_a_IF 27_R_b_ID 27_R_c_ID 27_R_d_IA	Agricultural Low density residential Unused?
27 Upper	27_R_e_IA	Agricultural Low density residential Unused?
41 Lower	41_R_b_ID 41_R_c_IA 41_R_d_ID	Agricultural Low density residential Tribal lands? Or unused?
41 Upper	41_R_e_IA	Agricultural Low density residential Unused?
45	45_L_a_ID 45_L_b_ID	Agricultural Medium density residential
49	49_L_a_ID 49_L_b_IA 49_L_C_ID	Agricultural Medium density residential
52	52_L_a_ID 52_L_b_ID	Agricultural Medium density residential
55	55_L_a_ID 55_L_a1_IF 55_L_b_ID 55_L_c_ID	Unused? Urban
68	68_R_a_ID 68_R_b_ID	Unused? Urban
69	69_L_a_ID 69_L_b_ID 69_L_c_ID	Agricultural Medium density residential

70	70_L_a_ID 70_L_b_ID 70_L_c_ID	Agricultural Medium density residential
72	72_L_a_IF 72_L_c_ID	Agricultural Medium density residential
73	73_R_a_IF 73_R_b_ID	Agricultural Medium density residential
89	89_R_a_ID 89_R_c_IF	High density residential Urban
92	92_L_a_ID 92_L_b_IF	High density residential Urban

Table A1 – Inflow identification and subsample identification from the 2014 Animas River Targeted Sampling study, as well as dominant land use type in each subwatershed. 44 subsamples were collected from 17 sample sites. Blanks and replicates were collected at 10% of inflow sites (~5 sites). Inflow source tags are at the end of subsample IDs: ID=in ditch, IS=in stream, IF= in flow, and IA= in arroyo.

Methods

The baseline data of the Lower Animas Targeted Sampling was collected to determine the most probable causes and locations of pollution within the project reach. Presence of bacteria and nutrient sources and the magnitude of pollution were compared with flow data and timing. Collection sites were selected to bracket inflows with a wide variety of potential pollution sources (e.g. septic systems, agriculture) so that, if pollution were found, managers could be informed for future restoration efforts.

As outlined in Table 1, 44 subsamples were collected from 17 sites identified as high nutrient contributors using 2006 Animas River Nutrient Study data**.** Sites were selected with two criteria in mind: 1) Sites should have known pollution problems, in order to increase chances of identifying and correcting the sources, and 2) Site locations should be spatially distributed to bracket inflows and possible loading sources. Total bacteria and nutrients, flow, and ambient water quality data were collected at regular intervals spanning the major changes in river flow throughout the year. Sampling occurred during three distinct periods to capture spring run-off and the first flush of irrigation water (April-May) monsoonal flows (July-August), and post-monsoon baseline flows (September-October).

Subsamples had varying inflow sources and were labeled with source tags: ID=in ditch (within an irrigation ditch or water conveyance canal), IS=in stream (in the Animas River), IF= in flow (any drainage or inflow to the Animas River which cannot be easily tied to a discrete hydrologic subwatershed), and IA= in arroyo (a discrete hydrologic subwatershed or intermittent/ephemeral tributary to the Animas River). Field blanks and field replicates were used for quality control (QC) to assess overall quality of sampling and laboratory analysis. Blanks and replicates were collected at 10% of field sites (approximately 5 sites) for bacteria and nutrient analysis.

The measures taken at each subsample location were total nitrogen, phosphorus, and E. coli; temperature, pH, dissolved oxygen, turbidity, conductivity, and discharge. Opportunistically, periphyton was collected at a subset of subsample locations to analyze for N15 and chlorophyll-a. The following methods were used for sample and data collection:

Nutrients - Nitrogen and Phosphorus: Water samples were collected using 500mL bottles provided by Green Analytical Labs (GAL), Durango, CO, and following the criteria outlined in NMED SOP 8.2 and 10.0. Bottles were labeled and delivered to GAL on the day the samples were collected. Following SOP EPA 8.2 Chemical Sampling in Lotic Environments, a field blank was collected at a rate of 10% of the total number of samples collected for nutrients. Bottles were labeled according to defined protocols and chain of custody forms were completed to be turned in at GAL. In the lab, analyses were performed for inorganic nitrogen (Nitrate-Nitrite as N), "Total Kjeldahl Nitrogen", and "Phosphate as P, Total" (EPA 353.2, EPA 351.2, and EPA 365.3).

E. coli: Samples were collected using 125mL sample bottles provided by San Juan Basin Health (SJBH), Durango, CO, and following the criteria outlined in NMED SOP 9.1. Samples were labeled and recorded in a field notebook and a chain of custody sheet. The samples were delivered to SJBH for immediate processing, the afternoon of the day collected, in accordance with their analysis protocols. Samples were also kept cool after collection, also in accordance with SJBH analysis protocols. Analysis began no later than 8 hours after collection.

