



The Paso del Norte Watershed Based Plan

Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande

The Paso del Norte Watershed Based Plan

Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande

This report was prepared by the Paso del Norte Watershed Council with funding from the U.S. Environmental Protection Agency through the New Mexico Environment Department under the authority of the Clean Water Act Section 319(h) Nonpoint Source grant program.
The New Mexico Department of Agriculture served as fiscal agent for the grant.

Acknowledgements

The Paso del Norte Watershed Council (Council) is an alliance of private citizens, non-governmental organizations, representatives of federal and state agencies, water utilities, municipal governments, and universities that partner and provide an integrated vision for watershed management in the Paso del Norte watershed region. The Council provides an open and inclusive forum for communication, collaboration, and innovative thinking concerning watershed issues for the benefit of agricultural, environmental, and municipal interests.

Creating *The Paso del Norte Watershed Based Plan – Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande* required a collaborative effort by many talented individuals. The Council would like to thank the following for their time, services, and dedication to this project:

- Brian Hanson, 319(h) project Watershed Coordinator
- Dr. Conrad Keyes, Jr., Council chair and consultant to the U.S. Army Corps of Engineers
- Dr. Ari Michelsen, Professor and Resident Director, Texas A&M AgriLife Research & Extension Center
- Chris Canavan, New Mexico Environment Department (NMED)
- Julie Maitland, Hilary Brinegar (Council co-chair), Les Owen, Patricia Depner, Sumer Guffey, Yvonne Alexander, and Pamela Huerta of New Mexico Department of Agriculture (NMDA)
- Board of Directors of the Elephant Butte Irrigation District (EBID) and Gary Esslinger, Valerie Beversdorf, James Narvaez, and Patrick Lopez
- Dr. Phil King and Dr. Geof Smith of New Mexico State University
- Paul Michaud, Senior Planner, City of Las Cruces
- Peter Bennett, Public Works Department, City of Las Cruces
- Elizabeth Verdecchia, Rebecca LittleOwl, and Gilbert Anaya of U.S. Section International Boundary and Water Commission
- Gil Sorg, Councilor District 5, City of Las Cruces
- Ray Lister, Cory Durr, U.S. Bureau of Land Management
- Staff at the Mesilla Park Recreation Center (Frank O'Brien Papen Recreation Center)
- The 319(h) Stakeholder Working Group:

Jan Kirwan, New Mexico State Parks
Valerie Beversdorf, EBID
James Narvaez, EBID
Fernando Cadena, EBID
Bill Quiñones, Quiñones Design Builds
Les Finley, City of Las Cruces
Tom Mobley, Rancher
Cory Durr, Bureau of Land Management
Angela Roberson, Doña Ana County
John Gwynne, Doña Ana County Flood Commission
Joe Gonzales, Gonzales Dairy and the Doña Ana SWCD

Many individuals contributed and participated in the making of this document and may not be listed. Their efforts are greatly appreciated.

Table of Contents

Table of Contents

Table of Contents

List of Figures

Table of Contents

List of Tables

Executive Summary

According to the U.S. Environmental Protection Agency, nonpoint source (NPS) pollution is the leading cause of water quality degradation in the United States and poses a substantial problem for the health of New Mexico's streams and rivers. NPS pollution is caused by diffuse contaminants, and coordinated efforts are needed for remediation. In 1987 the U.S. Congress recognized that state and local water authorities were in need of financial resources and created the 319(h) grant amendment to the Clean Water Act (CWA). The CWA does not regulate NPS pollution; rather, it encourages a stakeholder-driven approach and provides financial resources through 319(h) grant funding to develop a Watershed Based Plan (WBP) to reduce pollutant loading. A watershed based planning approach focuses on geographic boundaries defined by drainage basins instead of political or jurisdictional boundaries. This provides a flexible, coordinated framework to focus public and private efforts on problems within specific basins.

The guiding principles for creating a WBP are stakeholder partnerships, a geographic focus, and sound science. Over the years, successful 319(h) projects have demonstrated the positive effects of involving stakeholders in watershed management decisions by generating sustainable levels of long-term support. A good WBP establishes a framework for protecting and restoring watershed health and water quality. This document presents *The Paso del Norte Watershed Based Plan – Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande.* The watershed area is a subunit of the El Paso-Las Cruces Watershed United (USGS HUC 13030102) of the northern Chihuahuan Desert and is located in Sierra and Doña Ana counties in south central New Mexico. It extends from Caballo Reservoir, a main stem impoundment of the Rio Grande, to the New Mexico-Texas-Mexico boundary adjacent to the cities of Sunland Park, New Mexico; El Paso, Texas; and Ciudad Juarez, Mexico (approximately 105 river miles). This reach of the Rio Grande is entirely regulated for irrigation purposes under the Rio Grande Project which was authorized by the Secretary of the Interior on December 2, 1905, under the provisions of the Reclamation Act. The New Mexico portion of the Rio Grande Project includes Elephant Butte and Caballo Dams, three diversion dams, about 350 miles of agricultural drains, and about 300 miles of canals and laterals that provide irrigation water for over 4,000 farms consisting of 90,640 water-righted acres, of which about 70,000 acres are irrigated in a given year.

Based on data collected by the U.S. International Boundary and Water Commission, and additional data submitted by other entities, the Rio Grande from one mile downstream of Percha Dam to the international boundary with Mexico was listed as impaired for fecal coliform in the *2004-2006 State of New Mexico Integrated CWA §303(d) §305(b) Report*. Also in 2004, the New Mexico Environment Department (NMED) conducted an intensive water quality survey, which documented an exceedance of the New Mexico Water Quality Standards for *Escherichia coli* (*E. coli*) in the Rio Grande from one mile downstream of Percha dam to the international boundary with Mexico. As a result, the listing was changed from fecal coliform to *E. coli* in 2006. Subsequently, the cause of impairment was identified as *E. coli* bacteria and a TMDL was calculated for the main stem of the Rio Grande below Elephant Butte Dam. The resulting document, *Total Maximum Daily Load (TMDL) for the Main Stem of the Lower Rio Grande (from The International Boundary with Mexico to Elephant Butte Dam)* was completed 2007.

To determine the sources of *E. coli* in the watershed, a review of past data collection efforts was conducted followed by an intensive water quality survey that included opportunistic stormwater sampling, periodic sampling of agricultural drains, and routine (monthly) sampling of the Rio Grande at select locations. In addition, once "hotspots" were identified, a small bacterial source tracking study was conducted. The following conclusions were made as a result:

- The *E. coli* exceedance in the reach above Leasburg Cable is primarily related to stormwater runoff.
- The *E. coli* exceedance in the reach from Anthony to the international boundary with Mexico is primarily

related to non-stormwater flows.

- The drains on the east bank of the Rio Grande contain high levels of *E. coli* and may be a significant source of *E. coli* in the lower watershed.
- Two wastewater treatment plants (WWTPs) may be a source of *E. coli* in the bottom of the watershed.

Pollutant loading estimates for specific sources of *E. coli* were determined by several methods. Actual estimated daily loads for Sunland Park and South Central Regional WWTPs were calculated from direct measurements collected from the facility outfalls during survey conducted by NMED in 2011. Daily loads were estimated for cattle, sewage, pet, and horse sources in the East Drain as well as horse sources in Montoya Drain.

Targeted management measures to mitigate *E. coli* pollution were developed for the "hotspots" that were identified from the Anthony 225 Bridge in New Mexico to Courchesne Bridge in El Paso, Texas. Management measures were chosen to target specific areas of concern that were identified as chronic sources of *E. coli* loading. These include recommendations for facility upgrades at the Sunland Park and South Central Regional WWTPs, constructed wetlands, and dairy waste management in the form of a manure digester. General management measures are also recommended and include detention basins, main stem restoration projects, sub-watershed restoration projects, domestic pet waste management, liquid waste management, Green Infrastructure/Low Impact Development, and continued development of a regional strategy.

The Paso del Norte Watershed Based Plan – Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande also includes an Outreach Program; a discussion of technical and financial assistance needs; an implementation schedule that includes measurable milestones; a set of evaluation criteria to determine if the plan is working, and a monitoring plan to determine if mitigation measures are effective.

Chapter 1 INTRODUCTION

According to the U.S. Environmental Protection Agency (USEPA), nonpoint source (NPS) pollution is the leading cause of water quality degradation in the United States and poses a substantial problem for the health of New Mexico's streams and rivers. NPS pollution is caused by diffuse contaminants, and coordinated efforts are needed for remediation. In 1987 the U.S. Congress recognized that state and local water authorities were in need of financial resources to develop and implement measures to control NPS pollution. In order to meet these needs, the U.S. Congress created the 319(h) grant amendment to the Clean Water Act (CWA). The CWA does not regulate NPS pollution; rather, it encourages a stakeholder driven approach and provides financial resources through 319(h) grant funding to develop a watershed based plan (WBP) to identify causes and sources of impairment and recommend best management practices (BMPs) to reduce pollutant loading. A WBP approach focuses on geographic boundaries defined by drainage basins instead of political or jurisdictional boundaries. This approach provides a flexible, coordinated framework to focus public and private efforts on problems within specific basins.

Watershed Planning Process

The guiding principles for creating a WBP are stakeholder partnerships, a geographic focus, and sound science. Over the years, successful 319(h) projects have demonstrated the positive effects of involving stakeholders in watershed management decisions by generating sustainable levels of long-term support. A good WBP establishes a framework for protecting and restoring watershed health and water quality.

A watershed approach is effective due to the integration of the wide variety of issues between land use, climate, hydrology, drainage, and vegetation within a watershed basin. General components of a watershed include landscape condition, species habitat, hydrology, geomorphology, water quality, and biological integrity (USEPA, 2012). A WBP provides a non-regulatory, stakeholder driven, voluntary approach to addressing NPS pollutant impacts to water quality within a designated watershed. This WBP is not based on legal obligations; it is a general blueprint for a comprehensive, watershed-wide restoration program. A WBP consists of nine key criteria (USEPA, 2008):

1. Identification of the causes and sources of NPS water pollution that will need to be controlled.
2. An estimation of load reductions expected from the management measures used to achieve water quality goals.
3. A description of the management measures that will need to be implemented to achieve pollution load reductions, i.e. implementation of pollution control and natural resource protection measures.
4. Technical and funding needs to support the implementation and maintenance of restoration measures.
5. A public outreach method(s) and structure that will be used to engage and maintain public and governmental involvement including local, state, federal, and tribal governments.
6. A schedule for implementation of needed restoration measures and identification of appropriate lead agencies to oversee implementation, maintenance, monitoring, and evaluation.
7. A description of interim, measurable milestones for the actions to be taken and desired water quality goals and outcomes.
8. A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made toward achieving water quality standards.
9. Any monitoring and evaluation activities needed to refine the problems or assess progress towards achieving water quality goals.

New Mexico Water Quality Standards

Under the CWA and the New Mexico Water Quality Act, New Mexico is required to adopt water quality standards. New Mexico's water quality standards *(Standards for Interstate and Intrastate Surface Waters, New Mexico Water Quality Control Commission,* 20.6.4 NMAC, November 20, 2012*)* are written for three general categories: general criteria, designated use criteria, and segment specific criteria. The general criteria apply to all surface waters of the state unless a specified criterion is provided under the designated use criteria or the segment specific criteria.

The designated use criteria were developed to ensure that designated uses can be maintained. These uses include, but are not limited to, domestic water supply, irrigation, livestock watering, aquatic life, and wildlife habitat. Under the segment specific criteria, water bodies are divided into specific segments based upon the physical and chemical characteristics as well as designated uses of that segment. Determination of whether designated uses are being maintained is conducted by intensive water quality surveys performed by the Surface Water Quality Bureau (SWQB) of the New Mexico Environment Department (NMED).

Total Maximum Daily Load

Stream segments that do not meet water quality standards for diffuse pollutants must have a Total Maximum Daily Load (TMDL) calculated. A TMDL is the maximum amount of any given pollutant that a waterbody can assimilate (i.e. the loading capacity) without violating a state's water quality standards. A TMDL is calculated as the sum of the individual waste load allocations for point sources, the load allocation for nonpoint sources, and natural background conditions. A TMDL is a nonregulatory document describing a budget for pollutant influx to a specific waterbody. The USEPA defines a TMDL document as "a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standards, including consideration of existing pollutant loads, and reasonably foreseeable increases in pollutant loads."

Impairment of Concern in the Lower Rio Grande of New Mexico

Based on data collected by the U.S. International Boundary and Water Commission (USIBWC), and additional data submitted by other entities, the Rio Grande from one mile downstream of Percha Dam to the international boundary with Mexico was listed as impaired for fecal coliform in the state of *New Mexico CWA §303(d) Integrated List of Assessed Surface Waters* in 2004. That same year, NMED conducted an intensive water quality survey which documented an exceedance of the New Mexico Water Quality Standards for the coliform bacteria *Escherichia coli* (*E. coli*) in the Rio Grande one mile downstream of Percha dam to the international boundary with Mexico. As a result, the listing was changed from fecal coliform to *E. coli* in 2006. Subsequently, a TMDL was calculated for the main stem of the Rio Grande in New Mexico below Elephant Butte Dam. The resulting document, *Total Maximum Daily Load (TMDL) for the Main Stem of the Lower Rio Grande (from The International Boundary with Mexico to Elephant Butte Dam)* was completed in 2007.

Significance of the *E. coli* Water Quality Impairment

E. coli bacteria are commonly found in the digestive tract of warm blooded animals, including humans. Most strains of *E. coli* are not harmful to humans and can be beneficial to the digestive tract by preventing the establishment of some pathogenic bacteria and aiding in the production of vitamin K. However, *E. coli* 0157 is a toxic strain and has been implicated in several food borne illness outbreaks in the U.S. in recent years involving fresh vegetables.

E. coli enters the environment via excretion in feces, which can then be transported to surface waters. More toxic pathogens such as those associated with typhoid, hepatitis, cholera, and dysentery also inhabit the gut of warm blooded animals and may also be present in feces. Since *E. coli* is generally known to have a relatively short lifespan in water and is relatively easy and inexpensive to analyze, it is utilized by the USEPA as an indicator of recent fecal contamination of water. Therefore, the presence of *E. coli* confirms recent fecal contamination of surface waters and indicates the possible presence of other more toxic pathogens, which are more difficult and expensive to test. As a result, water quality standards are developed for *E. coli* to determine fecal contamination. The New Mexico Water Quality Standard for *E. coli* in the El Paso-Las Cruces Watershed is 410 coliform forming units per 100 mL (cfu/100 mL) in a single sample while for multiple samples a monthly geometric mean of 126 cfu/100 mL is used (20.6.4 NMAC 2012).

Exposure to *E. coli* from contaminated water has two primary pathways: direct ingestion of water and ingestion of uncooked food products that have been in contact with contaminated water. Untreated surface waters are not utilized for drinking in southern New Mexico, but accidental ingestion of water could occur while swimming or playing in the river. However, the Lower Rio Grande Valley of southern New Mexico produces a variety of foods that may be consumed fresh without cooking including lettuce, onions, tomatoes, jalapeños, melons, and squash. It should be noted that there has not been a documented case of waterborne illness due to ingestion of Rio Grande water from swimming or a documented case of foodborne illness from any food product grown in the Lower Rio Grande Valley of New Mexico resulting from exposure to irrigation water.

Fate of *E. coli* in the Environment

As mentioned above, it is generally accepted that *E. coli* dies off rapidly in the water column and is used as an indicator for recent fecal contamination. However, research has found that *E. coli* commonly inhabits tropical stream bank soils in Hawaii (Hardina and Fujioka 1991) and Guam (Fujikoa 1999). The presence of naturally occurring *E. coli* strains in temperate Minnesotan soils has also been documented (Ishii et al. 2006) as was their ability to overwinter and grow in the soil. The source of these naturalized *E. coli* populations remains unclear. Long-term survival of cow manure-borne *E. coli* in freshwater sediments has also been reported, although die-off was accelerated in the water column following resuspension from sediment (Garzio-Hadzick et al. 2010). There have also been documented reports of *E. coli* contamination resulting from airborne dispersion (Varma et al. 2003) and airborne bacteria associated with cattle feedlots (Wilson et al. 2002).

These studies have several important implications. Aquatic environments with high organic matter and nutrient content can harbor significant numbers of *E. coli* in their sediments. Periodic influx of manure-borne *E. coli* may accumulate in sediments forming a reservoir of *E. coli* that can be resuspended into the water column during scouring rain events or other sediment disturbing events. If adequate nutrients are present and other growth conditions are met, it is conceivable that the numbers of *E. coli* could be maintained or even multiplied in the water column. Airborne dispersal may also be a potential source to aquatic environments in close proximity to large feedlot operations.

The above discussion is significant because the persistence of *E. coli* in the environment may falsely indicate recent fecal contamination and may contribute to elevated colony counts indicating sizable loading of fecal contamination.

Geographic and Geologic Location of the Project Area

The watershed area is the portion of the Rio Grande basin from Caballo Reservoir (a main stem impoundment of the Rio Grande) to the New Mexico-Texas-Mexico boundary adjacent to the cities of Sunland Park, New Mexico,; El Paso, Texas and Ciudad Juarez, Mexico; approximately 35 miles south of Las Cruces (Figure 1). The area is a sub unit of the El Paso-Las Cruces Watershed (USGS HUC 13030102) of the northern Chihuahuan Desert and is located in Sierra and Doña Ana counties of south-central New Mexico. The watershed is comprised of 64 sixth level sub-watersheds (12 digit HUCs). The eastern edge of the watershed is bordered by the Caballo, Doña Ana, Organ, and Franklin mountain ranges. The western edge of the watershed is bordered by the Mimbres Mountains of the southern Black Range, the Sierra de las Uvas, the Robledo Mountains, and fault block volcanic uplands extending south to the East Potrillo Mountains (Hawley 2004).

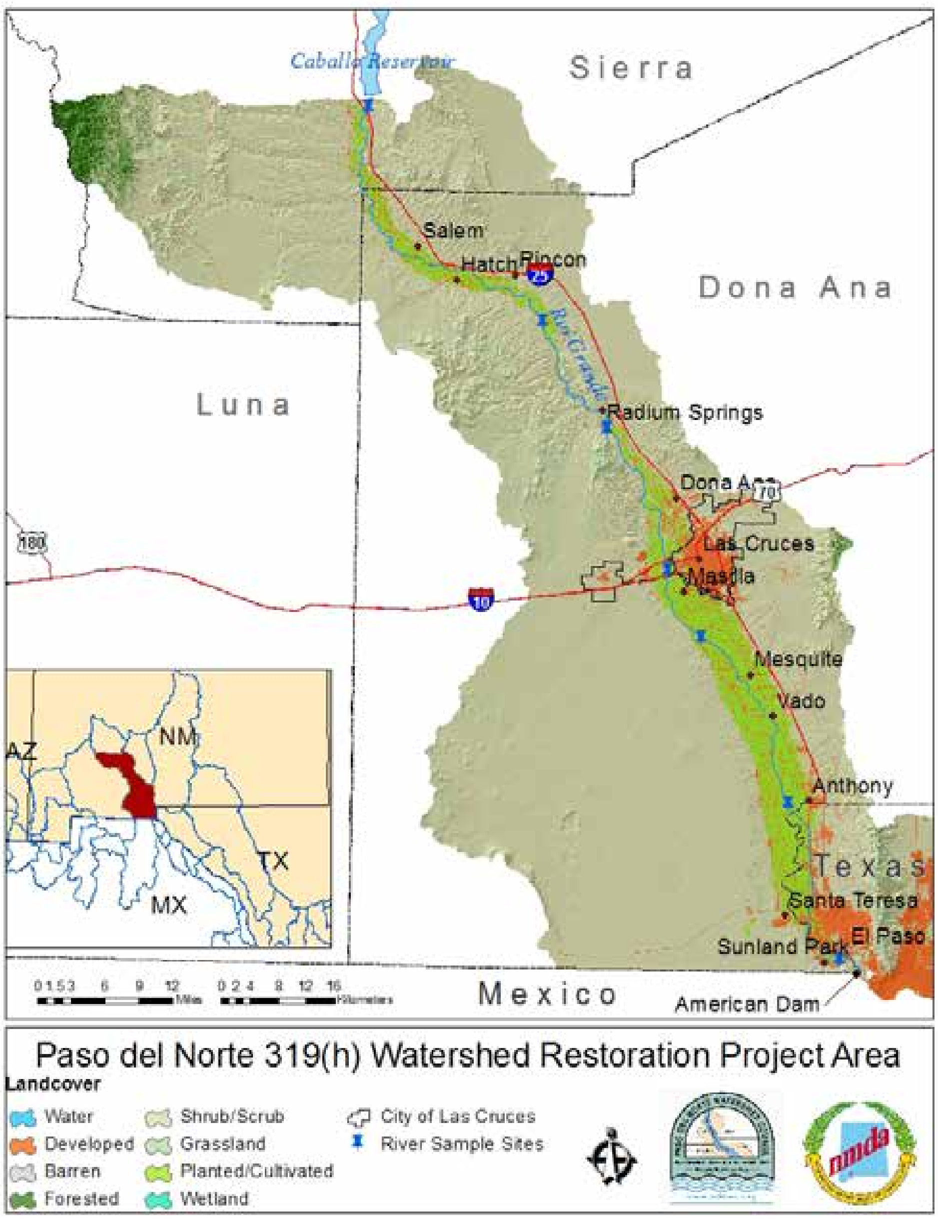


Figure 1: Paso del Norte 319(h) Watershed Restoration Project Area.

Climate in the Project Area

At the center of the watershed, Las Cruces, New Mexico, receives an average annual precipitation of 248 mm (9.76 in) as recorded at the New Mexico Climate Center at New Mexico State University. This is primarily in the form of rainfall, almost half of which (129 mm, 2.93 in.) falls during the summer thunderstorm season from July through September (Figure 2).