15N and Chlorophyll-a from periphyton: At a subset of sampling locations, seven in total (22A, 25A, 25B, 27A, 52A, 68A, and 69A) during the July and October collection events, periphyton were collected. No collection was made in April as it was deemed too early for periphyton growth. Samples were collected for both N15 and Clorophyll-a analysis following the methods in NMED SOP 11.2 and Anderson C.K. et al. 2011. Four cobbles at each location were scraped within an area of 10 cm^2 on each cobble. The material from each cobble was collected by rinsing, with Animas River water, into collection tubs. The samples were then transferred into 500mL WhirlPaks, and wrapped in foil to shade from sunlight and placed in coolers to keep chilled. Samples were filtered, on ashed glass fiber filters, or frozen within 12 hours of collection. Following the periphyton collection, the longest axis of each rock was measured and recorded and a picture was taken of the area scrubbed of periphyton. After field collection, periphyton samples which consisted of clumps or filaments were blended prior to filtration. Within 3 days, the frozen filter samples were dried at 60°C, and encapsulated in tin capsules. Samples were split for both Chlorophyll-a and N15 then sent to labs for analysis. The analysis for the July samples was performed by students in the Chemistry Department of Fort Lewis College, Durango, Colorado. Due to the lack of student availability, the October samples were sent to Aquatic Consulting and Testing, Inc., Tempe, Arizona for analysis.

Sonde Measurements: Sonde data (DO, pH, temperature, turbidity, and conductivity) was collected at each of the same sampling sites for each sampling period. All sonde readings were collected with either a YSI ProPlus or Horiba U- 52 meters. All sonde calibration, cleaning, and maintenance was done in accordance with manufacture's guidelines.

Flow Measurements: In-field flow measurements were conducted, where feasible and safe, for subsample locations from ditches and arroyos. In-field flow measurements conformed to USGS protocols and were conducted with either mechanical or electromagnetic flow meters. For sites with low flow or that were too shallow to measure with a flow meter, estimations were made as needed. Estimations were noted in the field notebook.

USGS gaging stations were used to approximate flow at the sampling sites located in the main stem of the Animas River. Most recent instantaneous flow at five gaging stations was recorded in the field notebook each morning before sampling began. This served the dual purpose of ensuring safety of the samplers (avoiding extremely high flow conditions or taking the appropriate safety precautions) and providing a flow estimate for comparison to other sampling sites/dates.

Final flow measurements are to be obtained and entered into the database once USGS changes its flow data from provisional to final (~6months from time of sampling).
All flow measurements either from USGS gauges or from field measurements were used to calculate loads from each sample location.

Results

The data collected from the 2014 Lower Animas Targeted Sampling study have been archived both with the SJWG, MSI, and provided to the Colorado Data Sharing Network (CDSN) for deposition in the EPA AWQMS repository. These data are freely accessible to any interested party.

Table A2 below is a summary of the nutrient and E. coli data collected in this study. Sonde and flow measurements can be found in the archived data. The data collected from periphyton for 15N and Chlorophyll-a analysis is also found in the archived data.

POINT ID	April 2014					July 2014					October 2014				
	Nitrate/ Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total P (mg/L)	E. Coli	Nitrate/ Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total P (mg/L)	E. Coli	Nitrate/ Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total P (mg/L)	E. Coli
20_A	0.144	ND	0.144	0.102	235.9	0.179	ND	0.179	0.043	127.4	0.173	ND	0.173	0.148	140.1
20_B	0.131	2.04	2.171	0.063	10.9	0.146	0.393	0.539	0.049	93.3	0.16	ND	0.16	0.182	123.6
22_A	0.123	0.369	0.492	0.082	8.5	0.035	0.374	0.409	0.061	24.9	0.156	0.247	0.403	0.148	117.8
22_B	0.125	0.476	0.601	0.074	12	0.022	0.422	0.444	0.023	24.0	0.149	0.232	0.381	0.219	101.2
22_B_D	0.129	ND	0.129	0.08	12.1	0.024	ND	0.024	0.035	28.5	0.15	ND	0.15	0.154	141.4
25_A	0.183	ND	0.183	0.063	18.9	0.05	ND	0.05	0.025	547.5	0.143	0.277	0.42	0.107	80.9
25_A_D						0.048	ND	0.048	0.055	410.6					
25_B	0.201	ND	0.201	0.061	23.8	0.028	ND	0.028	0.037	54.6	0.143	ND	0.143	0.106	156.5
25_C	0.178	ND	0.178	ND	14.8	0.091	0.42	0.511	0.049	517.2	0.144	0.269	0.413	0.141	66.3
25_C_D						0.09	ND	0.09	0.068	816.4	0.145	0.332	0.477	0.051	78
27_A	0.333	ND	0.333	0.033	78.9	0.392	ND	0.392	0.041	461.1	0.168	0.272	0.44	0.107	150
27_B	0.029	0.566	0.595	0.189	166.9	0.035	ND	0.035	0.025	16.0	0.011	0.348	0.359	0.135	13.2
27_C	0.017	0.502	0.519	0.169	2419.2					113.7	0.011	0.298	0.309	0.055	32.3
27_C1	0.047	ND	0.047	0.021	2419.2										
27_D	0.173	ND	0.173	ND	18.1	0.268	ND	0.268	0.059	1986.3	0.175	ND	0.175	0.08	127.4
27_E	0.183	ND	0.183	0.076	21.8	0.261	ND	0.261	0.086	1413.6	0.172	0.246	0.418	0.066	107.1
29_A	0.129	0.508	0.637	0.055	20.1	0.054	7.12	7.174	0.033		0.155	0.398	0.553	0.121	114.5
29_A_D						0.034	0.401	0.435	0.049	275.5					
41_A			0										0		
41_B	0.034	0.534	0.568	0.126	461.1	0.076	1.08	1.156	0.332	186.0	0.127	0.728	0.855	0.633	613.1
41_B_D	0.018	0.567	0.585	0.187	488.4						0.118	0.747	0.865	0.707	727
41_C	0.032	0.527	0.559	0.053	<1	0.041	ND	0.041	ND	1119.9	0.064	0.336	0.4	ND	15.8
41_C_D										816.4					
41_D	0.137	2.15	2.287	0.061	24.9	0.043	ND	0.043	0.025	222.4	0.163	0.287	0.45	0.215	95.9
41_E	0.096	0.494	0.59	0.232		0.034	0.424	0.458	0.15						
45_A	0.187	ND	0.187	0.059	209.8	0.123	ND	0.123	0.063	70.3	0.187	0.24	0.427	0.125	224.7
45_B	0.181	ND	0.181	0.049	160.7	0.209	0.571	0.78	0.072	65.0	0.181	ND	0.181	0.078	
49_A	0.138	0.626	0.764	0.218	68.9	0.099	0.559	0.658	0.211	547.5	0.315	0.391	0.706	0.225	
49_B	0.136	0.347	0.483	0.165	517.2	0.044	0.368	0.412	0.055	517.2					
49_C	0.125	0.425	0.55	0.149	64.5	0.039	1.14	1.179	0.174	58.1	0.145	0.235	0.38	0.074	344.8
49_D											0.177	0.275	0.452	0.115	96
52_A	0.194	ND	0.194	0.051	54.6	0.154	0.702	0.856	0.188	920.8	0.444	ND	0.444	0.035	131.3
52_A_D	0.148	ND	0.148	0.045	70.3	0.145	0.702	0.847	0.207	686.7					
52_B	0.213	ND	0.213	ND	214.3	0.117	0.772	0.889	0.17	387.3	0.264	0.228	0.492	0.18	108.1
55_A	0.194	ND	0.194	0.051	193.5	0.2	ND	0.2	0.137	325.5	0.539	ND	0.539	0.152	261.3
55_A1	0.149	ND	0.149	0.063	39.9	0.194	0.41	0.604	0.076	272.3	0.174	ND	0.174	0.145	137.4
55_B	0.192	ND	0.192	0.068	172.3	0.151	ND	0.151	0.127	167.4					