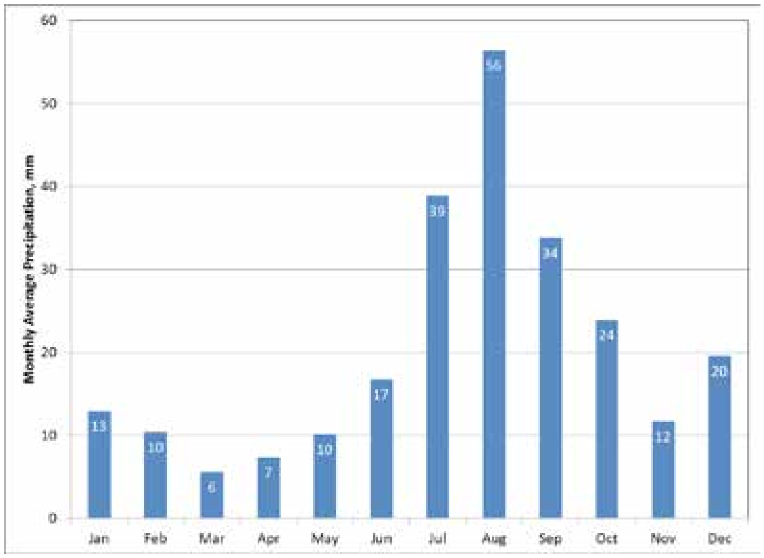


Figure 2: Average monthly precipitation recorded at the Climate Center, New Mexico State University, Las Cruces, N.M. 1981-2010.

The average annual maximum temperature is 25.6° C (78.1° F) with extended periods above 37.8° C (100° F) common in June and July. The average minimum temperature is 8.27° C (46.9° F). The coldest months are January and December with an average minimum temperature of -1.6° C (29.1° F) (Figure 3).

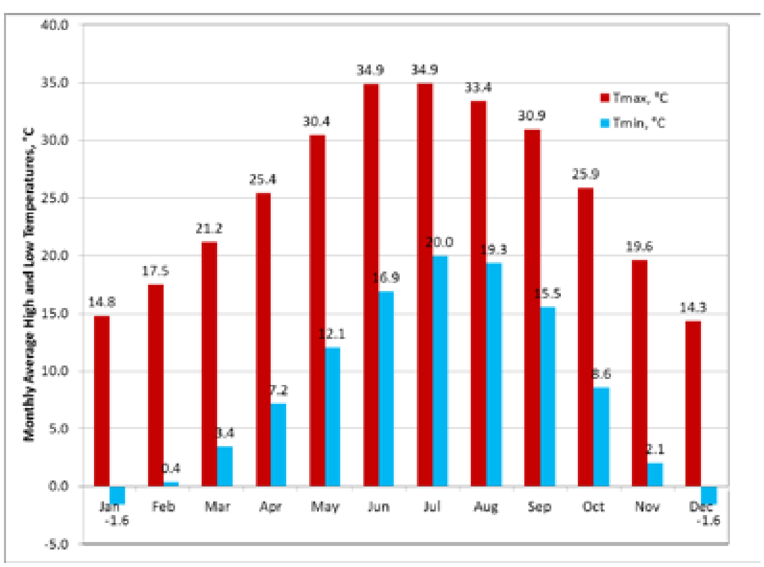


Figure 3: Average monthly daily high and low temperatures recorded at the Climate Center, New Mexico State University, Las Cruces, N.M 1981-2010.

Historical Description of the Rio Grande in the Project Area

Historically, the Rio Grande in the project area had a fairly wide floodplain with a sinuous and sometimes braided, meandering channel with small oxbows, sloughs, ciénegas, marshes, and other associated riparian features (Stotz 2002). A map prepared by John Pope in 1854 shows 25 meanders in the stretch of the Rio Grande from just above Doña Ana to Fort Fillmore a few miles south of Mesilla (Ackerly 1992). The map also depicts dual channels with small islands on many of the meander bends. Maps prepared for the U.S. Government Land Office (GLO) from the mid to late 1800's outlining the acequia system of the Mesilla Valley also depict a meandering channel and identify several sloughs and a lagoon (Ackerly 1992). Diego Pérez de Luxan, a member of the Espejo expedition of 1582-1583, described pools and marshes including associated wetland vegetation along the Rio Grande in both the Mesilla and Palomas valleys (Luxan 1929). There are numerous similar accounts which include descriptions of elevated salinity in many of these areas. A U.S. government survey in 1857 described incrustations of salt and alkali on soils in the bottom lands around present day Sunland Park and Mesquite, NM.

The river channel was constantly evolving and changing location depending on the flow patterns which shifted from low flows during drought periods to catastrophic floods that realigned the channel. The high sediment load of the Rio Grande in southern New Mexico led to the formation of point bars, sand bars, islands, and plugging of the channel which often forced the river to find a new path. The effects of the sediment load were felt during both high and low flows. The United States Bureau of Reclamation (USBR) mapped the various known remnant river channels in the Mesilla Valley in 1914 and identified over nine different abandoned channels from 1844-1912 (Ackerly 1992). Portions of many of these remnant channels are still visible today.

Colonization and Agricultural Development

Native Americans of the Mogollon culture are the earliest known inhabitants of the area. Petroglyphs and several small village sites which date from 100 BC to 1400 AD have been discovered in the Sierra de las Uvas and Robledo Mountains. The earliest Spanish explorers mention the Manso Apache Indians, and reports from Don Juan de Oñate's expedition describe encounters with the Mansos in the area around present day El Paso, TX and Doña Ana, NM. The first formal European settlement did not occur until the Doña Ana Bend Colony was established in 1843. Within the next 15 years several communities and military outposts were established in the Palomas and Mesilla valleys including La Mesilla, Las Cruces, Tortugas, Picacho, Fort Fillmore, and Fort Thorn. The principal economic activity was agriculture. The Rio Grande was tapped and extensive irrigation systems were built to supply water to the crops. It is not entirely clear when the first irrigation systems were established, but by 1858 they were extensive enough to warrant surveying and mapping by the GLO (Ackerly 1992). Today, the Mesilla and Palomas valleys are experiencing rapid growth. Agriculture remains a mainstay of the local economy with such diverse crops as pecans, cotton, onions, alfalfa,

Figure 4: Las Cruces, New Mexico and surrounding agricultural valley as seen from the west escarpment. Pecan orchards are visible in the center.

Figure 5: In addition to pecans, cotton, and alfalfa a variety of fresh fruits and vegetables are grown in the watershed.

corn, and chile grown throughout the area. The population of Doña Ana County is 210,000, and estimated to increase growth to 325,000 over the next 30 years (City of Las Cruces 2011). With a population of 97,618, (U.S. Census Bureau 2010) Las Cruces is one of the fastest growing metropolitan areas in New Mexico second only to the city of Rio Rancho, northwest of Albuquerque. This growth has caused the conversion of agricultural lands in the Mesilla Valley to residential subdivisions, while the majority of the land and residents in the southern Palomas Valley, around the communities of Hatch, Rincon and Garfield, remain deeply rooted in agriculture. The Rio Grande and its associated irrigation canals still remain the lifeblood of the community today.

The Rio Grande Project

The future of agriculture along the Rio Grande in Southern New Mexico and West Texas has not always been certain. Following the Civil War, agricultural growth in the San Luis Valley of southern Colorado, and along the middle Rio Grande in New Mexico, placed increasing demands on the waters of the Rio Grande. Downstream users in New Mexico and West Texas were getting less and less water, and at times the Rio Grande would dry up altogether. Beginning in the late 1800's fields in the Palomas and Mesilla Valleys began to dry up. In 1902, while on a trip through the Mesilla Valley, Bishop Henry Granjon described dry ditches, fallow and withered fields, and abandoned gardens (Ackerly 1992). Similar problems were apparent further downstream as well. As a result, the Rio Grande Dam and Irrigation Company (RGDIC) was formed by Dr. Nathan Boyd of Las Cruces with the intention of building a dam to capture spring runoff waters for use later in the season (Kelly 1986). The RGDIC also had no intention of sharing any captured water with its downstream neighbors in either Texas or Mexico. Incensed by this idea, the Mexican government filed a note of protest with the United States Secretary of State on March 21, 1895, claiming a violation of the U.S./Mexico Treaty of Guadalupe-Hidalgo.

There was a second concern as well. Since the Rio Grande had become the border between the United States and Mexico, its propensity to move laterally and change position had become a territorial boundary issue. All parties agreed that a dam was a reasonable solution to store water for later use, stabilize the boundary between the United States and Mexico, and reduce the impacts of flooding. After ten years of political wrangling on both sides of the border, President Theodore Roosevelt signed a Proclamation on a *Convention Between the United States and Mexico Providing for the Equitable Distribution of the Waters of the Rio Grande for Irrigation Purposes* on May 21, 1906. Article I of the proclamation outlined a proposed storage dam to be built near Engle, NM for the storage and subsequent delivery of 60,000 acre-feet of water annually from the United States to Mexico at the head of the Acequia Madre above Ciudad Juarez, Mexico. On March 4, 1907 the U.S. Congress appropriated an initial $1,000,000 to the Rio Grande Project to build a dam and associated distribution system, and on June 3, 1913, the first concrete was poured for what would later become Elephant Butte Dam.

Farmers in the Rio Grande Project area received their first deliveries of water in January of 1915, and by March 21, 1915 (the first day official records were kept) Elephant Butte Reservoir was already holding 47,515 acre-ft. a full year before the dam was completed. For the first time in decades, farmers had a reliable supply of water. Being unaccustomed to such an abundant supply of water, and in conjunction with the high water table in many areas, some fields became saturated. As a result, work began in 1917 on a series of drainage canals to drain off the excess water. Today, the New Mexico portion of the Rio Grande Project includes Elephant Butte and Caballo Dams, three diversion dams, about 350 miles of agricultural drains and approximately 300 miles of canals and laterals that provide irrigation water for over 4,000 farms consisting of 90,640 water-righted acres, of which about 70,000 acres are irrigated in a given year (King and Maitland, 2003). There are also 48 flood control structures on tributaries to the Rio Grande in the watershed that are not part of the Rio Grande Project.

Land Ownership

The U.S. Bureau of Land Management (BLM) is the major land owner within the project area, managing 58% of the watershed (Figure 6). Private landownership accounts for 22% of the watershed; the State of New Mexico accounts for 16%; U.S. Forest Service (USFS) 3% and the U.S. Department of Defense (DOD)1%. The United States Section of the International Boundary and Water Commission (USIBWC) owns 1%, primarily along the Rio Grande corridor.

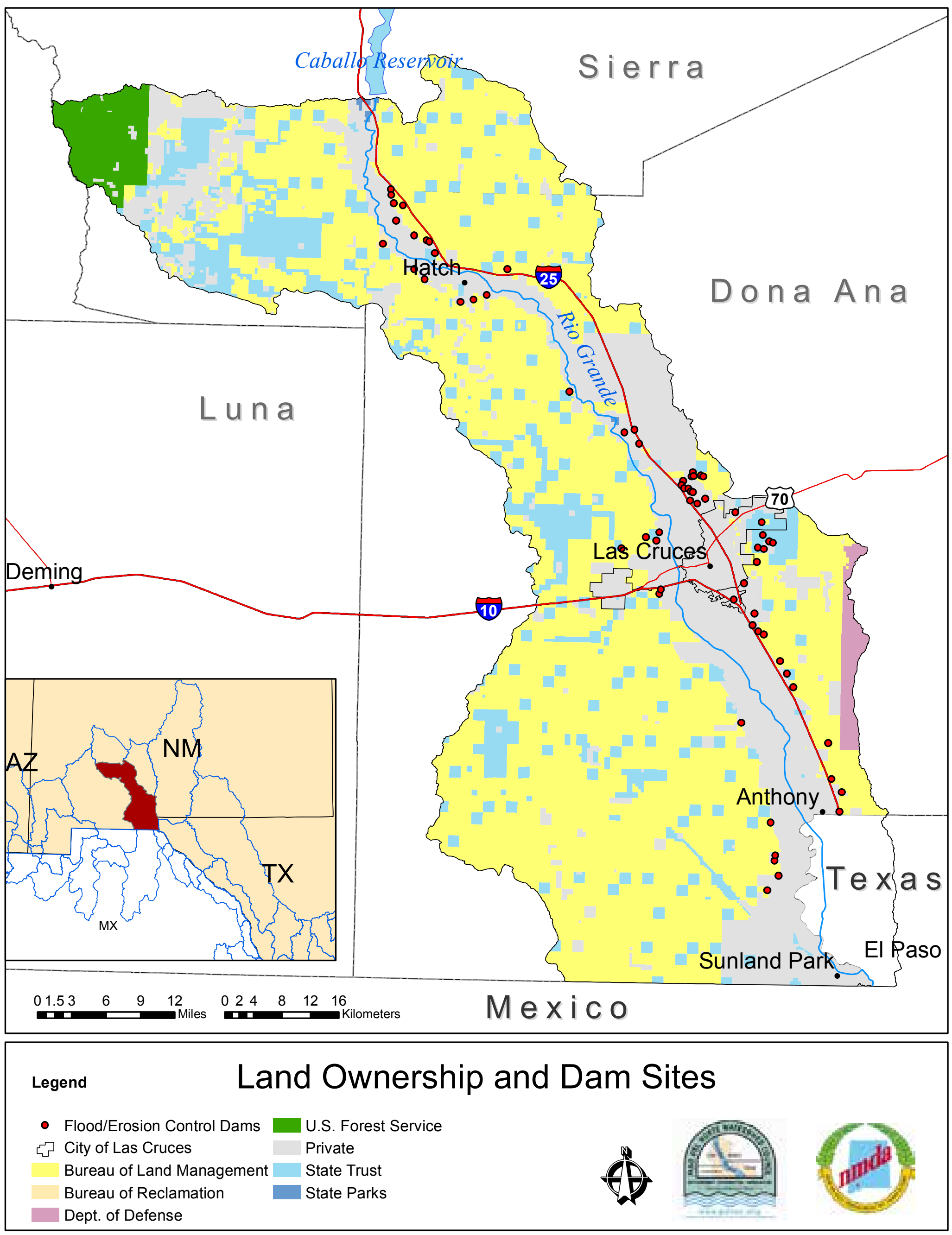


Figure 6: Land ownership in the El Paso-Las Cruces watershed and the location of flood control dams and major erosion control structures.

Watershed Hydrology

The Rio Grande is the major surface water feature in the project area. There are also two perennial streams in the far northwestern boundary of the watershed – Tierra Blanca Creek, and Berrenda Creek. While these two creeks are perennial in their upper reaches, they are ephemeral by the time they reach the Rio Grande. The remaining drainages in the watershed are ephemeral.

Figure 7: Leasburg Dam, one of three major diversion dams in the watershed.

The flow of Rio Grande water within the project area is almost entirely regulated and determined by irrigation needs. The combined storage capacity of the two reservoirs is 2,554,288 acre-ft. with a full annual irrigation allotment of 790,000 acre-ft. Annual water releases from Elephant Butte and Caballo reservoirs normally begin in February or March when the system is watered up and prepared for the irrigation season. Releases generally continue through mid-September to early October when the irrigation season ends. Flow during the winter months is generally a combination of agricultural return from drains, minor groundwater input, and point source discharges such as those from municipal wastewater treatment plants (WWTP's). During periods of drought, sections of the river may cease to flow entirely during the winter months. Stormwater inputs from ephemeral drainages and municipal storm drains sometimes carry a considerable amount of flow into the Rio Grande following the intense thunderstorms from July through September.

Until recently, the flow regime described above had been typical for 25 years and much of the time since Elephant Butte and Caballo reservoirs were built. The two reservoirs depend on spring runoff from the mountains in southern Colorado above the San Luis Valley. Due to onging drought throughout the west, snow pack in the southern Rockies has diminished in the last 15 years, reducing spring runoff considerably. Reservoir storage, which had been near capacity in the 1990's, began dropping rapidly in 2000, and dropped from 1,982,100 acre ft in 1998 to 101,500 acre ft by the end of the irrigation season in 2005. This has led to irrigation seasons shortened from 6 months in 1998 to 6 weeks in 2012, and has resulted in extended periods when the Rio Grande has gone dry in most of the watershed.

The cause of impairment was identified as *E. Coli* bacteria in the document *Total Maximum Daily Load (TMDL) for the Main Stem of the Lower Rio Grande (from The International Boundary with Mexico to Elephant Butte Dam)* (NMED 2007). To determine the sources of *E. Coli* in the watershed, a review of past data collection efforts was conducted followed by an intensive water quality survey that included opportunistic storm water sampling, periodic sampling of agricultural drains, and routine (monthly) sampling of the Rio Grande at select locations. In addition, once "hotspots" were identified, a small bacterial source tracking study was conducted.

Initial Data Analysis from Prior Studies and Efforts

A data survey consultant was hired in the spring 2007 to compile all existing data concerning both fecal coliform and *E. Coli* pollution in the Rio Grande from Caballo Dam downstream to the international boundary with Mexico. The data was analyzed to identify potential trends and to determine where data gaps existed. There were three data sets of primary significance from prior studies that were conducted by the U.S. Geological Survey (USGS); the USIBWC Texas Clean Rivers Program; and the NMED 2004 Survey that led to the development of the TMDL.

U.S. Geological Survey (1978-1995, 2003-2005)

The USGS maintains a flow measurement station at the El Paso Narrows above American Dam at Courchesne Bridge (USGS Station 08364000, Rio Grande at El Paso). Samples for bacteriological analyses were collected from January 1978 through May 1995 and from November 2003 to August 2005 at intervals ranging from about one to three months. Total coliforms were measured from October 1979 through October 1980. Fecal streptococcus was measured from January 1978 through May 1995. *E. Coli* was measured from November 2003 through August 2005. Fecal coliforms were assessed the entire period of record (Figure 8). The *E. Coli* data show exceedance of the regulatory limit of 410 cfu/100 mL in six of the 14 samples (42 percent). Four of these exceedances occurred between November 2003 and May 2004. Another exceedance, in July 2004, could be related to rainfall-induced runoff. Although the USGS data provide a long-term record, it is only a single site.

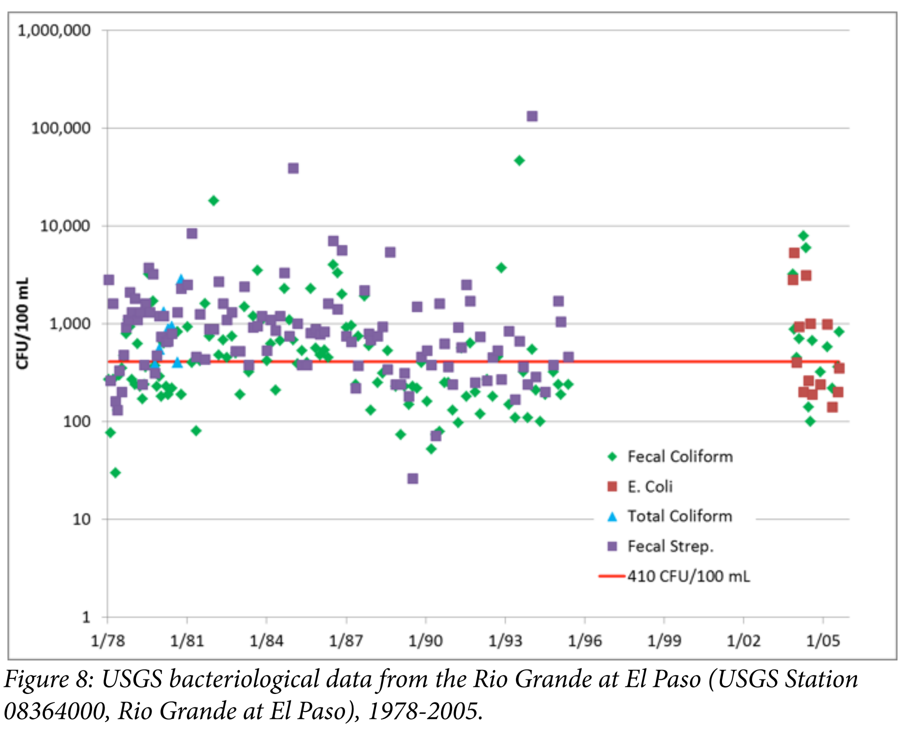


Figure 8: USGS bacteriological data from the Rio Grande at El Paso (USGS Station 08364000, Rio Grande at El Paso), 1978-2005.

U.S. International Boundary and Water Commission Texas Clean Rivers Program (2001-2012)

The USIBWC Texas Clean Rivers Program reports bacteriological data from three sites in the Rio Grande above the international boundary with Mexico (listed upstream to downstream): above the confluence of the East Drain and the Rio Grande near the New Mexico-Texas state line, at Anapra downstream of Sunland Park, and at Courchesne Bridge. These are all located near the bottom of the watershed. The data provide a bit more spatial and temporal coverage than the USGS data and reveal multiple exceedances of the 410 cfu/100 mL criterion and indicate that *E. coli* sources exist between the upstream sampling point above the East Drain and Courchesne Bridge (Figure 9).