	April 2014					July 2014					October 2014				
POINT ID	Nitrate/Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total P (mg/L)	E. Coli	Nitrate/Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total P (mg/L)	E. Coli	Nitrate/Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total P (mg/L)	E. Coli
68_A	0.38	1.02	1.4	0.084	26.5	0.462	ND	0.462	0.123	172.3	0.434	ND	0.434	0.098	2419.2
68_A_D						0.47	ND	0.47	0.107	156.5					
68_B	0.07	1.11	1.18	0.09	160.7	0.054	ND	0.054	0.117	325.5	0.117	0.428	0.545	0.223	1413.6
69_A	0.161	0.497	0.658	0.126	90.7	0.245	0.447	0.692	0.117	387.3	0.307	0.306	0.613	0.174	325.5
69_A_D						0.26	0.366	0.626	0.123	228.2					
69_B	0.169	0.443	0.612	0.297	52.1	0.251	0.409	0.66	0.106	325.5	0.32	0.234	0.554	0.135	307.6
69_B_D											0.319	0.517	0.836	0.191	613.1
69_C	0.09	ND	0.09	0.153	35.9	0.099	0.375	0.474	0.115	387.3	0.148	0.231	0.379	0.145	461.6
69_C_D						0.116	0.374	0.49	0.133	290.9					
70_A	0.066	ND	0.066	<.0163	43.7	0.335	1.09	1.425	0.328	2419.2	0.115	0.271	0.386	0.07	191.8
70_A_D	0.067	ND	0.067	0.053	37.3						0.109	ND	0.109	0.045	228.2
70_B	0.124	ND	0.124	0.017	51.2	0.551	1.16	1.711	0.399	2419.2	0.128	ND	0.128	0.1	71.7
70_C	0.065	ND	0.065	0.068	35	0.183	0.598	0.781	0.254	435.2	0.114	0.534	0.648	0.234	101.7
72_A	0.139	0.626		0.098	284.1	0.112	ND	0.112	0.047	201.4	0.171	0.417	0.588	0.07	131.3
72_A_D											0.168	0.267	0.435	0.109	141.4
72_B											0.174	0.368	0.452	0.172	131.3
72_C	0.108	ND	0.108	0.08	313	0.113	ND	0.113	0.111	1732.9					
73_A	0.246	0.525	0.771	0.055	517.2	0.178	ND	0.178	0.106	517.2	0.199	0.33	0.529	0.141	866.4
73_B	0.12	0.348	0.468	0.049	285.1	0.104	0.659	0.763	0.143	387.3	0.138	0.469	0.607	0.117	686.7
89_A	0.142	0.389	0.531	0.1	193.5	0.067	ND	0.067	0.053	56.4	0.183	0.279	0.462	0.121	172.3
89_B															
89_C	0.137	1.9	2.037	0.072	224.7	0.121	ND	0.121	0.027	91.0	0.187	0.243	0.43	0.08	152.9
92_A	0.146	0.403	0.549	0.114	104.3	0.097	ND	0.097	0.039	111.2	0.144	ND	0.144	0.047	313
92_B	0.143	ND	0.143	0.084	56.5	0.074	ND	0.074	0.084	95.9	0.171	ND	0.171	0.092	116.9

Table A2 – Summary of all nutrient and bacteria data from the 2014 Lower Animas Targeted Sampling study.

Blank rows indicate locations that were dry each sample period. Duplicates are indicated with "_D" after the point ID.

Discussion

Only a basic analysis of the 2014 data was performed to keep with the goals of the development of the WBP. Many of the inflow points, as identified from the 2006 Animas River Nutrient Study, were again found to exceed concentrations of total nitrogen, total phosphorus, and E. coli, which may have contributed to exceedances in TMDLs for the main stem of the Animas, Table A3. A preliminary analysis of these data indicated that sampling resolution was insufficient to pin-point any locations within the catchment areas of the selected Animas River inflows as pollutant sources.

TMDL exceedances are highlighted in red and values within 20% of the TMDL exceedance are highlighted in yellow, Table A3. An increase in concentrations of total N and total P was found across the sampling periods, with October having the highest number of exceedances. This high number is likely due to sediments and nutrients flushed into the system during monsoon events. However, only base flow was captured during the three sample periods, so further study is recommended to capture storm events.

E. coli exceedances spiked at the July sampling event. This spike is likely due to increased water temperatures in July.

It should be noted that several of our Animas inflow sample points did not exceed TMDLs and had much lower nutrient levels than those found in 2006. One possible cause of these reductions is that the 2006 sampling event occurred at a period of higher discharge levels in the Animas, Figure A1. This increased discharge suggests that there was more runoff during the 2006 sampling period than in 2014, which would indicate that inflows were contributing more water to the Animas in 2006. However, with these data alone, no definitive causal conclusions can be made about the decreases in nutrient levels.

Upon reviewing load values from both 2006 and 2014, the same trends hold; inflows to the Animas that were high in 2006 remain high with a few exceptions, Figure A2 and Figure A3.

For load calculations in the main stem of the Animas, please refer to the Lower Animas Watershed Based Plan.

While these data confirm that there are still significant impairments to water quality in the Lower Animas River, no specific contributor can be highlighted without in-depth analysis, both intra- and inter-annually. In addition, while improvements were found for several of the selected inflows between 2006 and 2014, the existing analysis limits our ability to determine why these improvements occurred.