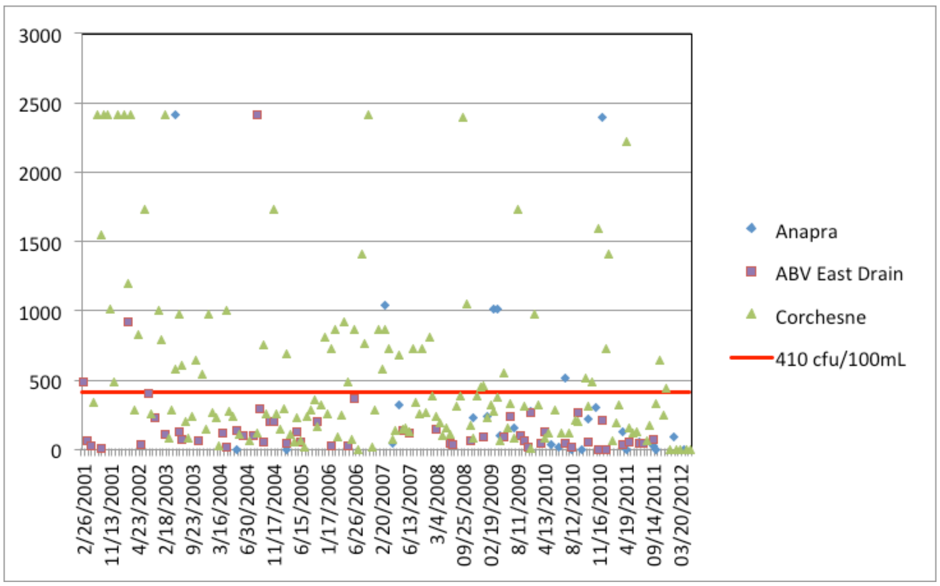


Figure 9: USIBWC E. coli data for the Rio Grande above the confluence with the East Drain, at Anapra, and Courchesne Bridge. The maximum reporting level is 2,420 CFU/100 mL.

NMED – Surface Water Quality Bureau 2004 Survey

In 2004 the NMED-SWQB conducted an intensive water quality survey in the watershed assessing a wide variety of potential pollutants as part of its regular monitoring program. Samples were collected from ten stations along the Rio Grande from just downstream of Caballo Reservoir to Sunland Park just upstream of the Texas-New Mexico border and the international boundary with Mexico. Oxygen, temperature, specific conductance, and pH were measured in the field. All samples were analyzed for nutrients, ions, and total and dissolved metals; and some were analyzed for bacteria, radionuclides, and anthropogenic organic compounds. Bacterial analyses included both fecal coliform and *E. coli*.

E. coli was the only pollutant that did not meet New Mexico's water quality standards. Of the 23 samples collected within the upstream reach between Caballo and Leasburg dams, 4 samples (17 percent) exceeded the water quality standard of 410 cfu/100 mL for *E. coli* (Figure 10). Of the 53 samples collected within the downstream reach from Leasburg Dam to the international boundary with Mexico, 16 samples (30 percent) exceeded the water quality standard of 410 cfu/100 mL for *E. coli* (Figure 11). Eight of the exceedances occurred in a reach (Anthony to Sunland Park) where there were known problems with non-compliant discharges from two WWTPs. A likely explanation for the exceedance of *E. coli* in this reach was from a point source discharge of fecal material into the river during the sample collection period. As a direct result of the 2004 study, the *Total Maximum Daily Load (TMDL) for the Main Stem of the Lower Rio Grande (from the International Boundary with Mexico to Elephant Butte Dam)* was written (NMED, 2007).

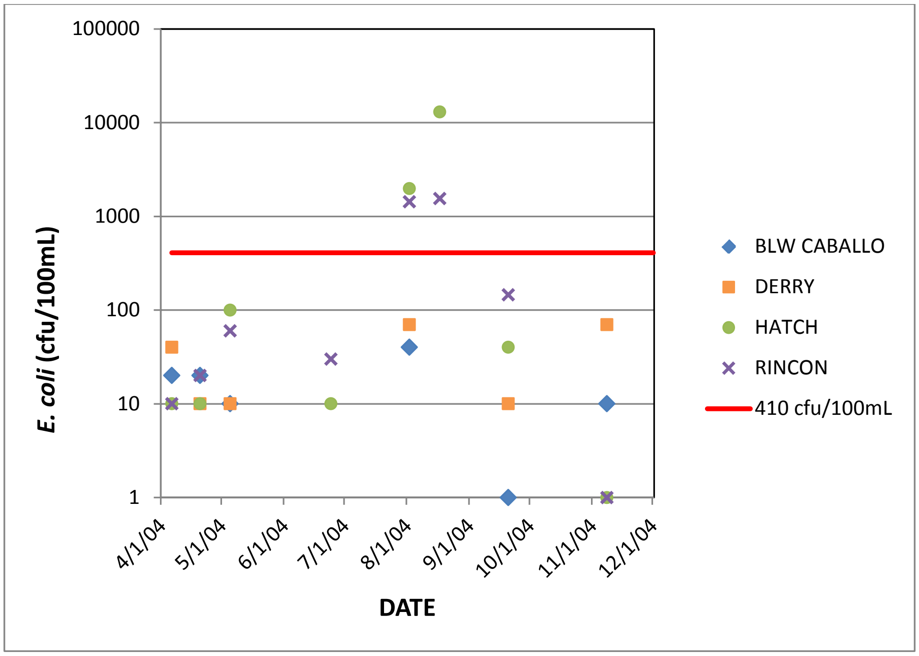


Figure 10: 2004 NMED-SWQB E. coli data from below Caballo Dam to Leasburg.

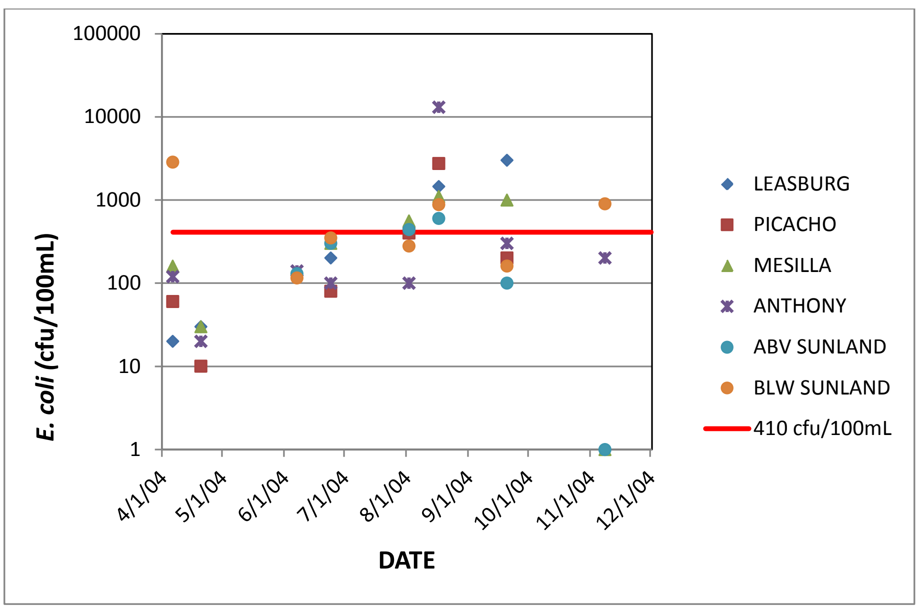


Figure 11: 2004 NMED-SWQB E. coli data from Leasburg to below Sunland Park.

There is evidence that some exceedances may have been related to precipitation events and subsequent stormwater flow. As part of the analysis, rainfall measurements were collected from the National Oceanic and Atmospheric Administration (NOAA) stations at Anthony, New Mexico, and Leasburg, New Mexico, and were used to identify potential trends between elevated *E. coli* levels and rainfall. In general, the data for the Palomas Valley reach (Caballo Dam to Leasburg Dam) showed low *E. coli* levels in the early months of the year with exceedances occurring downstream of Derry during the monsoon season from the end of June through September. The data showed a positive association between *E. coli* and rainfall events (r = 0.75) (NMED, 2007). The TMDL document concluded that elevated levels of *E. coli* in the reach from Leasburg Dam to Percha Dam were directly related to stormflow events (NMED 2007).

In the downstream reach from Leasburg Dam to the international boundary with Mexico, the exceedances primarily occurred in late summer, which was similar to that of the Palomas Valley. However, the site below Sunland Park showed exceedances in April 2004 reaching as high as 1.6 million cfu/100mL. The data showed no relationship between *E. coli* and rainfall events (r = -0.07) (NMED, 2007). The TMDL concluded that elevated *E. coli* levels in this reach are not associated with stormwater runoff but possibly associated with more chronic sources. Moreover, the Discharge Monitoring Reports (DMRs) revealed that the city of Sunland Park WWTP (NPDES permit #NM0030201) was in violation for fecal coliforms the weeks of April 8 - 14, April 15 - 21, April 22 - 28, and August 12 - 18, 2004. The South Central Regional WWTP (NPDES permit #NM0030490) was also in violation for fecal coliforms during the weeks of November 7-13 and November 21-27, 2004.

The 2007 NMED TMDL document identified probable sources of impairment based on general watershed characteristics, watershed hydrology, and natural and anthropogenic activities within the watershed. It identified nine probable sources of impairment, which include:

1. Impervious surface/parking lot runoff
2. Municipal point source discharges
3. Urbanized high density areas
4. On-site treatment systems
5. Permitted runoff from confined animal feeding operations (CAFO)
6. Rangeland grazing
7. Waste from pets
8. Waste from waterfowl
9. Waste from wildlife other than waterfowl

Identification of Data Gaps and Recommendations from Analysis of Prior Study Efforts

The impairment in the Rio Grande downstream of Percha Dam is clearly identified as *E. coli* in the NMED-SWQB's TMDL document. However, neither the 2004 study nor the interpretation method that led to the development of the TMDL was designed to identify sources of impairment other than in general terms. In 2007, members of the Council and other stakeholders identified the following data/information gaps critical to characterizing the sources of impairment in the watershed:

- There was concern that because 2004 was a drought year and stream flow was at a 30 year low, it was not a representative year for the watershed. While there was disagreement over this concern, it was agreed that no single year would have been representative. A multi-year sampling effort for *E. coli* was recommended.
- The complex nature of the watershed with respect to water releases (irrigation season), water diversions, irrigation return flows, drain return flows, stormwater flows, and point source discharges was not represented well enough in the sampling design of any of the prior studies to accurately characterize *E. coli* inputs from these sources, especially in the sub-watersheds.
- A greater understanding of the impact from point source discharges such as WWTPs, CAFOs, and possible unpermitted discharges is needed to differentiate these impacts from nonpoint sources.

Due to these data gaps, there was insufficient information to identify sources of *E. coli*, so development of a future study was recommended.

319(h) Water Quality Sampling and Monitoring 2008-2011

Based on the recommendations from the data analysis of prior studies, a monitoring program was designed to fill the identified data gaps. This *E. coli* monitoring program started in July 2008 and is ongoing. Data considered for this watershed plan was collected through 2011. Routine river sampling sites were co-located at stream gaging stations to assist in differentiating stormwater flow from base flow and the subsequent relationship to *E. coli* concentration. In addition to these sites, the river at Sunland Park was added to the study to monitor the terminal end of the study area. The seven routine sampling sites were Caballo Dam, Haynor Bridge, Leasburg Cable, Picacho Bridge, Mesilla Dam, Anthony Bridge, and Sunland Park (Figure 12). Because there is no flow gage in the Rio Grande at Sunland Park, flow data was used from the Rio Grande at El Paso gage at Courchesne Bridge, which is a short distance downstream of the Sunland Park site. Sampling of agricultural drains was also conducted. During the course of the study, sampling of the drains was modified to focus on specific drains where elevated *E. coli* concentrations were identified.

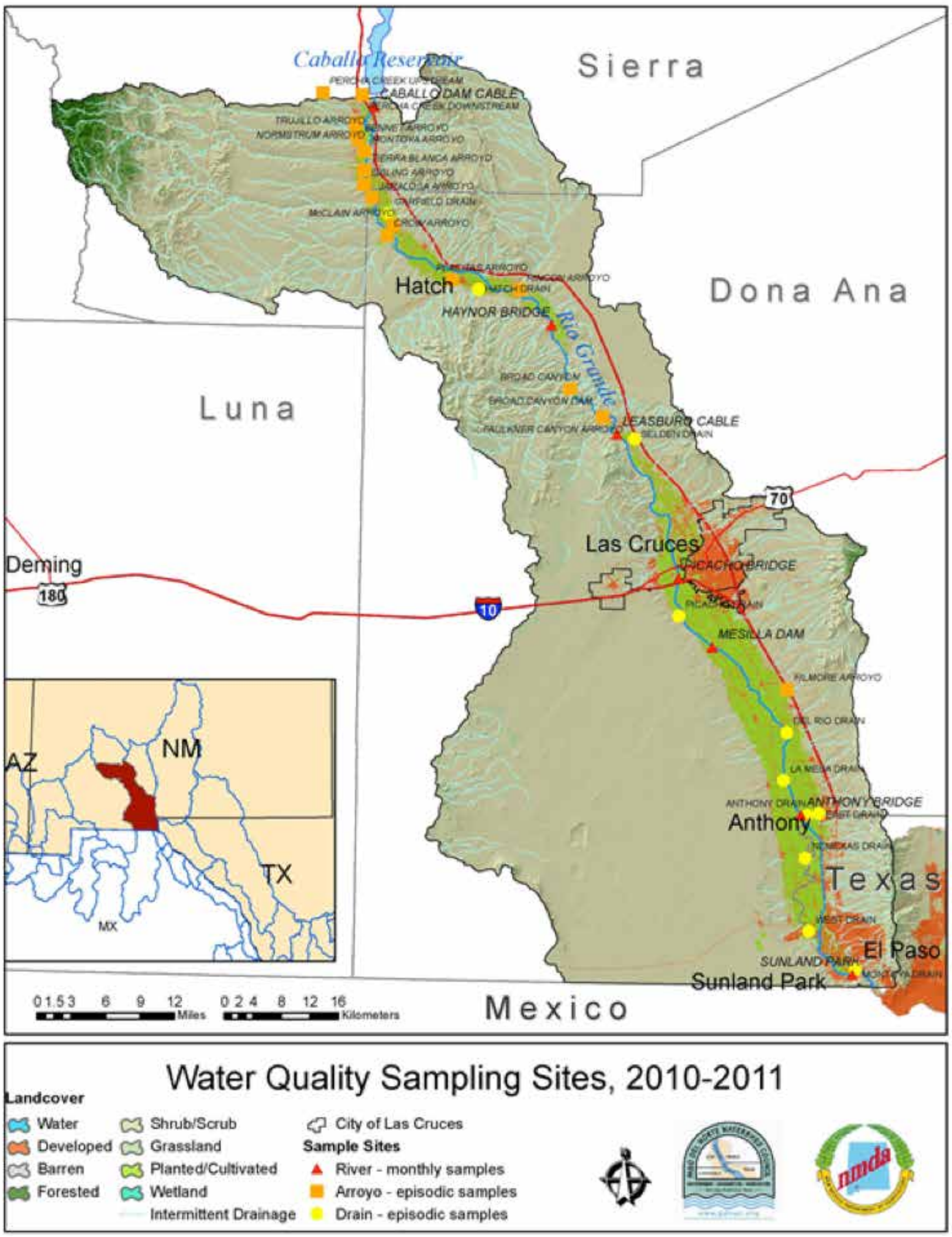


Figure 12: Map of sampling stations within the 319(h) project area.

The Caballo Dam site, upstream of the impaired reaches, was chosen to provide background data of water entering the system. It is located just downstream of Caballo Reservoir, which releases water for irrigation into the system. There are no major arroyos entering the Rio Grande between the dam and the sampling point. It should be noted the Caballo Dam site has a more stringent water quality standard of 235 cfu/100 mL than the river downstream. For purposes of this study, which was to determine causes and sources of impairment to the impaired reach, the significant criterion of 410 cfu/100 mL was used to evaluate the Caballo Dam site samples as well.

Figure 13: EBID staff collect a sample for E. coli analysis at the Leasburg gage on the Rio Grande.

Samples were collected by the hydrology staff at EBID in conjunction with their ongoing water quality monitoring program. Sample collecting and handling standards were modified from the USEPA report (1978) and described in the NMED Quality Assurance Project Plan (NMED 2010). A swing sampler mounted on a 12-foot extension pole was used for sample collection from the channel away from near bank flow eddies (Figure 13). Samples were analyzed utilizing the m-ColiBlue24® method approved by the USEPA. Other parameters were measured in the field including temperature, pH, turbidity, conductivity, and dissolved oxygen.

319(h) Water Quality Data Results and Discussion 2008-2011

2008 Monitoring

The 2008 sampling effort began prior to development of the routine monthly sampling plan and focused on opportunistic stormwater sampling in the upper watershed during the monsoon season. This effort revealed *E. coli* concentrations ranging from 400 cfu/100 mL to 560,000 cfu/100 mL at the arroyo sampling sites during storm events, and it is assumed these tributaries contributed to the observed elevated levels in the river (Figure 14). Three river sites were also sampled during July, 2008. Haynor Bridge was 900 cfu/100 mL on July 9, while Leasburg Dam was 700 cfu/100 mL on July 10. The Picacho Bridge site did not show a similar response. These were the only main stem river samples collected in July 2008. Monthly sampling of the main stem of the Rio Grande in 2008 consisted of just three sampling events beginning in October (Figure 15). All samples were below the 410 cfu/100 mL criterion for a single sample. *E. coli* concentrations ranged from <1 cfu/100 mL (Caballo Dam) to 210 cfu/100 mL (Sunland Park).

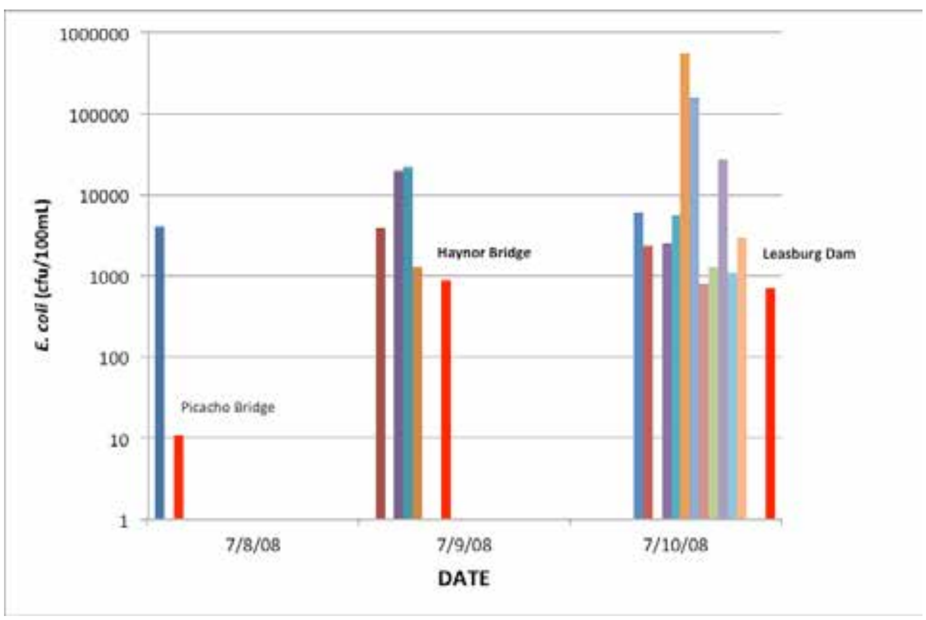


Figure 14: Opportunistic stormwater runoff sampling of arroyos July 2008 (Picacho Bridge, Haynor Bridge, and Leasburg Dam river stations in red).

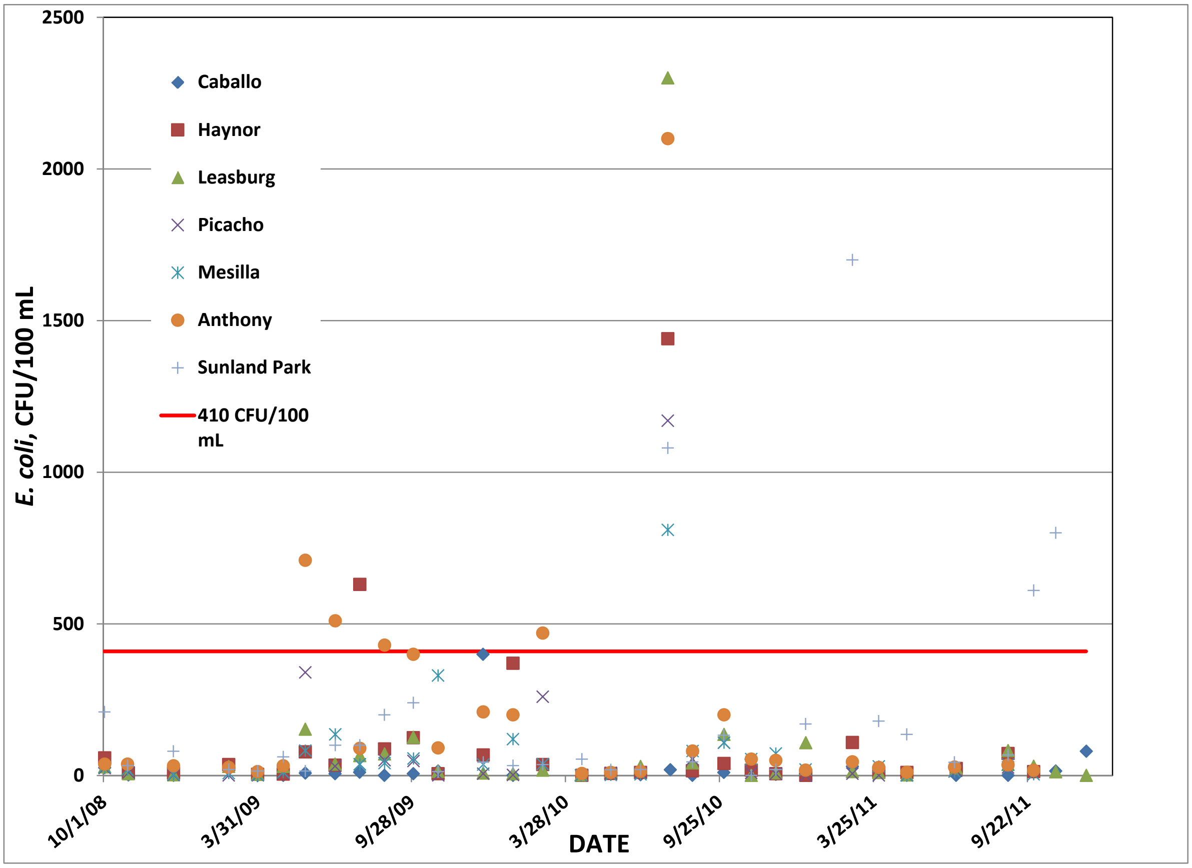


Figure 15: Routine E. coli sampling results from the Rio Grande, October 2008-December, 2011.
** On November 30, 2011, the sample collected at Sunland Park showed 4,800 cfu/100mL, which is off the scale of the graph.*

Only the Mesquite Drain was sampled in 2008. This sampling occurred on October 10 at four locations and revealed elevated levels that ranged from 200 cfu/100 mL to 1200 cfu/100 mL. The limited sampling in 2008 indicated that stormwater runoff could play a significant role in increasing *E. coli* concentrations above the 410 cfu/100 mL standard. No other patterns or trends could be determined from the 2008 sampling effort.

2009-2011 Monitoring

Samples were collected every four to five weeks at seven river sites: Caballo Dam, Haynor Bridge, Leasburg Cable, Picacho Bridge, Mesilla Dam, Anthony 225 Bridge, and Sunland Park Bridge. Quarterly sampling of eight drains began in March: Hatch Drain, Rincon Drain, Del Rio Drain, La Mesa Drain, East Drain, Anthony Drain, New-Mexas Drain, and West Drain. Some opportunistic stormwater sampling of arroyos was also conducted.

During 2009, four samples from the routine river sampling exceeded 410 cfu/100 mL (Haynor Bridge with 630 cfu/100 mL on July 29; Anthony 225 Bridge with 710 cfu/100 mL on May 29; 510 cfu/100 mL on June 30; and 430 cfu/100 mL on August 27 (Figure 15). All other stations remained below 410 cfu/100 mL, although one sample from the Caballo Dam site and one from the Anthony 225 Bridge site approached the limit. A storm on July 26, 2010, resulted in elevated *E. coli* levels throughout the system ranging from 800 cfu/100 mL at Mesilla Dam to 2,300 cfu/100 mL at Leasburg Cable. Anthony 225 Bridge had the only nonstorm-related exceedance in 2010 at 470 cfu/100 mL in March. There were four exceedances in the main stem of the Rio Grande in 2011 which occurred at Sunland Park on February 28, September 29, October 25, and November 30. These exceedances were also not stormwater related.

Drain sampling revealed extremely high *E. coli* concentrations in June and September of 2009, especially in the southern (downstream) drains. More intensive sampling occurred in East Drain and Mesquite Drain in 2010, which both had consistently shown elevated levels of *E. coli (Table 1)*.

Date	Sampling Location	*E. coli* cfu/100 ml
9/30/2010	East Drain	7500
10/5/2010	East Drain	24000
10/5/2010	East Drain - Above Ohara Road	14000
10/5/2010	East Drain - Above Joy Road	20000
10/5/2010	East Drain - Harding Road	25000
10/12/2010	Mesquite Drain - East Drain Confluence	4600
10/12/2010	Mesquite Drain - Franco Rd.	15000
10/12/2010	Mesquite Drain - Upstream of Franco Rd.	20000
10/12/2010	Mesquite Drain - Lechuga St.	2360
10/12/2010	Mesquite Drain - La Fe Ave	2100
11/16/2010	Mesquite Drain - Upstream of Franco Rd.	800
11/16/2010	Mesquite Drain - Lechuga St.	1100
11/16/2010	Mesquite Drain - Vado Rd.	600
11/16/2010	Mesquite Drain - Swannack Rd.	800

Table 1: Intensive sampling in mulitiple locations in East Drain and Mesquite Drain September-November, 2010.

Correlating Storm Flows with E. coli Concentration

Correlating rainfall to *E. coli* concentration is problematic due to the size of the watershed, localized thunderstorms, and limited weather stations. However, releases from Caballo Reservoir are known, and since all tributaries are ephemeral, flow that exceeds releases can be identified as resulting from stormflow runoff. As water moves down the watershed and is diverted, examining trends for base flow is the most practical method of determining storm flows. Although a detailed analysis was conducted by correlating sample collection date and time with gage data at the sample site, Figure 16 provides a graphical example of the flow vs *E. coli* analysis that was done. The exceedances at the Anthony 225 Bridge in 2009 were not storm related, nor was the one exceedance from March 2010. However, the *E.coli* exceedance in July 2010 was.

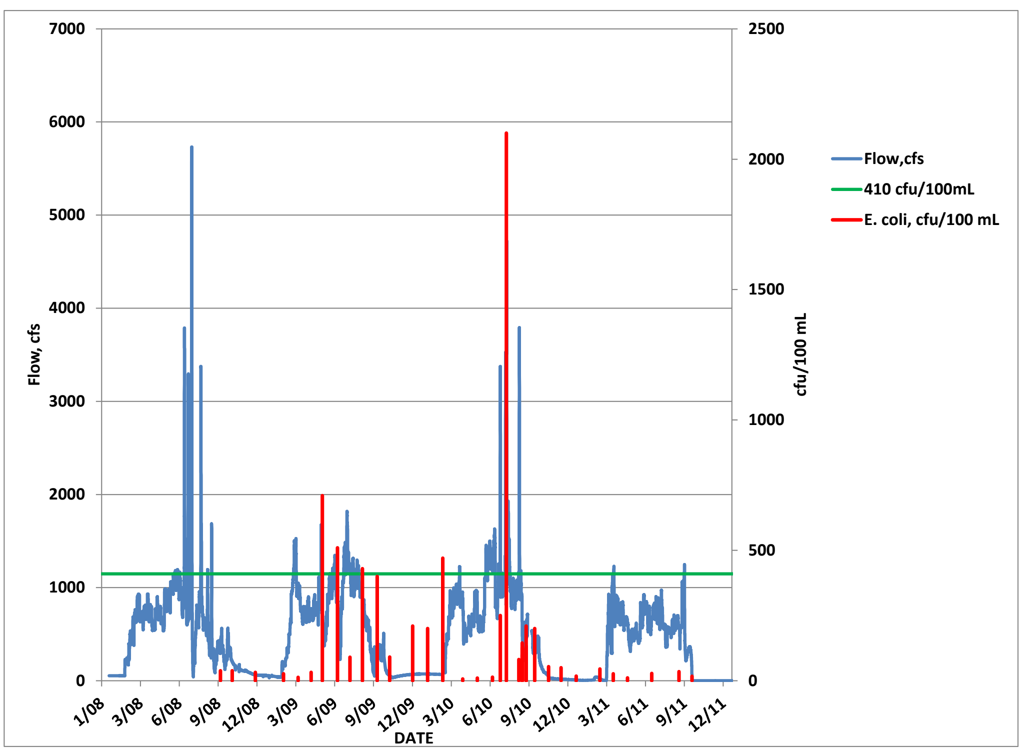


Figure 16: The relationship between flow and E. coli concentration at the Anthony 225 Bridge site.

Summary of Conclusions from the 2008-2011 Monitoring

From October 2008 to December 2011, only seven percent of the samples exceeded the 410 cfu/100 mL criterion for *E. coli* (Table 2). There were 15 samples; seven were directly related to stormwater runoff events and six of those seven occurred during a single thunderstorm event on July 26, 2010. With the exception of that date, elevated *E. coli* concentrations at Anthony 225 Bridge were unrelated to storm water runoff. The northern drains in the upper part of the watershed had several instances of elevated *E. coli* concentrations in the early stages of the monitoring program, but no clear pattern developed. The drains in the bottom section of the watershed continued to show elevated concentrations of *E. coli*. Mesquite Drain and East Drain were identified as problem areas. None of the exceedances in the drains were associated with stormwater runoff events. As a result of these efforts and review of the preliminary findings, four sites were chosen for a bacterial source tracking study in 2010.

Station	n	CFU/100mL>410	Percent	Average, CFU/100 mL
Caballo	32	0	0%	25
Haynor	30	2	7%	111
Leasburg	33	1	3%	105
Picacho	29	1	3%	77
Mesilla	29	1	3%	75
Anthony	30	5	17%	200
Sunland Park	32	5	16%	346
Total	215	15	7%	135

Table 2: Summary statistics for routine E. coli sampling on the Rio Grande.

Bacterial Source Tracking

As stated in the Introduction, *E. coli* is a natural inhabitant of the gastrointestinal tract of warm-blooded animals. Each *E. coli* variant is genetically adapted to its animal host, thus variants are genetically distinct between hosts. Consequently, it is possible to track *E. coli* in water samples back to its animal host using genetic analyses. There are limitations to the method (USEPA 2005), so source tracking studies must only be considered reasonable estimates as to sources of *E. coli* rather than exact attributions.

Sampling Site Selection

Due to budget constraints, source tracking was limited to four sampling sites, which were chosen based on previous occurrence of elevated *E. coli*. The Anthony 225 Bridge site and the East Drain site were chosen because of repeated exceedances observed in the river at both sites. The two other sites chosen were the Leasburg Cable site and the Sunland Park site because periodic high exceedances had been observed at both sites. Additionally, the Leasburg Cable and Sunland Park sites are located near the upper and lower reaches of the targeted area and, therefore, represent the water entering and leaving this reach of the Rio Grande. As with the *E. coli* sampling survey, all sites were co-located with a permanent stream gage to facilitate collection of flow data.

Sampling, E. coli Enumeration and Source Tracking Procedures

Samples were taken at each site using USEPA-approved sterile plastic I-Chem bottles for bacteriological testing. Bottles were attached to the end of a swing sampler mounted on a 12 foot extension pole, and samples were taken eight to ten feet from the bank of the river (Anthony 225 Bridge and Sunland Park) or from a sampling platform (Leasburg Cable and East Drain). Similar to a previous New Mexico source tracking study (Smith 2007), replicate samples were taken at five minute intervals in triplicate or quadruplicate and were analyzed separately for *E. coli* levels. The samples were enumerated using the m-ColiBlue24® method (USEPA Method 10029).

Due to limitations of the analytical procedure, only incubated samples with colony counts greater than 200 cfu/100 mL *E. coli* were shipped to the source tracking contract lab for analyses. Between five and 20 *E. coli* isolates were genetically identified from each sample date; and between 62 and 127 *E. coli* isolates were source-identified from each of the four sample sites, totaling 376 distinct isolates source-identified. Source track data is reported as percentage attributable to each source from the total number of *E. coli* analyzed from each sample.

E. coli Enumeration Results from Source Tracking Study

All water samples collected for source tracking were quantified for *E. coli*. The three river sites showed similar concentrations of *E. coli* with the highest levels typically occurring at Anthony. In contrast, *E. coli* levels in the East Drain were typically more than an order of magnitude greater than at the river sites. *E. coli* concentrations were the lowest at the most upstream sampling site at Leasburg (Table 3). The East Drain clearly exceeded both the 410 cfu/100 mL limit for a single sample and the 126 cfu/100 mL geometric mean for multiple samples.

Location	*E.coli* (CFU/100 mL)		
	Average (range)	Geometric Mean	Exceedance*
Leasburg River (n=117)	103 (0-705)	34	No/No
Anthony River (n=42)	249 (30-864)	126	No/Yes
East Drain (n=42)	5,562 (697-11,833)	4346	Yes/Yes
Sunland River (n=112)	218 (0-1,288)	78	No/No

*Table 3: Summary statistics for the four sampling sites in terms of the average, range, and geometric mean of the samples taken in 2010 and 2011 for bacterial source tracking. *NMED water quality standards are 410 cfu/100mL for a single sample or a geometric mean of 126 cfu/100 mL for mulitiple samples.*

Bacterial Source Tracking Results and Discussion

Over the two-year study, 376 *E. coli* were source tracked from the four sites. The largest percentage of isolates from the three river sites was tracked to birds, which are typically waterfowl in the absence of commercial chicken operations. In contrast, the largest percent of isolates at the single drain site were tracked to livestock, which are further broken down into cattle, horses, and other livestock. Figure 17 provides the percentage of isolates tracked to major sources averaged over all four sites: 32% of all *E. coli* typed were tracked to birds, followed by livestock (24%) and wildlife (17%). Livestock included cattle (12%) horses (8%) and the remaining distributed between

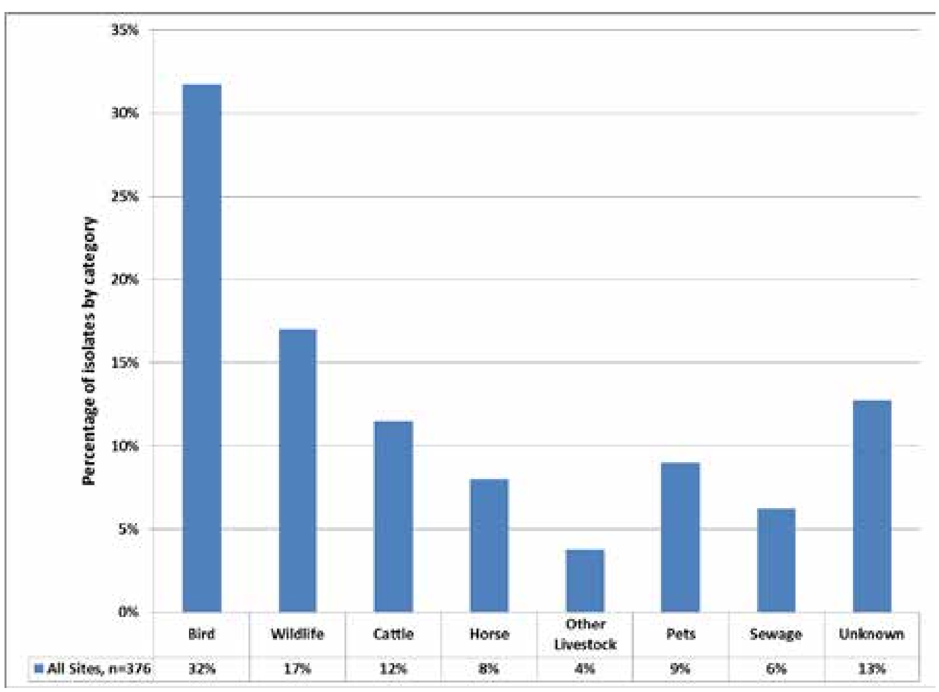


Figure 17: The top three sources of E. coli at all source track sites were bird, livestock (cattle+horses+other livestock) and wildlife.

pigs, sheep, and goats (4%). The top four sources of wildlife (other than ducks and geese in the avian category) were raccoons (5%), rodents (beaver, mice, etc., 5%) deer (4%), and coyote (1%). All the natural sources (avian+wildlife) summed together at the four sites accounted for 49% of the *E. coli* typed while the anthropogenic sources (livestock+pets+sewage) accounted for 38%. The remaining 13% of the *E. coli* were unidentified.

Sources of *E. coli* had similar percentages at the Leasburg and Sunland Park river sites with natural sources comprising 53% of the total at both sites (Figure 18). Anthropogenic sources (livestock+pets+sewage) were also similar with Leasburg (27.3%) and Sunland Park (31.5%). However, Leasburg had 10% more bird sources than Sunland Park, and the latter had 2.9 times more sewage sources than Leasburg. Also, there was relatively fewer horse sources at Sunland Park (3.1%) compared to Leasburg (8%).

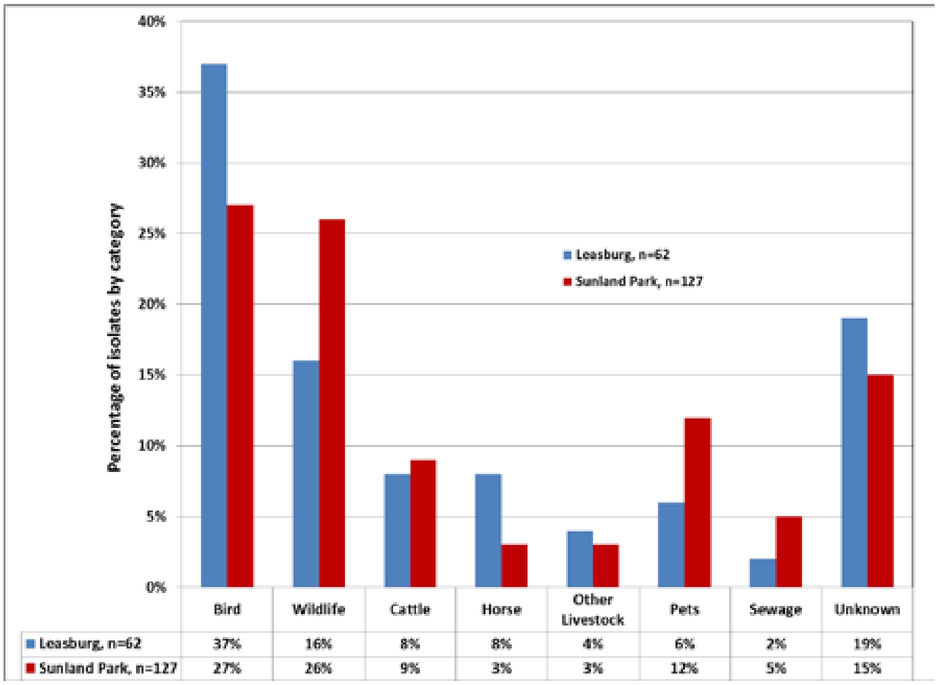


Figure 18: Sources of E. coli identified at Leasburg (mid-watershed) and the Sunland Park(bottom of the watershed) sites.

Compared to Leasburg and Sunland Park, the samples taken on the river at Anthony 225 Bridge and in the nearby East Drain showed significantly higher anthropogenic sources, (43.2% and 51.4%, respectively). The highest percentage of cattle *E. coli* was isolated at Anthony River (15%) and East Drain (14%). Similarly, the highest sources of horse derived *E. coli* were found at East Drain (12%). Compared to the sewage-originated *E. coli* at the three river sites (3.9%) the average percentage of sewage-originated *E. coli* at East Drain was significantly greater 13.3% (Figure 19).

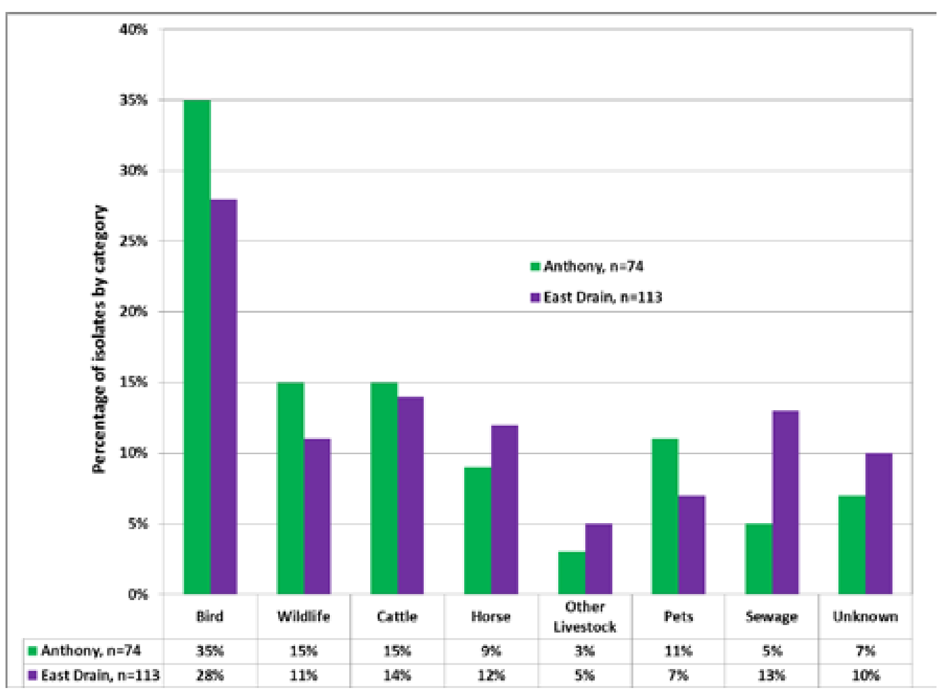


Figure 19: Sources of E. coli identified at the Anthony 225 Bridge and East Drain sites.

Though the current study is limited by its two-year time frame and only four locations, some conclusions can be made. It appears the East Drain is a significant source of human-derived *E. coli* (which, by definition, is an indicator of human pathogens, i.e., microbes that cause human disease). The East Drain sampling site is located 2.3 miles upstream of the confluence with the Rio Grande and had a flow rate of approximately nine cfs during sample collection. If the observed concentrations of *E. coli* are maintained to the confluence, then the East Drain could be discharging up to 4.3 million *E. coli* from human sewage per second into the Rio Grande. Compared to the sewage-derived *E. coli* already in the river at Anthony (5.4 %) when the East Drain (13.3 % sewage *E. coli*) discharges into the Rio Grande, it would more than double the amount of pathogen-indicating microbes in the river. For a complete discussion on *E. coli* loading from specific sources, see Chapter 4.

NMED – Surface Water Quality Bureau 2010-2012 Survey

From December 2010 through April 2012, NMED conducted an intensive water quality survey examining a wide variety of potential pollutants as part of its regular monitoring program and to assess the non-attainment of the primary contact water quality standard for *E. coli* in the 319(h) grant project area. Samples were collected from nine stations along the Rio Grande from just downstream of Elephant Butte Dam to Courchesne Bridge just upstream of the Texas and New Mexico border and the international boundary with Mexico. Sampling stations were chosen to provide good spatial coverage and to be consistent with the study conducted from 2008-2011 under the 319(h) project. The stations were located at the USGS gage downstream of Elephant Butte Dam, just downstream of the Truth or Consequences WWTP at Williamsburg, Caballo Dam, Haynor Bridge, Leasburg Cable, Picacho Bridge, Mesilla Dam, Anthony 225 Bridge, and Courchesne Bridge. Courchesne Bridge was chosen rather than the Sunland Park site because it is co-located with the Rio Grande at El Paso USGS gage and is at the very bottom of the reach before crossing the border into Texas. Samples were also collected from several tributaries in the upper watershed. In addition, samples were collected at the outfalls of all the WWTPs in the assessment area. These included the Sierra County WWTP, Truth or Consequences WWTP, Salem WWTP, Hatch WWTP, the city of Las Cruces Jacob Hands WWTP, South Central Regional WWTP, Anthony Water and Sanitation District, Gadsden Independent School District, Sunland Park WWTP, and El Paso Electric. Field measured parameters included dissolved oxygen, temperature, specific conductance, and pH. All samples were analyzed for nutrients, ions, and total and dissolved metals. More limited analysis was conducted for total coliforms and *E. coli* bacteria, radionuclides, and anthropogenic organic compounds.