Point ID	APRIL Total P (mg/L)	Point ID	JULY Total P (mg/L)	Point ID	Oct Total P (mg/L)	Point ID	APRIL Total N(mg/L)	Point ID	JULY Total N (mg/L)	Point ID	Oct Total N (mg/L)	Point ID	APRIL E. Coli	Point ID	JULY E. Coli	Point ID	Oct E. Coli
69_B	0.297	70_B	0.399	41_B_D	0.707	41_D	2.287	29_A	7.174	41_B_D	0.865	27_C	2419.2	70_A	2419.2	68_A	2419.2
41_E	0.232	41_B	0.332	41_B	0.633	20_B	2.171	70_B	1.711	41_B	0.855	27_C1	2419.2	70_B	2419.2	68_B	1413.6
49_A	0.218	70_A	0.328	70_C	0.234	89_C	2.037	70_A	1.425	69_B_D	0.836	49_B	517.2	27_D	1986.3	73_A	866.4
27_B	0.189	70_C	0.254	49_A	0.225	68_A	1.4	49_C	1.179	49_A	0.706	73_A	517.2	72_C	1732.9	41_B_D	727
41_B_D	0.187	49_A	0.211	68_B	0.223	68_B	1.18	41_B	1.156	70_C	0.648	41_B_D	488.4	27_E	1413.6	73_B	686.7
27_C	0.169	52_A_D	0.207	22_B	0.219	73_A	0.771	52_B	0.889	69_A	0.613	41_B	461.1	41_C	1119.9	41_B	613.1
49_B	0.165	52_A	0.188	41_D	0.215	49_A	0.764	52_A	0.856	73_B	0.607	72_C	313	52_A	920.8	69_B_D	613.1
69_C	0.153	49_C	0.174	69_B_D	0.191	69_A	0.658	52_A_D	0.847	72_A	0.588	73_B	285.1	25_C_D	816.4	69_C	461.6
49_C	0.149	52_B	0.17	20_B	0.182	29_A	0.637	70_C	0.781	69_B	0.554	72_A	284.1	41_C_D	816.4	49_C	344.8
41_B	0.126	41_E	0.15	52_B	0.18	69_B	0.612	45_B	0.78	29_A	0.553	20_A	235.9	52_A_D	686.7	69_A	325.5
69_A	0.126	73_B	0.143	69_A	0.174	22_B	0.601	73_B	0.763	68_B	0.545	89_C	224.7	25_A	547.5	92_A	313
92_A	0.114	55_A	0.137	72_B	0.172	27_B	0.595	69_A	0.692	55_A	0.539	52_B	214.3	49_A	547.5	69_B	307.6
20_A	0.102	69_C_D	0.133	22_B_D	0.154	41_E	0.59	69_B	0.66	73_A	0.529	45_A	209.8	25_C	517.2	55_A	261.3
89_A	0.1	55_B	0.127	55_A	0.152	41_B_D	0.585	49_A	0.658	52_B	0.492	55_A	193.5	49_B	517.2	70_A_D	228.2
72_A	0.098	68_A	0.123	20_A	0.148	41_B	0.568	69_A_D	0.626	25_C_D	0.477	89_A	193.5	73_A	517.2	45_A	224.7
68_B	0.09	69_A_D	0.123	22_A	0.148	41_C	0.559	55_A1	0.604	89_A	0.462	55_B	172.3	27_A	461.1	70_A	191.8
68_A	0.084	68_B	0.117	55_A1	0.145	49_C	0.55	20_B	0.539	49_D	0.452	27_B	166.9	70_C	435.2	89_A	172.3
92_B	0.084	69_A	0.117	69_C	0.145	92_A	0.549	25_C	0.511	72_B	0.452	45_B	160.7	25_A_D	410.6	25_B	156.5
22_A	0.082	69_C	0.115	25_C	0.141	89_A	0.531	69_C_D	0.49	41_D	0.45	68_B	160.7	52_B	387.3	89_C	152.9
22_B_D	0.08	72_C	0.111	73_A	0.141	27_C	0.519	69_C	0.474	52_A	0.444	92_A	104.3	69_A	387.3	27_A	150
72_C	0.08	68_A_D	0.107	27_B	0.135	22_A	0.492	68_A_D	0.47	27_A	0.44	69_A	90.7	69_C	387.3	22_B_D	141.4
27_E	0.076	69_B	0.106	69_B	0.135	49_B	0.483	68_A	0.462	72_A_D	0.435	27_A	78.9	73_B	387.3	72_A_D	141.4
22_B	0.074	73_A	0.106	45_A	0.125	73_B	0.468	41_E	0.458	68_A	0.434	52_A_D	70.3	55_A	325.5	20_A	140.1
89_C	0.072	27_E	0.086	29_A	0.121	27_A	0.333	22_B	0.444	89_C	0.43	49_A	68.9	68_B	325.5	55_A1	137.4
55_B	0.068	92_B	0.084	89_A	0.121	52_B	0.213	29_A_D	0.435	45_A	0.427	49_C	64.5	69_B	325.5	52_A	131.3
70_C	0.068	55_A1	0.076	73_B	0.117	25_B	0.201	49_B	0.412	25_A	0.42	92_B	56.5	69_C_D	290.9	72_A	131.3
20_B	0.063	45_B	0.072	49_D	0.115	52_A	0.194	22_A	0.409	27_E	0.418	52_A	54.6	29_A_D	275.5	72_B	131.3
25_A	0.063	25_C_D	0.068	72_A_D	0.109	55_A	0.194	27_A	0.392	25_C	0.413	69_B	52.1	55_A1	272.3	27_D	127.4
55_A1	0.063	45_A	0.063	25_A	0.107	55_B	0.192	27_D	0.268	22_A	0.403	70_B	51.2	69_A_D	228.2	20_B	123.6
25_B	0.061	22_A	0.061	27_A	0.107	45_A	0.187	27_E	0.261	41_C	0.4	70_A	43.7	41_D	222.4	22_A	117.8
41_D	0.061	27_D	0.059	25_B	0.106	25_A	0.183	55_A	0.2	70_A	0.386	55_A1	39.9	72_A	201.4	92_B	116.9
45_A	0.059	25_A_D	0.055	70_B	0.1	27_E	0.183	20_A	0.179	22_B	0.381	70_A_D	37.3	41_B	186.0	29_A	114.5
29_A	0.055	49_B	0.055	68_A	0.098	45_B	0.181	73_A	0.178	49_C	0.38	69_C	35.9	68_A	172.3	52_B	108.1
73_A	0.055	89_A	0.053	92_B	0.092	25_C	0.178	55_B	0.151	69_C	0.379	70_C	35	55_B	167.4	27_E	107.1
41_C	0.053	20_B	0.049	27_D	0.08	27_D	0.173	45_A	0.123	27_B	0.359	68_A	26.5	68_A_D	156.5	70_C	101.7
70_A_D	0.053	25_C	0.049	89_C	0.08	55_A1	0.149	89_C	0.121	27_C	0.309	41_D	24.9	20_A	127.4	22_B	101.2
52_A	0.051	29_A_D	0.049	45_B	0.078	52_A_D	0.148	72_C	0.113	45_B	0.181	25_B	23.8	27_C	113.7	49_D	96
55_A	0.051	72_A	0.047	49_C	0.074	20_A	0.144	72_A	0.112	27_D	0.175	27_E	21.8	92_A	111.2	41_D	95.9
45_B	0.049	20_A	0.043	70_A	0.07	92_B	0.143	92_A	0.097	55_A1	0.174	29_A	20.1	92_B	95.9	25_A	80.9
73_B	0.049	27_A	0.041	72_A	0.07	22_B_D	0.129	25_C_D	0.09	20_A	0.173	25_A	18.9	20_B	93.3	25_C_D	78
52_A_D	0.045	92_A	0.039	27_E	0.066	70_B	0.124	92_B	0.074	92_B	0.171	27_D	18.1	89_C	91.0	70_B	71.7
27_A	0.033	25_B	0.037	27_C	0.055	72_C	0.108	89_A	0.067	20_B	0.16	25_C	14.8	45_A	70.3	25_C	66.3
27_C1	0.021	22_B_D	0.035	25_C_D	0.051	69_C	0.09	68_B	0.054	22_B_D	0.15	22_B_D	12.1	45_B	65.0	27_C	32.3
70_B	0.017	29_A	0.033	92_A	0.047	70_A_D	0.067	25_A	0.05	92_A	0.144	22_B	12	49_C	58.1	41_C	15.8
25_C		89_C	0.027	70_A_D	0.045	70_A	0.066	25_A_D	0.048	25_B	0.143	20_B	10.9	89_A	56.4	27_B	13.2
27_D		25_A	0.025	52_A	0.035	70_C	0.065	41_D	0.043	70_B	0.128	22_A	8.5	25_B	54.6	25_A_D	
52_B		27_B	0.025	41_C		27_C1	0.047	41_C	0.041	70_A_D	0.109	41_C		22_B_D	28.5	29_A_D	
70_A		41_D	0.025	25_A_D		41_A	0	27_B	0.035	41_A	0	55_C		22_A	24.9	41_A	
25_A_D		22_B	0.023	27_C1		25_A_D		25_B	0.028	25_A_D		25_A_D		22_B	24.0	41_C_D	
25_C_D		41_C		29_A_D		25_C_D		22_B_D	0.024	27_C1		25_C_D		27_B	16.0	41_E	

Table A3. Summary of phosphorus, nitrogen and E. coli data at subwatershed sample points from the 2014 study, ranked by decreasing concentration for each sampling period.
TMDL exceedances are highlighted in red, and values within 20% of TMDLs are highlighted in yellow.