Summary Results for E. coli Bacteria for the SWQB Survey

All bacteriological samples were processed utilizing the IDEXX Colilert Quanti-Tray® incubation system. This is a most probable number (MPN) analytical technique with a method detection limit (MDL) of 2,419 cfu/100mL *E. coli*. There was only one exceedance of *E. coli* in the main stem of the Rio Grande and that occurred at Courchesne Bridge on August 18, 2011, which exceeded the MDL of 2,419 cfu/100mL. However, the South Central Regional WWTP exceeded the criterion of 410 cfu/100mL and the MDL of 2,419 cfu/100mL on three out of six sampling dates, while the Sunland Park WWTP exceeded the criterion of 410 cfu/100mL four out of six of the sampling dates (three of which were above the MDL of 2.419 cfu/100mL). Both WWTPs were exceeding the *E. coli* standard on August 18 when the Courchesne Bridge river station was also exceeding the standard. These results corroborate with earlier studies suggesting that some of the *E. coli* impairment at the lower end of the watershed may be attributed to point source discharges from WWTPs.

Conclusions of Data Analysis from Prior Studies and Recent Monitoring Efforts

The data collection efforts conducted by the USGS and USIBWC Clean Rivers Program clearly identify a trend of exceedance of the 410 cfu/100mL criterion for *E. coli* at the bottom of the watershed. The 2004 NMED water quality survey provided further data that confirmed these findings and, in addition, documented *E. coli* impairment in the upper watershed that appeared to be related primarily to stormwater runoff. The monitoring effort conducted as part of this planning effort from 2008-2011 provides additional data confirming the *E. coli* exceedance in the upper watershed correlates with stormwater runoff, while exceedance in the lower watershed may occur from stormwater runoff, but primarily correlates with non-stormwater flows. The targeted source tracking study further identified specific areas of concern and the percent attributable to anthropogenic activities. The 2010-2012 NMED survey identified problems at two WWTPs at the bottom of the watershed. As a result, the following conclusions can be made:

- The *E. coli* exceedance in the reach above Leasburg Cable is primarily related to stormwater runoff.
- The *E. coli* exceedance in the reach from Anthony to the international boundary with Mexico is primarily related to non-stormwater flows.
- Mesquite Drain and East Drain on the east bank of the Rio Grande contain high levels of *E. coli* and may be a significant source of *E. coli* in the lower watershed.
- Two WTTPs in the lower watershed may be a significant source of *E. coli* in the bottom of the watershed.

Potential Changes to the Impairment Status

The assessment units utilized during the 2004 NMED survey that led to the TMDL were changed in the *2006-2008 State of New Mexico CWA §§303(d)/305(b) Integrated List & Report* from two assessment units to four. The assessment unit from Leasburg Dam to one mile below Percha Dam was retained while the assessment unit from Leasburg Dam to the international boundary with Mexico was broken into three assessment units: the international boundary with Mexico to Anthony Bridge, Anthony Bridge to Picacho Bridge, and Picacho Bridge to Leasburg Dam. Based on these new assessment units and the data generated from the routine river sampling from 2008-2011 and the NMED 2010-2012 survey, there does not appear to be sufficient justification for continued listing of the Rio Grande from Picacho Bridge to one mile below Percha Dam (the assessment units: Picacho Bridge to Leasburg Dam and Leasburg Dam to one mile below Percha dam). All the data confirm that the reach of the Rio Grande from the international boundary with Mexico to Picacho Bridge is impaired although this appears confined to the bottom assessment unit (International Boundary with Mexico to Anthony Bridge).

Load analysis is critical to understanding the nature of the impairment relative to stream flow. It is also a critical component in watershed based planning to determine where pollution mitigation implementation is needed and has the greatest potential to reduce the impairment to the waterbody of concern. This section discusses the load estimates provided in the 2007 NMED TMDL document; a discussion of river hydrology for the Lower Rio Grande in New Mexico as it relates to potential impacts to pollutant loading, and a load analysis conducted for this planning effort.

TMDL for the Lower Rio Grande in New Mexico

NMED utilized a load duration curve method for the 2007 NMED TMDL document. Since pollutant loads are an expression of pollutant concentration in relation to flow, the TMDLs were calculated for the different flow conditions as determined by flow duration curve analysis in relation to when exceedance of *E. coli* occurred (Tables 4 and 5).

LOAD CALCULATION VARIABLES			FLOW CONDITIONS		
	High	Moist	Mid-Range	Dry	Low
Measured *E. coli* (cfu/100mL)	--	--	1662	--	--
Mid-point flow (cfs)	--	--	982	--	--
Measured Loads (cfu/day)	--	--	4.00×10^{13}	--	--
Target Loads (cfu/day)	--	--	1.05×10^{12}	--	--
Percent Reduction	--	--	97.40%	--	--

Table 4: Flow and Load Estimates: Rio Grande (Percha Dam downstream to Leasburg Dam).

LOAD CALCULATION VARIABLES			FLOW CONDITIONS		
	High	Moist	Mid-Range	Dry	Low
Measured *E. coli* (cfu/100mL)	--	1,308	523	228,732	150
Mid-point flow (cfs)	--	826	490	133	28
Measured Loads (cfu/day)	--	2.65×10^{13}	6.29×10^{13}	7.45×10^{14}	1.01×10^{11}
Target Loads (cfu/day)	--	1.93×10^{12}	9.63×10^{11}	1.82×10^{11}	8.08×10^{10}
Percent Reduction	--	92.70%	84.70%	100%	20.20%

Table 5: Flow and Load Estimates: Rio Grande (Leasburg Dam to International Boundary with Mexico).

Exceedances in the reach from Percha Dam to Leasburg Dam only occurred under mid-range flow conditions (as determined by the flow duration curve). As a result, only a single TMDL was calculated indicating a percentage reduction to *E. coli* loading of 97 percent to meet water quality standards. However, for the reach from Leasburg Dam to the international boundary with Mexico, exceedance of the standard occurred under all but high flow conditions indicating a percentage reduction to *E. coli* loading ranging from 20.2 percent to 100 percent necessary to meet water quality standards (NMED, 2007).

The TMDL document concluded: "The duration curve method, by itself, is limited in the ability to track individual source loadings or relative source contributions within a watershed. Additional analyses is needed to identify pollutant contributions from different types of probable sources and activities (i.e., construction zone versus agricultural area) or individual sources of a similar source category (i.e., WWTP #1 versus WWTP #2). Practitioners interested in more precise source characterization should consider supplementing the duration curve framework with a separate analysis. An added analytical tool might aid in evaluating allocation scenarios and tracking individual sources or source categories. This could allow for improved targeting of restoration activities." (NMED, 2007)

River Hydrology and Impacts to Potential Pollutant Loading

The flow duration curve method used by NMED to determine the TMDL target loads is not an accurate representation of the flow regime in the Rio Grande from Caballo Dam downstream. While it provides a range of flow conditions and associated target loads for *E. coli*, it does not take into account the highly regulated flow below Caballo Dam. As mentioned in the Introduction, the Rio Grande in southern New Mexico is regulated for irrigation purposes. During the irrigation season (March to September), flow is determined by demand. Long-term flow records maintained by EBID show an average flow rate of 1,200-1,300 cfs above the Leasburg diversion and a flow rate of 500-600 cfs below the Mesilla diversion during the irrigation season. In the past, during years with abundant water supply, the river often continued to flow after termination of releases as a result of the hydrologic connection between the shallow groundwater table and the river. These flows were somewhere on the order of 20-30 cfs, depending on location. However, in recent years the shallow groundwater table has receded due to decreased recharge from limited irrigation releases and increased groundwater pumping to supplement the decreasing surface water supply. A consequence of this is that some of the drains have temporarily dried up, and most of the drains cease to flow following cessation of releases. Large stretches of the river also cease to flow. As such, when releases are terminated for the season, the main contributor to flow is either the system drains or point source discharges such as WWTPs. There can also be a minor contribution from small upwelling of deeper groundwater in specific areas.

Figure 20: Initial release of irrigation water into the Leasburg Canal, June 1, 2013.

As discussed previously, it has been determined that the primary driver for *E. coli* input to the river from Leasburg Dam to Caballo Dam is stormwater flow during the summer monsoon season which also coincide with flows released for irrigation (1,200-1,300 cfs). This roughly corresponds to the mid-range flows identified in the TMDL for this reach of the river. On the other hand, from Leasburg Dam to the international boundary with Mexico, it has been determined that much of the exceedance is more chronic in nature and not limited to stormwater flow. From Leasburg Dam to the international boundary with Mexico, two significant flows have been determined. The first is associated with base flow following cessation of releases (<20 cfs). The second is the flow associated with the average flow during the irrigation season (500-600 cfs). These flows correspond to the low and mid-range flows in the TMDL for this reach. As a result, the target loads associated with these flows are considered to take precedence over the others.

Load Analyses of *E. coli* at the Anthony Bridge and East Drain Sampling Sites, 2009-2010

At the Anthony 225 Bridge and the East Drain sites, which each have a gaging station, bacterial load analyses were performed to normalize the *E. coli* data reported during the source tracking survey to take into account flow rate differences between the river and the drain. Following the cessation of the irrigation season during the late fall and winter months, reservoir releases are terminated and flow in the river and drains is minimal. Only data from the summer months were chosen for analyses when flow rate data is most accurate. Though this analysis is limited to only five distinct samples over a two-year period, some interpretations can be made. The Anthony 225 Bridge site flow rate is significantly higher than that of the East Drain site (by a factor of 38), but the *E. coli* concentrations in the East Drain are similarly as big a difference (the drain on average had 32 times more *E. coli*, (Tables 6 and 7).

When these factors are integrated, the bacterial load in the drain is 82 percent of the load at the Anthony 225 Bridge site. East Drain discharges into the Rio Grande 2.3 miles south of the East Drain sampling site. Though the *E. coli* concentrations at this confluence are unknown, this means the East Drain could potentially almost double the daily load of *E. coli* in the river.

Date	*E.coli*	Flow	Daily Load
	cfu/100 mL	cu/ft/sec	cfu/day
6/30/2009	510	805	$1.00x10^{13}$
9/30/2009	400	243	$2.37x10^{12}$
8/24/2010	81	988	$1.96x10^{12}$
9/30/2010*	200	260	$1.27x10^{12}$
9/30/2010*	182	260	$1.16x10^{12}$
Average	275	511	$3.44x10^{12}$

*Table 6: E. coli daily loads at Anthony 225 Bridge on select sampling dates. * Represents duplicate samples*

Date	*E.coli*	Flow	Daily Load
	cfu/100 mL	cu/ft/sec	cfu/day
6/30/2009	4000	25.2	$2.46x 10^{12}$
9/30/2009	20000	9.5	$4.65x10^{12}$
8/24/2010	270	13.3	$8.81x10^{12}$
9/30/2010*	7500	9.2	$1.68x10^{12}$
9/30/2010*	11833	9.2	$2.66x10^{12}$
Average	8721	13.3	$2.81x10^{12}$

*Table 7: E. coli daily loads at East Drain on select sampling dates. * Represents duplicate samples*

Figure 21: Dairy manure piles and calf carcasses adjacent to the East Drain.

Both the Mesquite Drain and the East Drain run parallel and adjacent to the area known locally as dairy row (≈ 12 dairies) in the Mesilla Valley. Each dairy has in place a Nutrient Management plan to dispose of any land-applied waste that is on the facility or other land utilized by the dairy to grow crops to ensure protection of water resources. However, some of the manure is sold for use as fertilizer. There is currently little regulation governing this activity. On occasion, manure has been stockpiled adjacent to irrigation drains and canals which could facilitate movement into surface waters. In addition, as discussed in the Introduction, there have been reports of airborne distribution of *E. coli* in the literature, indicating the potential for unintentional distribution of *E. coli* without there being a discharge from a dairy. It is unknown if that is occurring here. However, given the close proximity of the drains to the dairies, occasional improper storage of manure, and the annual occurrence of high wind and dust storms, there is the potential for *E. coli* to enter either of the drains.

Estimating Pollutant Loads from Specific Sources

Pollutant load estimations allowed under the NPDES permit were calculated for the Sunland Park and South Central Regional WWTPs. Actual estimated daily loads for the WWTPs were calculated from direct measurements collected from the facility outfalls during the 2011 NMED survey. Daily loads were estimated for cattle, sewage, pet, and horse sources in the East Drain as well as horse sources in the Montoya Drain. The estimated daily loads for the East Drain were calculated from data collected during the source tracking study. The estimated daily loads for Montoya Drain were calculated utilizing agricultural census statistics and ground truth surveying. Estimates were determined using methods outlined in the *Protocol for Developing Pathogen TMDLs* (EPA 2001) (Appendix I).

WWTP Daily Load Estimates for E. coli

WWTP NPDES permit limits for *E. coli*
(discharge in mL/day)(126 cfu/100mL) = cfu/day
Sunland Park (7.57 x 10^9 mL/day)(126 cfu/100mL) = **9.54 x 10^9 cfu/day**
South Central Regional (3.97 x 10^9)(126 cfu/100mL) = **5.00 x 10^9 cfu/day**

WWTP Actual Estimated Loads from NMED sampling 2011
(discharge in mL/day)(observed cfu/100mL) = cfu/day
Sunland Park estimated load (7.57 x 10^9 mL/day)(705 cfu/100mL)= **5.34 x 10^{10} cfu/day**
South Central Regional estimated load (3.98 x 10^7 mL/day)(605 cfu/100mL)=**2.40 x 10^{10} cfu/day**

WWTP Estimated Load above permitted discharge (Actual – Permit)

Sunland Park**= 4.39 x 10^{10} cfu/day**
South Central Regional= **1.90 x 10^{10} cfu/day**

East Drain Daily Load Estimates for E. coli

East Drain (actual load from BST study)= **2.81 x 10^{12} cfu/day**
Cattle (14%)(2.81 x 10^{12} cfu/day)= **3.93 x 10^{11} cfu/day**
Sewage (13.3%)(2.81 x 10^{12} cfu/day)= **3.74 x 10^{11} cfu/day**
Pets (7.1%)(2.81 x 10^{12} cfu/day)= **2.00 x 10^{11} cfu/day**
Horse (12%)(2.81 x 10^{12} cfu/day)= **3.37 x 10^{11} cfu/day**

Montoya Drain (estimated from NMDA census statistics and field observation)

There are an estimated 2,206 horses in Dona Ana County (NMDA Census 2007). The primary concentration is in the vicinity of Montoya Drain, which runs adjacent to Sunland Park Race Track and was estimated to comprise 50 percent of the total (1,103). The *E. coli* load was estimated using a conservative assumption that 0.2 percent of the *E. coli* from 1,103 horses is discharged to Montoya Drain per day. One horse is estimated to produce 2.1 x 10^8 cfu *E. coli* per day (EPA 2002; Doyle and Erickson 2006).

Estimated Load transmitted to Montoya Drain = **4.62 x 10^8 cfu/day**

Estimated E. coli Load from Dairies

There are ≈ 20,000 dairy cows at the dairies adjacent to Mesquite and East Drains. One dairy cow is estimated to produce 5.0 x 10^{10} cfu *E. coli*/day (EPA 2002, Doyle and Erickson 2006). Utilizing a conservative assumption that 0.01 percent of the cattle-source *E. coli* is transmitted to drain (2 cows).

Estimated Load transmitted to East Drain= **1.00 x 10^{11} cfu/day**

The scientific literature and technical guidance documents related to mitigation of pollutants provide numerous examples of best management practices (BMPs) with various degrees of suitability and efficacy (Clary et al 2008,; C. Brozozoski 2012). In recent years, the term BMP has often taken on the connotation of structural implementation with the focus lost on management (Cudia 2012). The best mitigation plans include a balance of structural implementation with adaptive management plans and practices. The vast majority of stakeholders in a position to implement mitigation measures for *E. coli* in the watershed are land and water managers. Therefore, mitigation measures to reduce bacterial pollutant sources should focus on overall management strategies that provide a balance of structural implementation and integrative adaptive management.

As summarized in Chapter 4, exceedances of *E. coli* in the watershed can be separated into episodic (stormflow related) and chronic. The sources were further delineated by stormwater driven impacts in the upstream portions of the watershed (Leasburg Dam to one mile below Percha Dam), and chronic sources at the bottom of the watershed (International Boundary with Mexico to Anthony Bridge). The targeted management measures listed below were developed to address the chronic "hotspot" areas identified during the planning process, and all but one were designed to address specific sources at a specific location. Estimated load reductions for *E. coli* were calculated for each of the targeted management measures. A list of general management measures that address a range of watershed issues and water quality problems are also provided for use throughout the watershed to provide additional water quality benefits. Estimated load reductions were not calculated for the general management measures although potential for load reduction and benefits to water quality are presented.

Targeted Management Measures

WWTP Upgrades

The DMRs submitted under the NPDES permit requirements indicate the South Central Regional WWTP is in compliance for *E. coli* for the last three years. The DMRs submitted for the Sunland Park WWTP indicate that the plant has been out of compliance periodically for more than 10 years. The results of the NMED water quality survey suggest that there may be a bigger problem than indicated by the DMRs submitted by these facilities. WWTP upgrades are a priority mitigation measure identified in this plan to reduce the *E. coli* load to the Rio Grande in an effort to meet the TMDL.

Sunland Park WWTP(s)

The Camino Real Regional Utility Authority (CRRUA) was formed in 2009 to manage and operate the water and wastewater systems in Sunland Park, Santa Teresa and the adjacent unincorporated areas in southern Doña Ana County. As of 2012, CRRUA manages both the Main Sunland Park WWTP (Figure 22) and the North Sunland Park WWTP (formerly known as the Sunland Park-Santa Teresa WWTP). Both facilities are authorized to discharge to the Rio Grande under NPDES. A third plant located on the escarpment to the west of Sunland Park, the West Mesa/Santa Teresa WWTP, has a groundwater discharge permit issued by the state of New Mexico to land apply their effluent and does not currently discharge to the Rio Grande.

The North Plant was built in the 1970's and has a design capacity of 0.53 MGD. It has been receiving flows exceeding its design capacity since the early 2000's. As of 2012, it was receiving flows as high as 0.8-0.9 MGD, exceeding the hydraulic capacity of the facility. Due to the inability to effectively treat flows above the design capacity, the effluent from the North Plant (a mix of pre-treated water from the effluent holding pond and raw sewage) has been pumped to the Main Sunland Park WWTP for treatment since 2006. Combined with the growth of the community at large, this has placed an increased burden on the Main Sunland Park WWTP. Upgrading or replacing the North Plant is viewed as a priority to bring the Main Sunland Park WWTP into compliance.

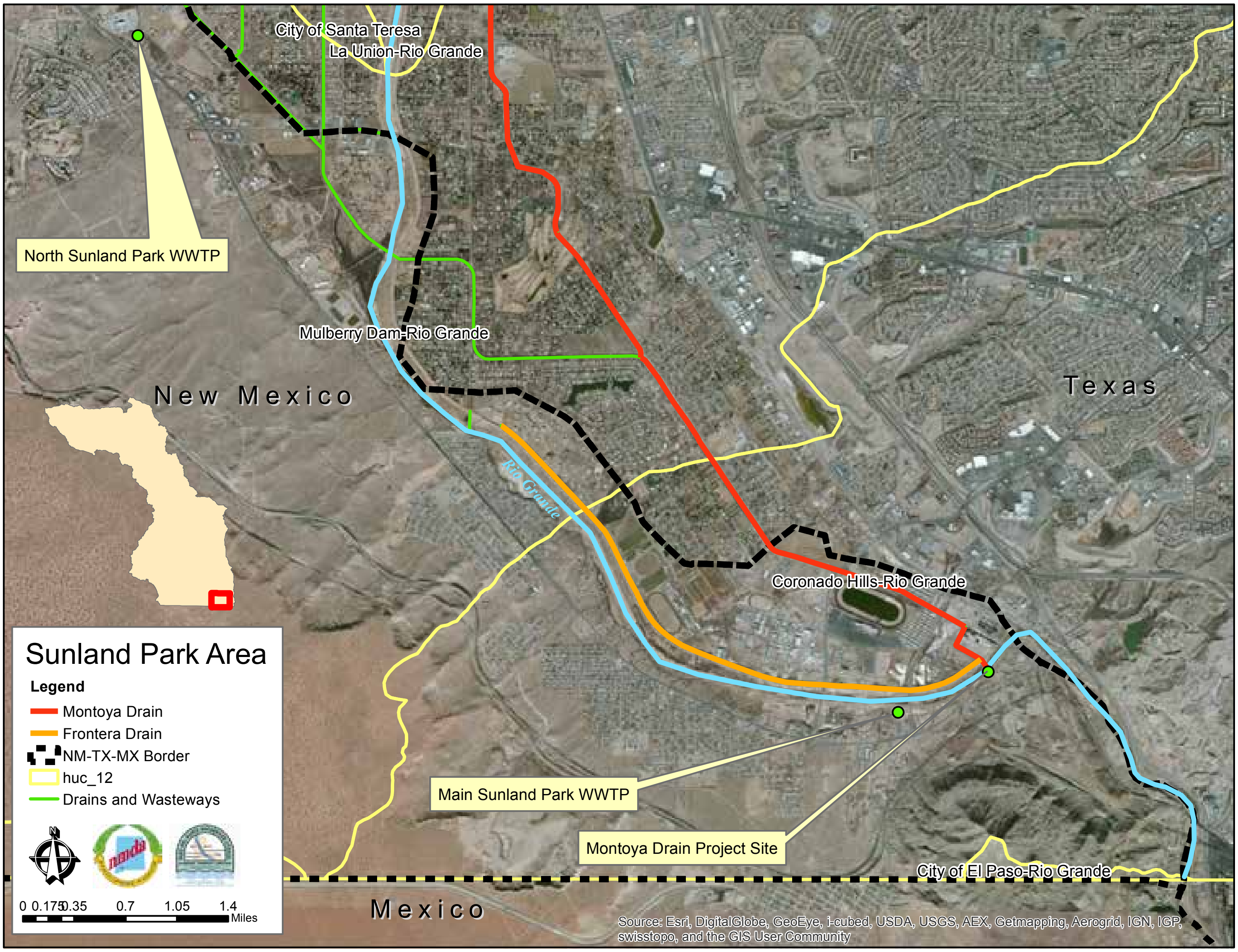


Figure 22: Targeted Management Measures in the vicinity of Sunland Park.