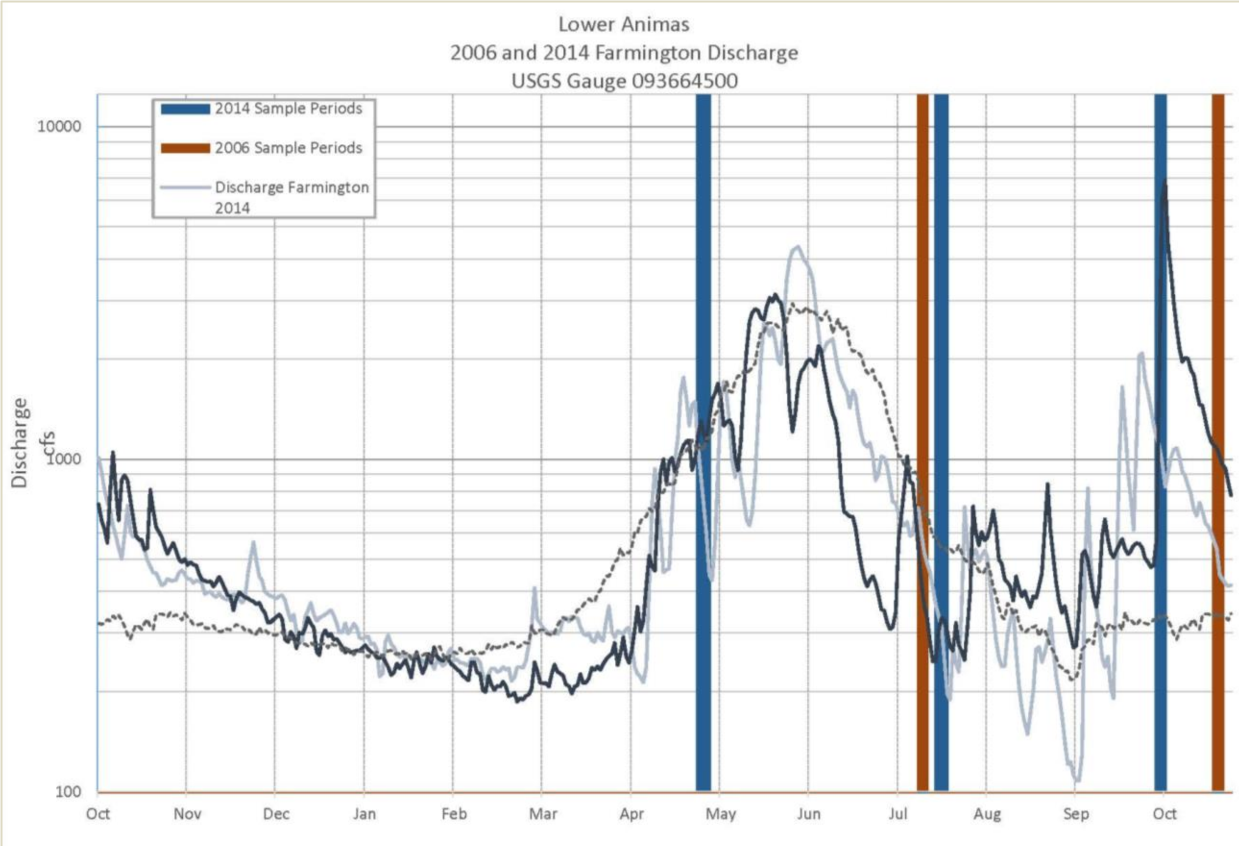


Figure A1 – Animas River discharge and sampling comparison between 2006 and 2014.

Dotted line shows median annual discharge at the USGS gaging station, solid line shows 2006 discharge.

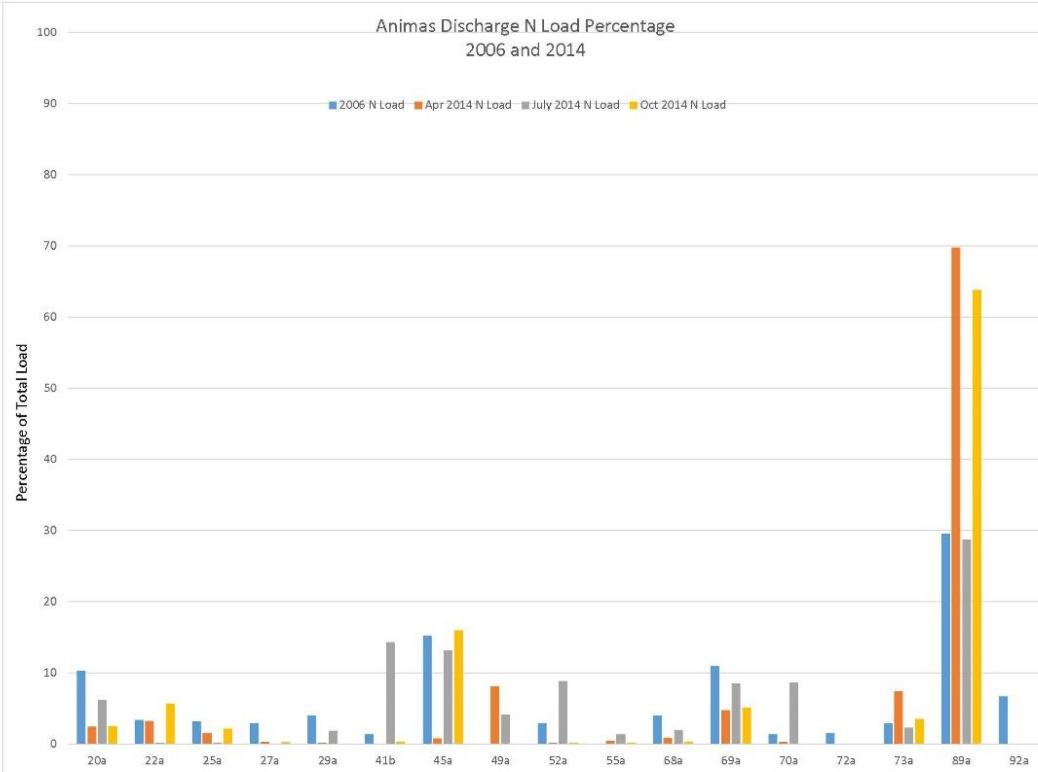


Figure A2 – Total Nitrogen load per inflow to the Animas River, 2006 and 2014.

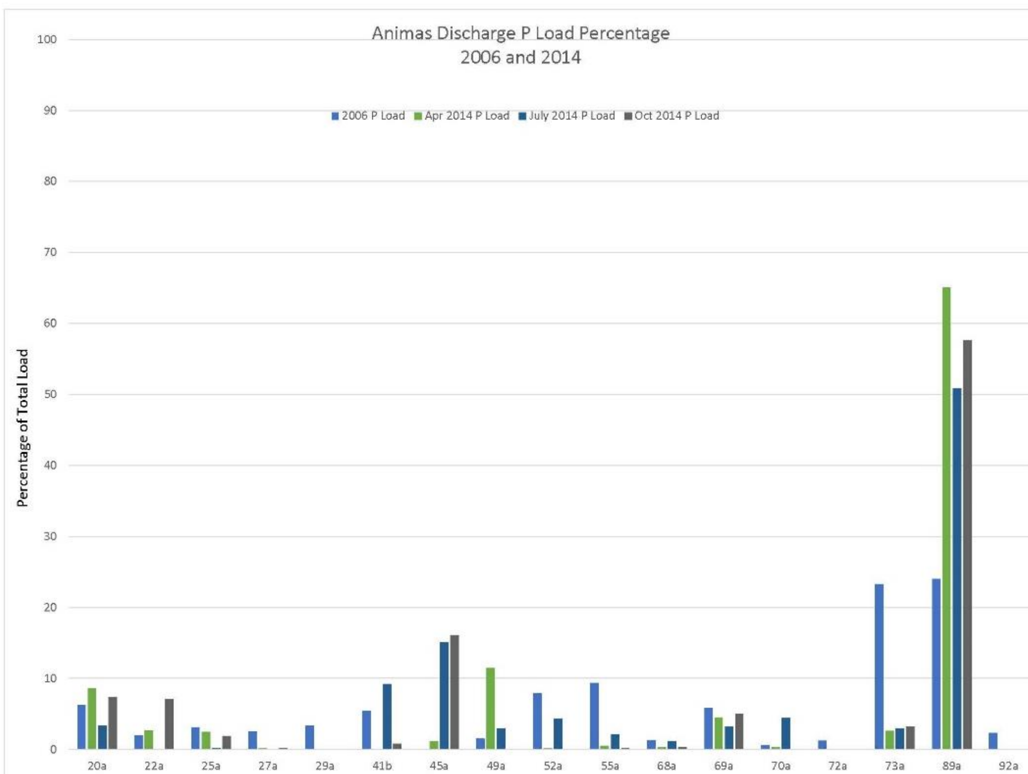


Figure A3 – Total Phosphorus load per inflow to the Animas River, 2006 and 2014.

Conclusions

While the results of the 2014 sampling did not reveal specific bacteria and nutrient load contributors, these data are relevant to the evaluation of the health of the Animas River as a system. The data reinforce the need to apply a variety of BMPs across the entire watershed to attain meaningful reductions, as outlined in the watershed based plan. This holistic approach may support greater flexibility in the types and implementation methods of BMPs used (as opposed to singling out one land use type or user). The approach may also provide greater potential for community and landowner engagement.

Due to the limitations of the present data and analyses, the project team makes the following recommendations to assess continued impairments to the Lower Animas as well as potential improvements associated with implemented BMPs as defined in the watershed based plan.

- Develop methods and protocols to capture monsoon and storm events that bring sediment, and potential bacteria and nutrients, from the uplands into the Animas. Continue monitoring Kiffen Creek and Cox Canyon due to the size of their watersheds, the energy extraction that causes surface disturbance in those watersheds, and the high potential for loading due to the dominant soil types in those watersheds.

- Develop better methods to capture and monitor storm flow from urban areas. Several of the inflows highlighted for high load in the 2006 study were not flowing in 2014, notably point 89 in Farmington. Like the uplands, the urban areas along the Lower Animas River only flush during monsoon or storm events.

- Continue monitoring inflows to the main stem of the Animas, defined by the 2006 study and sampled in 2014.

- Monitor each ditch system to determine better focus areas for BMPs, or define BMPs related to each ditch.