Plans to upgrade or replace the North Plant were initiated in 2009 by the City of Sunland Park. CRRUA has continued with those efforts and a plan to replace the plant has been developed. Plant designs are currently being reviewed by the USEPA and the NMED Constructions Program Bureau. CRRUA has requested financial assistance from the Border Environmental Cooperation Commission (BECC) under the USEPA funded Border Environmental Infrastructure Fund (BEIF) to replace the North Plant. A Technical Memorandum has been prepared that will be used in the acquisition of funding from the U.S. Department of Agriculture-Rural Development Agency, New Mexico Finance Authority's Colonias Program, and the North American Development Bank through BEIF.

Capital Outlay Requests were submitted to the 51st Legislature of the New Mexico House of Representatives. In 2013, $600,000 under HB 337 was authorized to repair, design and construct water and wastewater system infrastructure in the area. In 2014, $3,700,000 under HB 55 was authorized to plan, design and construct a new North WWTP. Both bills were approved and signed by the governor. The remaining funding will come from BECC. Contract bidding is anticipated for November 2014 with construction to commence in 2015.

South Central Regional WWTP

The South Central Regional WWTP has been in operation since 2003 and serves the communities of Vado, Del Cerro, La Mesa, San Miguel, Berino and Chamberino (Figure 23). The Village of Mesquite was added in 2012.

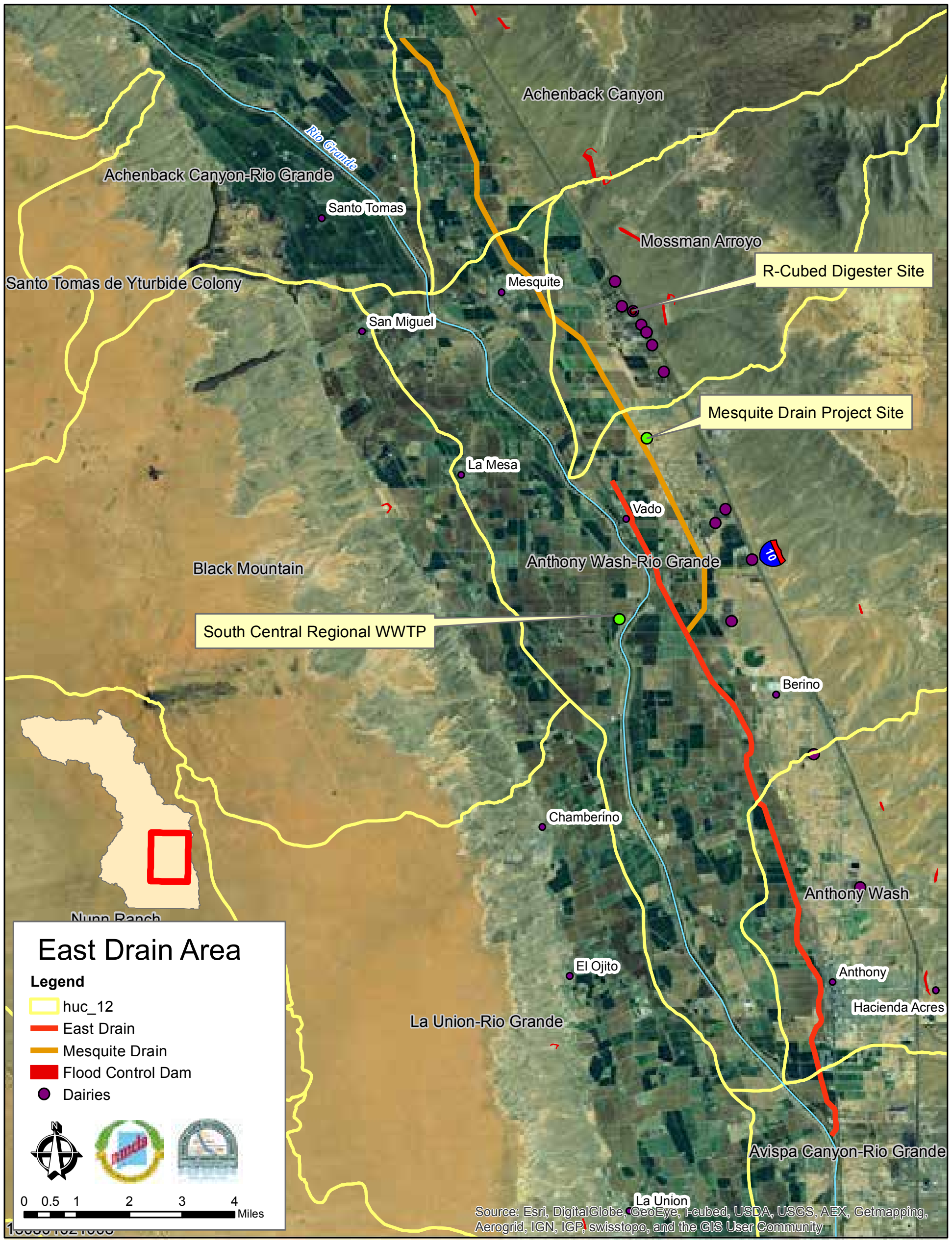


Figure 23: Targeted Management Measures in the vicinity of East Drain.

The communities are designated as Colonias, which are rural unincorporated subdivisions within 62 miles of the U.S.-Mexico border that lack adequate sewage systems and in some cases, decent, safe, and sanitary housing. During a facility inspection in August 2011, the operator indicated the plant had a periodic problem with disinfection since it was built (this is not reflected in the DMRs). The plant underwent a small facility upgrade in September 2011 that involved installing a new UV disinfection system. However, the South Central Regional WWTP faces some of the same challenges as Sunland Park with respect to increasing residential growth in the area. A thorough assessment of the efficacy of the upgrade of the UV system is recommended. DMRs submitted since that time, show that the system is in compliance, but that was the case prior to the upgrade when sampling in 2011 revealed discharges exceeding state water quality standards for *E. coli*. If the 2011 upgrade was insufficient to reduce *E. coli* to within water quality standards, then a facility upgrade supported by state and federal funding options is recommended for the South Central WWTP as well.

A Capital Outlay Request to expand and upgrade the facility was submitted during the 51st legislature of the New Mexico House of Representatives but failed to pass. Potential additional funding sources include: BECC under BEIF; the U.S. Department of Agriculture – Rural Development Agency, New Mexico Financial Authority's Colonias Program; and the North American Development Bank through the BEIF.

Constructed Wetland

Constructed wetlands that intercept storm flow, or are utilized as a final filtration for wastewater, are a proven tool to reduce *E. coli* loading. A primary function of wetlands is water purification including filtering of pathogens from stormwater. The design and placement of the constructed wetland is critical to achieve reduction. Improper design and placement can actually lead to an increase in *E. coli* (Clary et al 2008).

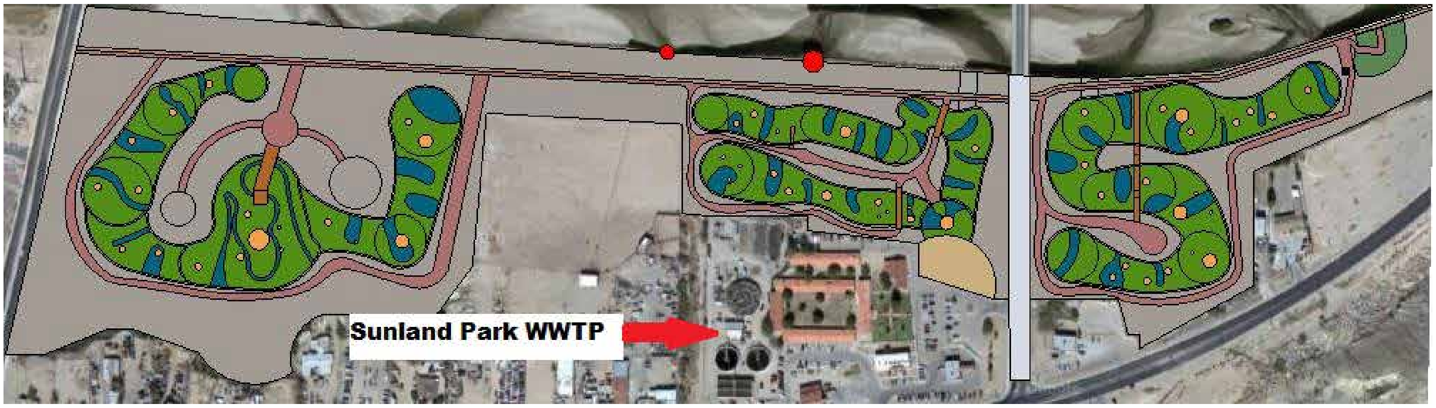


Figure 24: Proposed conceptual design of constructed wetland at the Sunland Park WWTP.

Constructed Wetland-WWTP Discharge Polishing

A feasibility study was conducted in 2011 on behalf of the Council to build a wetland to treat the Sunland Park WWTP effluent prior to discharge to the Rio Grande (Figure 24). The resulting study determined that the site had been a wetland previously and still retained the qualities that would improve viability of a successful project. The process for developing the proposed design included an analysis of removal rates for fecal coliforms as well as BOD, nitrogen, phosphorous and TDS. Potential drawbacks that were identified included mosquitos and increased fecal coliforms from birds drawn to the wetland. These were addressed with design criteria that included a multiple cell design, cell configuration, flow path and water level regulation. Specific detail was given to a sub-surface flow design prior to discharge to enhance removal of coliforms.

The project was also conceived as an outreach tool to promote awareness of large scale liquid waste management, present innovative techniques for treatment, the benefits of improved water quality, and the beniefits of wetlands and a healthy riparian community. Additional design criteria include elevated walkways, viewing areas and educational signs.

Constructed Wetland-Drain Modification

Agricultural drains serve to drain off excess water and salts from cropland that utilize flood irrigation by intersecting the shallow groundwater table and returning excess water to the river that supplies the water. As stated in the Introduction, the El Paso-Las Cruces watershed contains approximately 90,640 acres of irrigated agriculture with an extensive system of irrigation canals and agricultural drains crisscrossing the valley floor. As such, in addition to carrying agricultural return flow, the drains may also receive stormwater from the numerous arroyos that drain the surrounding watershed. Unfortunately, the drains have also been occasionally used as disposal sites for materials ranging from tree limbs to manure and trash.

Both the East Drain and Mesquite Drain have documented elevated levels of *E. coli*. The results of the source track analysis showed the highest level of *E. coli* in the study coming from livestock (31%) and sewage (13%) at the East Drain sampling site. The source of both the sewage and livestock *E. coli* in the East Drain is unknown. The source, both the host and where it is coming from, of elevated *E. coli* in Mesquite Drain is also unknown.

Modification of drain morphology to create a constructed wetland is an innovative approach that was developed by EBID in recent years out of necessity due to repeated structural damage to a drain by storm flows. The Selden Drain Habitat Restoration and Inline Storage Project was designed with three goals; to provide controlled release of storm flows; mitigation of *E. coli;* and to create wildlife habitat. It was completed in 2009 and involved reinforcing the drain at its confluence with Edwards Arroyo, widening the drain to create an overbank area, and installing a flood control gate. The depth of the original drain channel was kept intact to allow it to function as designed. The resulting small linear retention basin facilitates the attenuation of stormwater, reduces the volume through infiltration to groundwater and improves water quality.

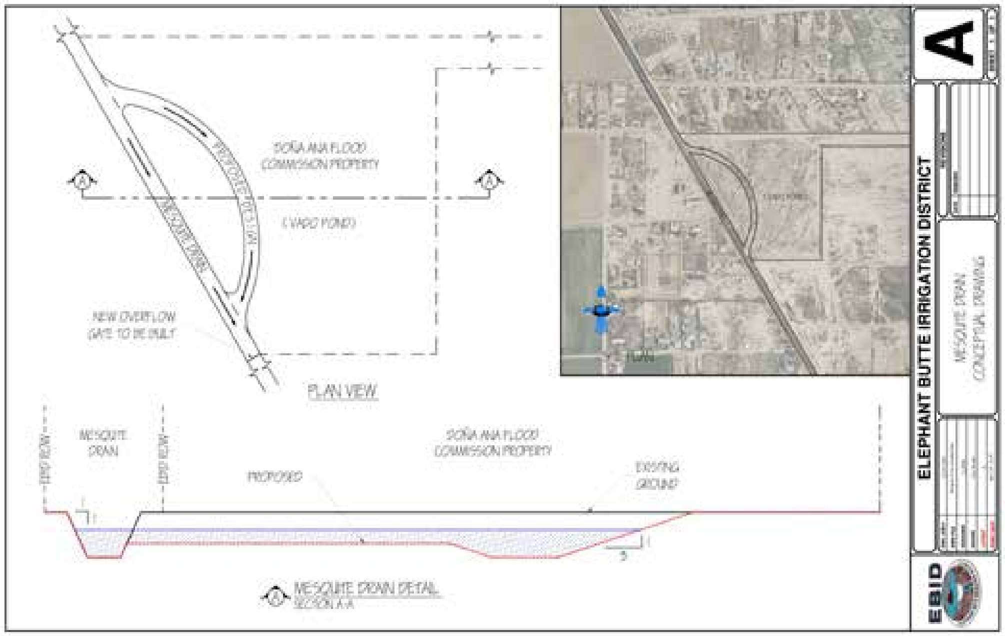


Figure 25: Conceptual design of overflow wetland for Mesquite Drain.

A similar project has been identified to be implemented along Mesquite Drain (Figure 23). The concept has been modified to include a wider floodplain with a secondary channel along the back side to create a sort of oxbow (Figure 25). The drain will be expanded into an adjacent shallow ponding area that already collects stormwater. The expansion will be below the grade of the existing area and provide an overflow ponding area for stormwater coming down the drain from upstream of the site. An overflow drop gate will be installed on the downstream end of the project to facilitate water retention and controlled release. The estimated retention time will increase from 0.3 days to as much as 12 days depending on the volume of the incoming flow. This will facilitate mitigation of *E.coli* by prolonged exposure to UV radiation and increased infiltration to groundwater.

A second drain modification project has been identified for the outlet of Montoya Drain located just downstream of the Sunland Park WWTP (Figure 22). Montoya Drain flows through a large concentration of horse farms and the east side of the Sunland Park Racetrack. This project also involves widening the drain, but leaves the drain free flowing without a drop gate. The widened area would be enhanced with wetland vegetation to improve the filtering capability of the project.

Dairy Waste Management- Manure Digester

Both the Mesquite Drain and the East Drain run parallel, and adjacent to, the area known locally as dairy row (≈ 12 dairies) in the Mesilla Valley of New Mexico (Figure 23). The close location of the drains to the dairies, and the annual occurrence of high wind and dust storms, there is the potential for *E. coli* to enter the drain. Some of the manure is also sold and, at times, has been stockpiled adjacent to the drains. Any efforts at improving manure management at the dairies may have a beneficial impact on mitigating *E. coli* in the drains. A development that has occurred since beginning work on this watershed plan is a proposal to install a manure digester to process manure generated by the dairies. This is a separate and distinct effort from work conducted or suggested by the Council and will incorporate a facility that promotes an economical and efficient method of solid waste and liquid waste recycling through anaerobic digestion and composting. Animal solid and liquid waste from dairy cow herds will be transformed into electricity, ammonium products, fertilizer, and compost. The primary impact will be to reduce nutrient impacts to groundwater with a secondary impact of improving water quality in the drains. This effort is supported by the stakeholders as a viable alternative to current dairy waste management. The digester will be privately funded. Additional support to assist producers (dairies) to upgrade facilities to be compatible with the digester will come from National Water Quality Initiative funds under the New Mexico Natural Resources Conservation Service Environmental Quality Incentives Program.

Combined Enforcement Activities and Stakeholder Outreach

As noted above, illegal dumping of manure in the drains has been recognized as a source of fecal contamination.

The physical complexity of the agricultural drainage system, the large surface area it encompasses (both rural and urban) and lack of resources for a comprehensive oversight and enforcement program presents a significant hurdle in mitigating *E. coli* pollution from illegal dumping. A two pronged approach is in development that would combine a cooperative enforcement effort between NMED and EBID and stakeholder outreach.

Beginning in the summer of 2013, NMED and EBID began working jointly to investigate complaints of illegal dumping of manure into the agricultural drains (Figure 26). In the first six months of this effort, three notices of violation were issued by NMED followed by similar notices sent by EBID. These all involved the dumping of horse manure. All three cases were successfully resolved with voluntary cleanup by the alleged violators. The stake-holder outreach component of this BMP will provide information on the importance and function of agricultural drains and issues related to illegal dumping.

Figure 26: Joint NMED and EBID enforcement with succesful outcome. Horse manure and bedding materials placed adjacent to West Drain (top). The pile was 800'x30'x18". A closeup of manure in West Drain at the site (middle right) and following cleanup of the site (bottom).

Potential Load Reductions from Targeted Management Measures

Load reductions for *E. coli* were estimated for all targeted management measures to be implemented in the Rio Grande between Anthony, New Mexico and the international boundary with Mexico (Table 8). Estimated daily loads for the WWTPs were calculated from direct measurements collected from the facility outfalls during the 2011 NMED survey. The estimated daily loads for the East Drain were calculated from data collected during the source tracking study. Estimated daily loads for Montoya Drain were calculated utilizing agricultural census statistics and ground truth surveying. Reductions for management measures were calculated utilizing a combination of data collected from the surveys, and accepted value constants for bacteria found in scientific literature. For a complete description of the process see Appendix I.

SOURCE	ESTIMATED LOADS (cfu/day)	REDUCTION FROM MANAGEMENT MEASURES (cfu/day)		
		WWTP	Manure	Constructed Wetland
		Upgrade	Mgmt.	Drain Modification
Sunland Park WWTP*	5.34×10^{10}	4.39×10^{10}		1.34×10^{10}
South Central WWTP	2.40×10^{10}	1.90×10^{10}		
East Drain	2.81×10^{12}		1.00×10^{11}	7.03×10^{11}
Cattle	3.93×10^{11}		1.00×10^{11}	9.83×10^{10}
Sewage	3.74×10^{11}			9.35×10^{10}
Horse	3.37×10^{11}			8.43×10^{10}
Pets	2.00×10^{11}			5.00×10^{10}
Montoya Drain				
Horse	4.62×10^{8}			1.16×10^{8}

Table 8: Expected load reductions from targeted management measures addressing specific sources at a specific location.

Estimating load reductions from the combined enforcement efforts and stakeholder outreach is speculative. However, it is clear that these activities will have a beneficial impact on a major source of *E. coli* to the system. Based on the current success of the combined enforcement efforts alone and considering only horse manure, a conservative load reduction estimate assumes decreasing the load by 2 horses/day and yields a load reduction of 4.2×10^{8} cfu/day *E. coli*.

General Management Measures

A comprehensive watershed plan includes a complete analysis of available and practicable management and mitigation measures to improve the health of the watershed. The following is a summary of BMPs recommended by the stakeholders to improve water quality and watershed health. These include industry standard BMPs, BMPs specifically developed for the local environment and conditions, and several comprehensive management plans directed at improving watershed health. Given the broad scope of application for these management measures, load reductions were not calculated. However, load reductions can be estimated in the future on a sub-watershed scale prior to implementing a given management practice to a specific area. Load reduction potential is presented in Table 9 at the end of this section.

These management measures are primarily directed at mitigating the impacts from stormwater. These stormwater management measures address three main factors: flow control, pollutant removal, and pollutant source reductions to control NPS pollution and reduce *E. coli* input to the receiving stream in both rural and urban settings. Traditional stormwater management is aimed at conveying stormwater away from infrastructure or property in the most efficient way possible and delivering the water downstream. In this scenario, water is viewed as a nuisance (Kaspersen 2013). Much of the benefit of infiltrating water back into the groundwater table is lost. It also efficiently delivers increased pollutant loads to the receiving stream. New developments in stormwater management promote water infiltration, reduce pollutant loading, and decrease the capital outlay investment of large stormwater collection systems. This plan recommends an integrated watershed management approach to stormwater management that utilizes new approaches coupled with traditional methods and new innovative techniques. The following management measures have been included in this plan to improve stormwater management and water quality.

Detention Basins- Existing Detention Basin Repair

Detention basins are a proven effective method of mitigating numerous forms of pollution by increasing infiltration and reducing the head, as well as the volume, of storm flow entering the receiving stream. Detention basins with short detention times, which are typical for this region, should increase mortality of E. coli resulting from increased exposure to UV light and increased infiltration. This is not always true in wetter environments where infiltration is low and the water persists. Because there are a wide variety of detention basin designs depending on the location, specific design elements are not presented here.

Development of new detention structures is expensive. There are currently numerous aging detention basins in the watershed that are in need of repair. Under the Watershed Protection and Flood Prevention Act (PL-566), the approximately fifty dams installed in the 1960s in the watershed have exceeded their intended lifespan. Dams not hydrologically connected to the Rio Grande or a tributary would not mitigate *E. coli* pollution in the river. However, some of these structures are hydrologically connected to the Rio Grande and maintenance and repair is warranted as an effective tool for reducing storm flow and mitigating *E. coli*. There are four specific detention dams that may be of particular importance; Apache-Brazito Dams 1-4, east of Interstate 10 near Mesquite, New Mexico, that discharge their tailwater into Mesquite Drain may be in need of upgrade to obtain maximum efficiency.

Main Stem Rio Grande Management Practices

The USIBWC is the agency charged with maintaining the levees and the floodplain between the levees on the Rio Grande within the El Paso-Las Cruces watershed. In March 2009, the USIBWC released a document outlining various restoration projects for implementation on the main stem of the Rio Grande. A few restoration projects with the potential to mitigate *E. coli* have been developed. A template for these designs can be found in the *Conceptual Restoration Plan and Cumulative Effects Analysis, Rio Grande—Caballo Dam to American Dam, New Mexico and Texas* (www.ibwc.gov/EMD/CanalizationWebpage/RestPlanMarch2009.pdf) commissioned for the USIBWC.

Sub-watershed Management Practices

As indicated in Figure 6, the BLM is the largest landowner in the watershed, managing over 343,134 hectares (847,899 acres). They are primarily uplands but cover many of the 64 12-digit HUC sub-watersheds. The BLM has recently released the *TriCounty Draft Resource Management Plan (RMP) and Draft Environmental Impact Statement (EIS)* for Otero, Sierra and Doña Ana counties which include the El Paso-Las Cruces watershed. This is a comprehensive plan which will guide management of BLM lands in the watershed for the next 20 years. It includes a variety of alternatives for watershed management to improve watershed health. Two management practices identified beneficial to this watershed plan are vegetative management and grade control.

Vegetation Management

Vegetation management in the watershed is primarily directed at restoring native grasslands to increase gound cover. Grassland restoration is difficult in this arid region. However, the BLM has had success under their Restore New Mexico Program to restore upland rangeland. The benefits include decreased sheet flow, increased infiltration, decreased runoff and associated contaminants, reduced erosion and development of a healthier biotic community in the watershed. For further information see http://www.blm.gov/nm/st/en/prog/restore_new_mexico.html.

Grade Control/Stabilization Structures

Grade control and stabilization structures are a useful management tool to reduce ersosion in degrading arroyo systems that the BLM employs to reduce flood velocity, capture sediment, and reduce impacts from erosion. They are also effective at slowing storm flow and increasing infiltration. They are sited on a case by case basis following assessment of individual sub-watersheds.

Domestic Pet Waste Management

It is a common practice throughout the watershed to walk dogs for recreation and exercise. As noted earlier, pet waste does contribute *E. coli* to the river. Particular areas of concern are recreation areas along the river and the network of irrigation ditches, which are both favorite areas to walk dogs. Owners can be encouraged to be responsible and pick up after their dogs and properly dispose of the waste by the following actions:

- Post signs encouraging residents to pick up after their pet
- Provide small bags for waste collection near riparian recreation areas
- Provide trash cans for waste disposal
- Support dog waste cleanup events in areas near surface water.
- Conduct educational outreach to pet businesses and organizations such as kennels, animal control, etc.

Liquid Waste Management

- Connect residents to a centralized sewer system
- Tighter liquid waste hauler regulations
- Septic system upgrades

Green Infrastructure/Low Impact Development

Green infrastructure is an interconnected network of natural areas and open spaces. By preserving and restoring natural landscapes (planting vegetation, establishing natural flow areas), communities can improve water quality while providing outdoor recreation areas and wildlife habitat. On a small scale, practices include rain gardens, porous pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting. Benefits of green infrastructure include reduced and delayed runoff, enhanced ground water recharge, storm water pollutant reductions, reduced sewer overflow events, reduced air temperatures, creation of wildlife habitat and green space, improved human health, improved air quality (plants remove carbon dioxide), and increased land values.

Low Impact Development (LID) practices are now being implemented in urban areas to decrease pollutants in fresh water, increase the use of stormwater for irrigation, and maintain the effectiveness of flood water distribution. LID is effective in new development, reconstruction, and as retrofits in existing development; in other words, LID can be implemented almost anywhere at any time to fit the needs of urban growth and development (Canavan 2010). A few LID methods are used on a municipal level to reduce flooding and pollution. Permeable pavements, green parking lot and highway medians, and vegetated swales are all types of urban infrastructure designed to divert storm water runoff into the surrounding soil. This type of infrastructure is beneficial in a multitude of ways, providing urban developments with natural growth and beautiful landscapes while preventing both flooding and impacts from NPS pollutants.

Rainwater harvesting incorporates many aspects of green infrastructure and LID and can be implemented on both the large and small scale. There are a wide variety of techniques and strategies. A few of them are mentioned here.

Cisterns

Cisterns harvest rainwater that can be used to collect water for potable use or to water indoor and outdoor plants. Harvesting water for potable use can be high tech and expensive, but simple systems can be installed to augment water used for plants. As with all water capturing systems, cisterns reduce the amount of stormwater leaving a site.

Rain Gardens, Bioswales

Rain gardens or bioswales are depressions that naturally harvest rainwater. They reduce or eliminate the need for supplemental water by using native vegetation. Rain gardens not only provide a beautiful addition to the landscape but they also help to prevent flooding in a way that reduces pollution in fresh water.

Figure 27: Rain garden in Mesilla, New Mexico.

Figure 28: Detention basin serving as a park in Mesilla, New Mexico.

Small-scale detention basins – Parks

It has become a common practice to create small green space areas when installing a detention basin and there are examples of this practice on both the small and large scale within the community. This management practice should be encouraged and incorporated into community planning when practicable.

Permeable pavements/walkways

Permeable pavement and walkways are made of porous materials that promote infiltration and reduce sheet flow runoff. They can be as small scale as a patio or larger projects such as sidewalks and parking lots. This provides the benefits of reducing storm flow, improving infiltration, and reducing the associated pollutant load to surface waters.

Figure 29: Curb cuts in a parking lot providing irrigation to median.

Curb and Gutter – parking medians, road medians

Rather than raising sidewalks, medians, and curbs, one method is to lower or make them the same height as the road, allowing water to naturally irrigate adjacent landscapes. Another technique is to place cuts in existing curbs and install new curbs with gaps if a more traditional curb and gutter system is desired. This reduces runoff, allows water to infiltrate and reduces the associated pollutant load to surface waters.

Further Develop the Vision 2040 Regional Strategy

Anthony, Hatch, Las Cruces, La Mesilla, and Sunland Park, in a cooperative effort with Doña Ana County and local stakeholders, have developed a regional plan entitled *One Valley, One Vision 2040* (City of Las Cruces, 2011) that encompasses many factors of the growing community. It includes sections on land use, water demand, transportation, housing, utilities and infrastructure, economic growth, the environment, and quality of life. It is a comprehensive document with many general strategies and ideas including promoting water quality, stormwater management, and the principles of LID. The ideas and strategies in the document should be further developed and built upon to improve community buy in and support from the real estate community, the construction and business community, and local governments. The Vision 2040 website and document can be accessed at http://www.las-cruces.org/code/vision_2040/index.html

The Potential for *E. coli* Loading Reductions from General Management Measures

Pollutant loading in the watershed upstream from Leasburg Dam is primarily related to storm related runoff that can best be described as flash flooding. The population density and anthropogenic activity of the surrounding uplands is low. The abundant course-grained, bare soils throughout the watershed restrict infiltration and increase surface runoff. Mitigation measures are restricted in this broad landscape, and load reduction potential is expected to be minimal. Since there is inherent variability in the efficacy related to each of these management measures regarding drainage area, placement, size, BMP efficiency, etc., discreet load reduction values were not directly calculated. Project specific load reductions should be calculated for any future mitigation project development using the guidance provided with this plan. Load reduction potentials are presented in Table 9. The table is derived from a technical manual titled *A Manual of Conservation Practices to Reduce Pollution Loads Generated from Nonpoint Sources*, prepared by Tetra Tech (2004) in cooperation with the Natural Resources Conservation Service (NRCS), and provides a summary of BMPs for pathogenic NPS pollution.

The manual is a useful tool and identifies BMPs that can be used to abate NPS pathogenic pollutants primarily in an agricultural setting. Each BMP has multiple benefits that extend beyond controlling pathogenic pollutants and includes controls for nutrients, salinity, sedimentation, erosion, and several others. Management levels, projected load reduction potentials, targeted sources, and treatment areas are just some of the types of information provided by this guide. The manual suggests that these practices can be implemented in areas immediately adjacent to the stream channel or water body and in upland areas. It also advises that multiple practices be implemented in chorus to maximize the effectiveness of pollution control.

BMP	Level of Effort Needed	Load reduction potential	Time for load reduction	TMDL sources	Other pollutants addressed	Treatment areas
Pet waste management	Active management	low	up to 2 years	domestic pets activities	nutrients low dissolved oxygen	Urban areas, parks, irrigation, canals
Main stem restoration	Active management	moderate	up to 2 years	drain and irrigation wasteways	sediments, nutrients	USIBWC floodway and EBID system
Detention basin	Moderate engineering	high	immediate	animal feeding, disturbed areas, storm water	sediments, nutrients, pesticides	Arroyos, urban drainages,
Sub-watershed restoration	Moderate engineering	low	up to 2 years	rangeland, rural drainages	sediments	Range uplands
Liquid waste infrastructure	Intense engineering, regulations	high	up to 2 years	septic systems, liquid waste haulers	sediments, nutrients, salinity, heavy metals, pesticides	Non-incorporated county, rural
Constructed wetland	Intense engineering	medium	up to 2 years	animal feeding, industrial sourc-es, storm water	sediments, nutrients	WWTPs, drains, wasteways, subdrainages
Regional strategy development	Intense engineering	medium	Greater than 5 years	stream erosion, ag practices	sediments, nutrients	Agricultural lands
Green infrastructure LID	Engineering, active management	medium	Greater than 5 years	urban areas, impervious surfaces, storm water	sediments, nutrients, low dissolved oxygen dissolved oxygen, water temp	Streamside, agricultural lands
Waste utilization	Active management	low	immediate	animal feeding ops, ag practices sediments, nutrients, pesticides	sediments, nutrients, pesticides	Agricultural lands

Table 9: Summary of general BMPs to address pathogenic NPS pollution.

Chapter 6 OUTREACH PROGRAM

The goal of the Outreach Program is to inform stakeholders and the general public about water quality issues in the Rio Grande, and encourage active stakeholder participation in the development of the watershed plan. The objectives are to provide a framework to educate the public on local water quality issues (community awareness), gain stakeholder insight on the nature of the identified water quality issues, obtain stakeholder participation in the development of BMPs to address the identified water quality impairment, and to encourage the use of the BMPs prescribed in the watershed plan. As part of this process, the Council encourages active participation in the wider variety of watershed issues undertaken by Council activities with a goal of increasing Council membership. To facilitate this initially, an innovative approach was used to engage stakeholders through individual stakeholder interviews. These were followed by the development of larger stakeholder meetings that eventually developed into a stakeholder working group.

Initial Outreach Efforts 2006-2007

The Council launched its outreach/education program in Phase I of the watershed planning process in the spring of 2006. Stakeholders were engaged in a program to understand the watershed planning process and solicit meaningful input to the 319(h) water quality project, taking into consideration the limited understanding of probable sources of the bacterial impairment at the time.

Key Informant Interviews

Key informants were identified who have a direct managerial capacity related to the probable sources of impairment in this section of the river. The Outreach Coordinator conducted interviews to learn more about management issues, gain respect and trust from each stakeholder group, and provide a balanced narrative for other stakeholders to learn about each other. Each key informant was interviewed and asked then following series of questions:

- Can you describe the general management practices and guidelines used in your work related to watershed protection? What is the geographic scope?
- What are some of the management practices that have been most effective?
- What are some of your constraints?
- How is information communicated within your area? What are sources of information for you?
- Who is involved in this process?
- Do you have any write ups on this project? Or a website?
- Is GIS and data part of the scope of your work?
- How can our work best complement yours? Are there any considerations that are important to you that we include in writing the WBP?
- Who do you feel might best represent your interests in creating a stakeholder committee that develops criteria for next steps and recommended BMPs?

Neighborhood Conversations

The Outreach Coordinator also engaged additional stakeholders on a neighborhood basis to formulate a priority list of bacterial problems in the watershed. Numerous neighborhood associations throughout the project region that represent various socioeconomic subgroups were approached to discuss such considerations. Residents in

Del Cerro/Vado, near the Armijo Drain in Las Cruces, the West Mesa in Las Cruces, and Radium Springs were approached. This process facilitated communication with individual stakeholders at a different level and yielded valuable information concerning what is required to engage the public in the watershed planning process and to address their concerns. In summary, neighborhood residents wanted the problem to be strategically addressed to motivate others through health concerns, avoid punitive actions, and to encourage grassroots approaches.

Stakeholder Events

Meetings were facilitated throughout the region in order to capture a sense of how local stakeholders viewed the most effective way to address bacterial problems in the river. Two larger stakeholder events were held following the individual interviews. During the first event, stakeholders were presented with a synthesis of the water quality data analysis, a biological perspective of the watershed, and a summary of stakeholders' concerns. Participants were asked to provide input to an approach for future investigations of water quality impairments as well as for developing criteria for BMP options in the watershed. Although there were discussions about the value of a healthy living river that was swimmable and fishable, there was no firm commitment to more ambitious strategies for watershed restoration given the lack of firm data and many of the stakeholders' unfamiliarity with data analysis and its relationship to ecological health. The second event focused on biological characteristics of the watershed to stakeholders. Also presented were BMP practices from Tetra Tech's, *A Manual of Conservation Practices to Reduce Pollution Load Generated from Nonpoint Sources* (2004). The following list is a summary of events that occurred during this time period.

- Discussions and interviews with individual stakeholders.
- Six stakeholder neighborhood conversations.
- Meeting April 24, 2007, hosted by the Council to discuss issues with the 319(h) project.
- Meeting May 17, 2007, in Las Cruces concerning water quality data.
- Meeting June 19, 2007, in Las Cruces concerning biological characteristics.
- Watershed tour May 5, 2007, along the Rio Grande from Selden Canyon downstream to Gonzales Dairy in Vado, New Mexico, with stops at Hot Springs Hotel and Selden Canyon, Leasburg Dam, Kerr Irrigation Lateral, Burn Lake, Las Cruces WWTP outfall, Mesilla Valley Bosque State Park, and Mesilla Dam.
- Throughout this period, progress on the 319(h) project was developed with oversight and suggestions from the Council's Clean Water Subcommittee (22 meetings) and at Council meetings that occurred approximately every six weeks.

Watershed Tour, 2007

The watershed tour in summer 2007 was hosted by the World Wildlife Fund and NMDA. The tour was led by Dr. Phil King, Professor and Associate Department Head of Civil Engineering at New Mexico State University (Figure 30). The watershed tour presented stakeholders with a visual representation of water quality issues from Selden Canyon to the Gonzales Dairy in Vado. The issues discussed ranged from salt cedar removal to wild arroyos and agricultural water infrastructure. Land management responsibilities, sediment transport, flooding, water monitoring, irrigation efficiencies, septic systems, and WWTPs were also topics of discussion as the group traveled south through the watershed. Besides providing

Figure 30: A stop at Mesilla Dam on the watershed tour, 2007.

an interdisciplinary forum to view watershed issues, the tour strengthened stakeholder relationships as they recognized the value of everyone's input through scheduled commentaries throughout the tour.

Outreach, 2010 – 2012

Stakeholder Working Group

Water quality stakeholders were engaged, and a stakeholder working group was developed. They met regularly to discuss the watershed planning process, water quality issues, and potential remediation practices that could lead to improved water quality in the Rio Grande. Participating agencies/entities on the 319(h) Stakeholder Working Group included representatives of EBID, USIBWC, NMED, NMDA, Doña Ana County, Doña Ana Flood Commission, New Mexico State Parks, Doña Ana Soil and Water Conservation District, the City of Las Cruces and the BLM. In addition, a local rancher and contractor both provided essential input.

Figure 31: The stakeholder working group discussing the nature of E. coli as an impairment and strategies to develop a watershed based plan.

Development of Informational Materials

Informational materials were developed for education and outreach, including a factsheet about the 319(h) project, *E. coli* as a water quality parameter, BMPs, and general watershed education. Presentations were given at multiple events that described the Council, the watershed planning process, the NPS problem in the Rio Grande, water quality data and results, and pathogenic NPS remediation practices. Posters were developed for multiple age and focus groups; posters displayed facts about the watershed including geography, function and water quality modeling, *E. coli*, and water quality improvement practices. Display materials for the Council's booth were updated for use at outreach events. Topics included the Council, the Rio Grande, the watershed planning process, and water quality. An Enviroscape™ watershed model was purchased to demonstrate basic watershed functions, multiple point source and NPS pollution sources, impacts of rainfall, and pollution prevention techniques. Council water bottles were distributed at events throughout the life of the project. Monthly newsletters were disseminated that included information about point source and NPS pollutants in the watershed and provided tips on remediation activities that members of the community could adopt to reduce watershed pollutants. The Council's website is still maintained with information about the 319(h) project, monthly newsletters, meetings and events. The website contains pertinent documents, informational handouts, the Outreach Coordinator's monthly newsletter (the "Coordinator's Corner"), and other informational website links.

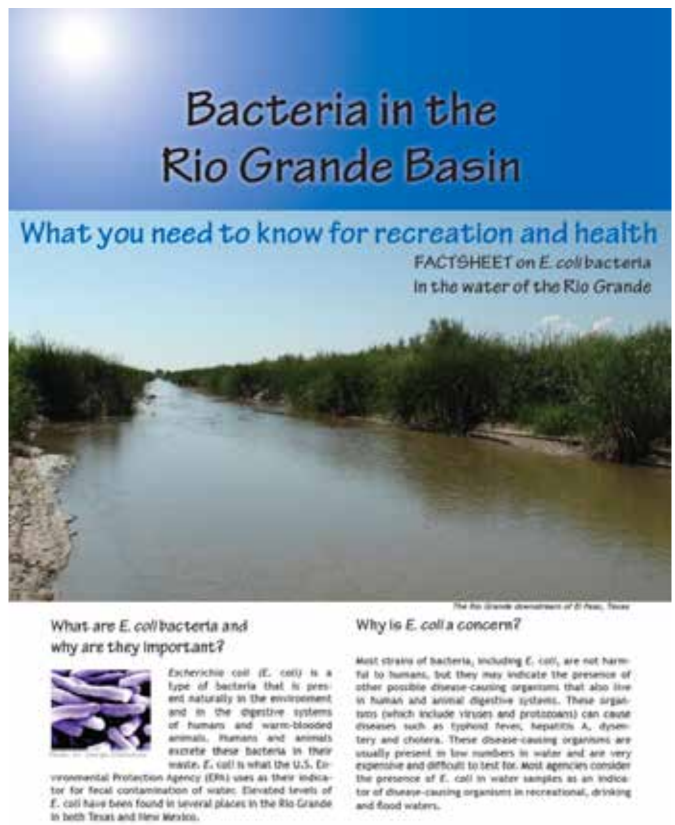


Figure 32: Cover of the Bacteria in the Rio Grande Basin *brochure.*

Mulitimedia presentations about the 319(h) project were provided to the following groups:

- USEPA staff on a Paso del Norte watershed tour (August 30, 2010).
- National Audubon Society volunteers (September 18, 2010).
- New Mexico Chapter of the Wildlife Society (September 21, 2010).
- New Mexico Watershed Forum (September 24, 2010).
- Doña Ana Soil and Water Conservation District (January 13, 2011).
- Caballo Soil and Water Conservation District (March 30, 2011, and April 25, 2012).
- USIBWC's Rio Grande Citizen Forum in El Paso, Texas, (December 13, 2010) and in Las Cruces, New Mexico, (January 19, 2011, and January 16, 2013).
- Mesilla Valley Audubon Society (February 15, 2011).
- U.S. Green Builders Council, Chihuahua Desert Chapter (October 25, 2011).
- Texas Watershed Steward Workshop in Socorro, Texas, (May 9, 2012).

Outreach Events, 2010-2012

- Watershed tour of the lower Rio Grande from Selden Canyon downstream to Las Cruces (November 19, 2010).
- River Day at the New Mexico State Capitol in Santa Fe (March 14, 2011).
- Franklin Mountains Poppies Celebration in El Paso (March 26, 2011).
- Earth Day in Las Cruces (April 16, 2011).
- Raft the Rio on the Rio Grande at Las Cruces (June 11, 2011).
- Whole Enchilada Fiesta, Las Cruces (September 23-25, 2011).
- Dia del Rio event at Mesilla Valley Bosque State Park (August 12, 2011, and August 6, 2012). Students collected water quality samples and learned how to test them. The Outreach coordinator and members of the Council talked to several school classes about surface water quality. This was part of a Rio Grande basin-wide water quality sampling project.
- NRCS Conservation Planning Day at Triple D Farms, Anthony, New Mexico, (February 15, 2012).
- Water Festival in Las Cruces at Young Park (March 15, 2012). Approximately 1,000 second and third grade students attended to learn about water resources. The Outreach Coordinator and staff from the City of Las Cruces demonstrated the NPS watershed model.