- Since each major ditch crosses between one and two 12-digit HUC boundaries, it is recommended that a ditch-based approach to monitoring be conducted, i.e. sequentially determining sampling locations along the entirety of a ditch to tease out pollutant contributions. Alternately, sample from each inflow to a ditch that might contribute pollutants to the main stem of the Animas, similar to the 2006 Animas River Nutrient Study.

- Map minor ditches and field drains within the subwatersheds (defined by the 2006 inflows) to determine local hydrology.

- Complete a full survey of bank erosion on the main stem of the Animas. This was conducted in 2006 but not in 2014. As defined in the watershed based plan, one of the most effective BMPs, in terms of cost and mitigation, is streambank stabilization. Anecdotally, it was observed during 2014 sampling that streambank erosion had increased since 2006.

- Determine methods to effectively sample the potential contributions to loading of septic systems due to the prevalence of high density septic systems along the Animas. Revisiting a periphyton study, refining methods focused on optical brighteners, or a targeted version of the microbial source tracking study could help determine septic system impacts.
- Complete the analysis of periphyton data from 2014 and compare with 2006 and 2010 collections.
- Further analyze 2006 data alongside 2014 data. 2014 Lower Animas data should also be compared with the data gathered in the 2013-14 microbial source tracking study. Finally, a broader analysis of bacteria and nutrient data from any past or future sampling from the Lower Animas should be compared to data from the Upper Animas (upstream of the Florida River confluence), and that data collection should ideally be coordinated between the Animas Watershed Partnership in Colorado and the San Juan Watershed Group in New Mexico, to facilitate consistency in the timing of sampling as well as the methods used.

The 2014 Lower Animas sampling project team supports the watershed based plan for the Lower Animas River, as well as continued monitoring to provide insight into the implementation of BMPs and management decisions that will contribute to the improvement of the overall health of the Animas River.

Appendix C. Costs and Descriptions of Specific Stormwater BMPs

The following Stormwater Management Measures are discussed generally, as background for the more specific project recommendations that follow. The benefit of stormwater BMPs is that they are applicable across most land uses, from urban to agricultural to upland forest and oil and gas areas.

Filter Strips & Vegetated Swales

A filter strip is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach a water body, drainage ditch, or tailwater ditch (Tetra Tech 2011) Two similar practices (which are more commonly used in wetter climates) are the vegetated swale and vegetated waterway. From the STEPL BMP Definition Manual: "Grass swales are elongated depressions in the land surface that are at least seasonally wet, usually heavily vegetated, and normally without flowing water. Swales direct storm water flows into primary drainage channels and allow some of the storm water to infiltrate into the ground surface. Swales are vegetated with erosion resistant, and flood tolerant grasses. A grassed waterway is a natural or constructed channel that is shaped or graded and planted with suitable vegetation for the stable conveyance of runoff without causing erosion to the channel (Tetra Tech 2011)."

While the arid climate of New Mexico and flashy nature of arroyos may make implementation of these practices impractical under some scenarios, the general principles can be used for a very efficient pollution reduction tool – STEPL estimates that a filter strip can remove pollutants with 70% efficiency.

Filter strips can be planted at the downslope edge of agricultural fields, along road right-of-ways, in city parks and golf courses, on the edge of parking lots, and alongside any flowing water course including drainage ditches, irrigation ditches, arroyos, and the river itself. For ephemeral and intermittent water courses, the grass swale or grassed waterway model may be more appropriate.

In general, areas on *any land use* that can be revegetated in native grasses for as much of the year as possible, but especially from monsoon season into the winter, will have a positive effect on water quality. Replacing bare ground with native grasses has numerous benefits: increasing water holding capacity and infiltration, reducing stormwater volume and intensity, filtering storm runoff, increasing soil organic matter, and improving competition with invasive weeds, among others.

Dry Detention Basins

A detention basin is a low area designed to collect and temporarily hold stormwater runoff so that sediment and pollutants can settle instead of draining to water bodies (EPA 2000; Tetra Tech 2011). Detention basins, if properly designed, constructed, and maintained, are very effective at capturing sediment and reducing high stormwater flows that can cause erosion of stream banks.

Dry detention basins have a moderate sediment reduction potential, but a lower nutrient reduction potential. They may be effective at capturing nutrients and bacteria that are sorbed to sediments however, including *E.coli*, TP and TKN.

Brown and Schueler (1997) present the construction cost of a detention pond as follows (e.g., $41,600 for a one acre-foot pond):

$$C = 12.4\, V^{0.76}$$

where C = Construction, design, and permitting cost, and
V = Volume (ft³) needed to control a 10-year storm.

Periodic dredging and maintenance costs would be in addition to the initial construction costs listed above.

Infiltration Basin

An infiltration basin is a shallow impoundment designed to capture stormwater so that it slowly infiltrates into the soil (EPA 2000). Infiltration basins differ from dry detention basins in that dry detention basins slowly discharge to a downstream water body whereas infiltration basins do not have an outlet. Infiltration basins are ideal for arid settings since they contribute to groundwater recharge, perennial flow, and flood peak attenuation: Stormwaters that would otherwise charge straight into the river instead drain through shallow soils over a period of several hours or days.

Infiltration basins have a moderate load reduction potential, and require regular maintenance, though generally require less than detention basins. In both instances, care should be taken to work with the Office of the State Engineer to ensure state water law governing impoundments is not violated.

The construction cost of infiltration basins has been estimated at $2 per ft^3 (SWRPC 1991).

Appendix D. QAPP for Lower Animas Targeted Sampling

See attached Appendices document.

Appendix E. QAPP for 2014 bacteria and nutrient study

See attached Appendices document.