Watershed Tour, 2010

The watershed tour in November 2010 was held for stakeholders and Council members and began at the Radium Springs Community Center with several presentations on a variety of issues related to understanding watershed processes. Gary Esslinger, Manager of EBID, provided background on the nature of the irrigation system and challenges the community faces from flooding and stormwater management. Dr. King discussed changing weather patterns, flooding and innovative approaches to flood control. Hilary Brinegar with NMDA and a member of the Executive Committee of the Council, laid the groundwork for understanding the steps in developing a watershed based plan to address the *E. coli* impairment in the watershed. The tour vis-

Figure 33: A stop on the 2010 watershed tour at the Selden Drain Project, an agricultural drain modified to reduce flooding while mitigating NPS pollution (Selden Drain is in the background).

ited four sites along the Rio Grande starting at Broad Canyon to look at riparian restoration activities. The group then proceeded south to the Selden Drain Habitat Restoration and Inline Storage Project where Dr. King provided an overview of the project design and function. The third stop was back along the river where the USIBWC discussed a proposed project from their *Conceptual Restoration Plan and Cumulative Effects Analysis, Rio Grande—Caballo Dam to American Dam, New Mexico and Texas.* The tour ended at La Llorona Park on the Rio Grande with a group discussion about stormwater management and septic systems. The tour was attended by over 30 stakeholders and was a big success.

Figure 34: At the final stop of the 2010 watershed tour Peter Bennett with the City of Las Cruces discusses managing NPS pollution in Las Cruces at La Llorona Park on the Rio Grande.

Potential Future Outreach Campaign for the Paso del Norte Watershed

Outreach efforts in the lower Rio Grande have indicated a broad concern for water quality and a willingness to work toward improving the condition of the river. Future outreach should build on prior efforts and have several important components for engaging and educating stakeholders on water quality, data analysis, and mitigation practices. This should include the following initiatives:

- Provide continued general watershed outreach that addresses overall health of the watershed by providing basic information on the problems and solutions. This should include several target audiences such as targeted stakeholder groups and students at the elementary, middle, and high school levels.
- Develop outreach materials that provides information on the importance and function of agricultural drains and issues related to illegal dumping. Develop an associated distribution plan to reach a maximum target audience.
- Continue hosting stakeholder meetings quarterly or semiannually to review success and failures to ensure an adaptive management approach in addressing the water quality goals.
- Provide e-mail updates to stakeholders on mitigation projects and progress.
- Maintain the 319(h) project webpage with current updates on the Council's website.
- Improve understanding of contamination by creating a Citizen's Water Quality Monitoring Program.
- Highlight successful BMP implementation to recognize accomplishments and encourage wider participation.
- Continue encouraging wider stakeholder participation in the Council by hosting a series of lectures that would be useful to targeted stakeholders.

Engaging stakeholders during the BMP implementation stage should involve linking up with neighborhood associations, community centers, and civic organizations to invite participation. This could mean "adopting" restoration wetland and buffer strip sites by making seed balls, planting and weeding, and performing general maintenance. Agencies and organizations with expertise and experience (such as the Soil and Water Conservation Districts, the NRCS, and other local professionals) in developing BMPs that improve impairments should be promoted to stakeholders and supported collegially and, if possible, financially. A water quality conversation series is another strategy for engaging water quality stakeholders. Table 10 displays target audiences and possible topics for discussion.

Site	Topic	Target Audience	Details
Fort Selden State Park	BMPs to reduce bacterial loading	Homeowners, ranchers	Rangeland and septic issues
City of Las Cruces	BMPs for housing devel-opments along arroyos	Developers, Homeowners, city and county planners	Erosion control, construction techniques, policies
City of Las Cruces	How do water quality BMPs link to Vision 2040	City and county planners, open space activists	Incorporating BMPs into Vision 2040
Mesilla	Open space in other southwest cities	Open space activists	Bring someone from Phoenix and Tucson to discuss how open space improves water quality
Sunland Park	The 319(h) process in Texas	Federal, state, city, and county agencies	How Texas watersheds draining into the river impact New Mexico water quality
Anthony	Agricultural BMPs	Farmers and resource agencies	On-farm practices to re-duce erosion and more
Hatch	Conservation easements	Farmers and agencies	State and federal opportunities for farmers
Mesquite	Wastewater BMPs	Towns, water utilities	Examples of waste water treatment using wetlands and other techniques
Las Cruces	319(h) Campaigns	PDNWC Council	Laura de la Garza from Arroyo, Colorado

Table 10: Suggested conversation series for water quality outreach.

Chapter 7 TECHNICAL AND FINANCIAL ASSISTANCE

Technical Assistance Resources

The Council provides a forum for exchanging information about water quality and quantity, ecosystem integrity, the quality of life, and economic sustainability in the Paso del Norte watershed on the Rio Grande. Within the Council membership there is wide ranging expertise concerning water quality and watershed issues including engineers, hydrologists, economists, biologists, geographers, community planners, and public health experts. Among its members are representatives of nongovernmental organizations, federal and state agencies, water utilities, municipal governments, and universities, as well as private citizens.

In addition to the Council executive committee and associated subcommittees, the following individuals and agencies were identified and engaged during the stakeholder process.

George D. Di Giovanni, Ph.D.
Texas AgriLife Research, Texas A&M

Dr. Geoffrey Smith, Biology
New Mexico State University

Dr. Phil King, Civil Engineering
New Mexico State University

James Narvaez
Hydrology Director, EBID

Chris Canavan, Project Officer
New Mexico Environment Department

Dr. William Hargrove, Director
Center for Environmental Resources Management
University of Texas, El Paso

Cory Durr
Bureau of Land Management

Cliff Sanchez
Natural Resources Conservation Service

Adrian Tafoya
Natural Resources Conservation Service

Fernando Cadena, Civil Engineering
New Mexico State University (Emeritus)

Andrew Robertson
United States Geological Survey

John Unruh
United States Geological Survey

Paul Dugie, Director
Dona Ana Flood Commission

Jan Kirwan
New Mexico State Parks

Lisa Ramirez
USIBWC Clean Rivers Program

Tom Mobley
Rancher, Doña Ana County

Financial Needs

Budget Category	Unit Description	Unit Cost	Total Cost
Project Management			
Part time project coordinator (possible student intern) for outreach, grant writing, stakeholder development, organizing meetings (Dia del Rio, Raft the Rio, etc. two days per week)	Salary/year for four years	$15,000	$60,000
Implementation Project Oversight Manager. (fiscal and reporting responsibilities)	Salary/year for four years	$20,000	$80,000
Coordinator for WQ Monitoring (24 hrs/month)	Salary/year for four years	$12,000	$48,000
Project Implementation			
Drain modification	One to three projects	$120,000-$170,000	$360,000-$521,000
Constructed wetland	One to three projects	$100,000-$200,000	$300,000-$600,000
Manure digester infrastructure	Initial infrastructure with potential for growth dependent on success	$1,000,000	$1,000,000
Detention basin upgrade or repair	One to three projects	$50,000-$1,000,000	$150,000-$3,000,000
Grade control/stabilization structures	Rock or brush structure	$200-$400	N/A
Upland vegetation improvement	1 acre brush control, seeding, etc.	$300-$3000	N/A
WWTP Upgrade			
North Sunland Park WWTP (AKA Santa Teresa WWTP)	New treatment plant and infrastructure upgrades	$17,000,000-$20,000,000	$17,000,000-$20,000,000
South Central Regional WWTP	One upgrade including infrastructure	$3,000,000-$5,000,000	$3,000,000-$5,000,000
Outreach			
Outreach materials to address illegal waste disposal in agricultural drains	Develop, print and distribute pamphlets	$4,000-$7,000	$4,000-$7,000
Watershed model	Portable model	$1,000	$1,000
Maintaining website	Yearly upkeep of website	$1,000	$5,000
Watershed tours	Two stakeholder tours to select areas of interest	$2,500	$5,000
Workshops (rainwater harvesting, waste management, LID, etc.)	One workshop every other year beginning 2015	$10,000	$20,000
General outreach materials	Event giveaways, literature, and brochures	$2,000	$10,000
Participating in community events	Outreach at select community events	1,000	5,000

Table 11: Estimate of Financial Needs for Implementation years 2014-2018.

Financial Assistance

A variety of funding programs that assist watershed groups in watershed protection and restoration were investigated. Information on each program is detailed to provide insight to specific funding opportunities for the Paso del Norte watershed in the lower Rio Grande. USEPA's Catalog of Federal Funding Sources for Watershed Protection provides an overview of potential federal and nonfederal funding sources.

NPS Implementation Grants [CWA Section 319(h)]

The NPS Implementation Grants Program [CWA Section 319(h)] has provided the foundation of financial resources for the Council to address water quality issues in southern New Mexico. The 319(h) program funds projects and programs in concurrence with Section 319(h) of the CWA that are geared toward addressing NPS pollution. Projects like the development of a water pollution remediation plan, the design and implementation of BMP's, hiring watershed coordinators and public outreach and education programs are eligible for 319(h) funding. States are required to provide a 40 percent nonfederal match.

NMED releases a request for proposals for 319(h) funding yearly between February and April. Stream and river segments with a written TMDL and included in the NMED 303(d) list are eligible for this funding.

Environmental Quality Incentives Program (EQIP)

USDA's NRCS supports the EQIP financial assistance program. This voluntary program is targeted toward agricultural producers for addressing local natural resource needs and goals. The major program goals are enhancing agricultural production and optimizing environmental benefits on lands that, for instance, are affected by problems with soil erosion, water quality and quantity, wetlands, or grazing lands, among others. EQIP contracts can extend the length of one year after project implementation to ten years maximum. A comprehensive plan of operations is developed by NRCS and the applicant to best identify and prioritize suitable conservation practices that would address specific resource goals. A typical match amount equals 25 to 50 percent; the local average of required match is approximately35 percent. In addition, CWA Section 319(h) funds can also be used as match.

Within the watershed in southern New Mexico, there are two local work groups that are qualified for EQIP funding: the Doña Ana and the Sierra Soil and Water Conservation Districts. These are the entities that approve all local operation plans and provide assistance with the management of EQIP funds. Eligible persons include landowners, landlords, operators, or tenants of eligible agricultural lands. Also, producers who face threats to their natural resources and those in need of assistance in complying with federal and state environmental law are encouraged to apply. Examples of projects include watershed management, restoration, monitoring, NPS controls, BMPs, education/outreach, mitigation of ranching impacts, and water conservation efforts.

National Water Quality Initiative

The National Water Quality Initiative will work in priority watersheds (identified by a state's 319(h) program) to help farmers, ranchers, and forest landowners improve water quality and aquatic habitats in impaired streams. NRCS will help producers implement conservation and management practices through a system's approach to control and trap nutrient and manure runoff. Qualified producers will receive assistance for installing conservation practices such as cover crops, filter strips, terraces, and manure management BMPs.

USEPA Targeted Watershed Grants Program

This grant is geared toward funding collaborative partnerships aimed at protecting and restoring water resources. Generally, grants are awarded for use in on-the-ground implementation of watershed based projects that contain a strong element of stakeholder collaboration for producing environmental changes. A technically sound watershed based BMP implementation plan is necessary; this may present itself as a future funding option for member organizations of the Council. A nonfederal match of 25 percent is required. See www.epa.gov/owow/watershed/initiative/ for more information.

Border Environment Cooperation Commission (BECC)
North American Development Bank (NADB)

Created as interdependent institutions, NADB and BECC function as a team, working with communities and project sponsors to develop, finance and build affordable and self-sustaining municipal drinking water and wastewater projects that have broad community support. Each institution is charged with specific responsibilities. BECC focuses on the technical aspects of project development, while NADB concentrates on project financing and oversight for project implementation. Financing is provided by the USEPA under BEIF. The objective of the BEIF program is to make infrastructure projects affordable by combining grant funds with loans and other forms of financing for communities along the border.

USDA-Rural Develpment Agency

The USDA Rural Development Agency provides funding opportunities in the form of payments, grants, loans, and loan guarantees, for the development and commercialization of vital utility services. This includes funding rural water and wastewater systems to help address water quality. More information can be found at http://www.rurdev.usda.gov/Utilities_Assistance.html.

New Mexico Finance Authority Colonias Infrastructure Program

The Colonias Infrastructure Act was adopted in 2010 to ensure adequate financial resources for infrastructure development for recognized colonia communities, provide for the planning and development of infrastructure in an efficient and cost-effective manner, and develop infrastructure projects to improve quality of life and encourage economic development. More information can be found at http://www.nmfa.net/financing/colonias-loans-and-grants/colonias-infrastructure-board/.

Small Watershed Rehabilitation Program

This program is aimed at the rehabilitation of aging dams that were originally constructed under the USDA Watershed Program in the last 50 years. The goal is to address public health and safety issues, including those associated with NPS pollution. Applications may be submitted year-round and a 35 percent match is required. See http://www.nrcs.usda.gov/programs/WSRehab/ for more information.

National Research Initiative Competitive Grants Program

USDA's Cooperative State Research, Education, and Extension Service support the Water and Watersheds Program, which is aimed at protecting and enhancing natural resource bases and watershed environments. Specific goals include, but are not limited to, protecting food safety through clean irrigation and livestock drinking water supplies. Long-term goals for this program reduce pathogens from watersheds and maintain adequate water supplies for agricultural and livestock production as well as rural water use water supplies. See http://www.csrees.usda.gov/funding/rfas/pdfs/08_nri.doc. for more information.

State Revolving Funds

The State Revolving Fund (SRF) is a fund administered by a U.S. state for the purpose of providing low-interest loans for investments in water and sanitation infrastructure (e.g., sewage treatment, storm water management facilities, and drinking water treatment) as well as for the implementation of NPS pollution control and estuary protection projects. A SRF receives its initial capital from federal grants and state contributions and then emits bonds that are guaranteed by the initial capital. Finally, it "revolves" through the repayment of principal and the payment of interest on outstanding loans. There are currently two SRFs:

1. The Clean Water State Revolving Fund created in 1987 under the Clean Water Act.
2. The Drinking Water State Revolving Fund created in 1997 under the Safe Drinking Water Act.

The following general implementation schedule (Table 12) was developed to encompass the primary tasks set out in this watershed plan. It includes a series of action items to obtain funding, implement projects and disseminate information. Any action selected for implementation for all years is already in place and ongoing.

Actions	2014	2015	2016	2017	2018
Grant Writing to Secure Funding For					
Developing stakeholder outreach materials to address illegal waste disposal in agricultural drains	x	x			
BMP Project Implementation	x	x	x		
WQ monitoring studies at greater resolution for Mesquite, Del Rio, West, Montoya and East drains		x	x		
Forge Partnerships					
Develop agreement with fiscal agent for project implementation or foster cooperative partnership between stakeholders	x	x	x	x	x
Partner with a Texas entity to address WQ at the bottom of the project area where NPS pollutant sources and impairments are shared. (Texas 319(h) counterpart)		x			
Coordinate with the USIBWC Texas Clean Rivers Program on water quality monitoring within shared area of New Mexico-Texas border.	x	x	x	x	x
Work with USIBWC ROD Committee to further develop management measures and restoration projects	x	x	x	x	x
Expand participation with South Central New Mexico Stormwater Coalition	x	x	x	x	x
Seek partnership to develop further *E. coli* source identification from Courchesne Bridge to above the Anthony 225 Bridge "hotspot area"		x			
Project Implementation					
Select implementation project (site selection, management measures, implementation schedule, and estimated load reduction goal derived from WBP)	x	x	x		
Secure funding		x			
Begin project implementation – hire contractors, purchase equipment, etc.		x			
Monitor implementation schedule for progress		x	x	x	x
Report project results, evaluate project success, and make recommendations		x	x	x	x
Stakeholder Engagement					
Seek increased participation in Council from larger stakeholder community	x	x	x	x	x
Continue stakeholder workgroup meetings twice a year	x	x	x	x	x
Outreach					
Maintain www.pdnwc.org with dedicated section on *E. coli* impairment and restoration projects	x	x	x	x	x
Develop and disseminate outreach materials to address illegal waste disposal in agricultural drains		x	x	x	
Provide biannual updates to the USIBWC Rio Grande Citizens Forum as requested	x	x	x	x	x
Participate in at least one community outreach event annually to promote healthy watersheds, restoration activities, and Council awareness (Earth Day, Raft the Rio, Dia del Rio, etc.)	x	x	x	x	x

Table 12: General Implementation Schedule to track progress in accomplishing primary tasks.

The general implementation schedule was developed to provide a framework to implement the watershed plan while recognizing the difficulites in scheduling long term committments in a changing economy. The PdNWC is a non-profit organization without a stable funding stream. Funds are dependant on the aquisition of grant money from a variety of sources. However, the Council membership is comprised of a variety of stakeholders including representatives of governmental agencies including, but not be limited to, the EBID, City of Las Cruces, Doña Ana County, the South Central New Mexico Stormwater Coalition, and the USIBWC. Securing funding is imperative to the success of project implementation, and grant writing to secure funds takes priority in the general implementation schedule. Additional specific projects will be identified as needed and implementation will be conducted following procurement of funding.

Schedule and Measurable Milestones for Specific Implementation Projects

The Executive Committee of the Council meets on a regular basis and will be responsible for tracking the progress of the implementation schedule and meeting the measurable milesones. A standing item on the agenda are reports from sub-committees. The Council will use the reports submitted by the Technical Committee and the Clean Water Committee to track the implementation of this watershed plan.

Oversight of the progress of implementing the general plan and specific projects is imperative to assure success of this plan. Tracking the implementation progress will provide information for a feedback loop to address general deficiencies in the plan as well as the progress of specific projects. To track the progress of the specific projects that have associated load reductions for *E. coli* that were presented in Chapter 5, a schedule with measurable milestones was developed (Table 13). Monitoring in this instance is intended to address project progress toward implementing the management measure and does not refer to measuring project efficacy.

Management Measure	Project Design	Secure Funding	Begin Project	Begin Monitoring	Project Completion
WWTP Upgrade(s)					
North Sunland Park WWTP[1]	2013	2014	2015	2014	2016
South Central Regional WWTP	2016	2016-2018	2018	2016	2021
Constructed Wetland					
Mesquite Drain[1]	2014	2015	2015	2015	2018
Montoya Drain	2015	2016	2017	2016	2019
Constructed Wetland for Main Sunland Park WWTP[2]	2014	[2]	[2]	[2]	[2]
Dairy Waste Management-Manure Digester	2012	2013[3]	[3]	[3]	[3]
Combined Enforcement Activities	2013	2013	2013	N/A	N/A
Outreach					
Develop targeted stakeholder outreach materials addressing illegal waste disposal in agricultural drains	2014	2015	2015	2014	2015
Disseminate outreach materials developed to address illegal waste disposal in agricultural drains	N/A	2015	2015	2015	2015
Seek partnership to develop further *E. coli* source identification from Courchesne Bridge to above the Anthony 225 Bridge "hotspot" area	2015	2016	2017	2017	2020

Table 13: Schedule and measurable milestones for specific Implementation Projects.

[1] Both the North Sunland Park WWTP and the Mesquite Drain Project have completed project designs. The North Sunland Park WWTP has secured funding and is in final stages of public outreach and design approval.

[2] Conceptual design has been completed. Securing funding has not been forthcoming, but efforts have continued.

[3] NWQI funding for infrastructure was secured in 2013. Securing funding for the digester has stalled, but efforts continue.

Chapter 9 EVALUATION CRITERIA AND MONITORING PLAN

The goal of this watershed based planning effort is to address the bacteriological impairment of *E. coli* and meet the New Mexico water quality standards for the Rio Grande in southern New Mexico. To attain this goal, measurable milestones were developed (Chapter 8). A set of evaluation criteria and a monitoring program were developed to monitor progress toward achieving the goals and objectives outlined in this WBP.

Evaluation Criteria

The following evaluation criteria have been developed to determine if the project objectives are making progress toward meeting the overall goal.

- Implementation Project Oversight – Was the management measure implemented as intended and designed?
- Mitigation Performance – What was the percent efficiency/effectiveness of the management measure toward meeting load reduction expectations for that practice?
- Mitigation Performance – What was the percent reduction in *E. coli* loading for a particular management measure relative to the TMDL target load?
- Mitigation Performance – If applicable-What was the performance of a management measure relative to other measures? Which are most efficient and economical?
- Watershed-Based Plan Performance – Are the prescribed management measures being implemented and performing as expected?
- Overall Load Reduction – What is the combined impact of the implemented management measures? Have the combined management measures reduced the *E. coli* loading down to the target TMDL load?

Periodic assessment of the implementation of *The Paso del Norte Watershed Based Plan – Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande* will determine the progress toward attaining the goal of meeting the state water quality standard for *E. coli* in the Rio Grande in southern New Mexico. This assessment will also be used to determine the strong points and weaknesses of the WBP and provide the information necessary to make changes and improvements to facilitate success in meeting the project goal. The Executive Committee of the Council will utilize the Evaualtion Criteria in conjunction with the Implementation Schedule and Milestones to track progress through reporting from the Technical and Clean Water subcommittees.

Monitoring Program Goals and Objectives

The goal of the monitoring plan is to determine if *The Paso del Norte Watershed Based Plan – Mitigation Measures to Reduce Bacterial Pollution in the Rio Grande* is achieving the goal of reducing the bacteriological impairment of *E. coli* in the Rio Grande in southern New Mexico. The monitoring should also continue to complement and, where practicable, coordinate with the assessment monitoring conducted by NMED. The following set of objectives is identified to facilitate development of the monitoring program.

- Continue the baseline monitoring program.
- Continue to delineate the sources of *E. coli* at a higher resolution to assist in further development of management measures.
- Monitor for effectiveness of implementation of the prescribed management measures of the WBP.
- Provide sufficient data to evaluate implementation of the WBP and provide the appropriate information to modify the WBP where needed.
- Provide sufficient quality data to meet the above objectives.

Modify Current Monitoring Efforts

The current *E. coli* monitoring effort began in 2008 for routine monitoring of select sites. The sampling stations were chosen to target potential inflows of *E. coli* into the main stem of the Rio Grande. Each river station was located at a stream gaging station and chosen to provide good spatial distribution. The drain sampling stations were chosen to provide data on perennial inflows into the river. Many of the drain sampling stations are also co-located with a stream gage. This provided flow measurements to evaluate pollutant loading. The recommended monitoring program is a continuation of that effort. A component of this monitoring effort should also be to continue to coordinate with the sampling efforts of the USIBWC Texas Clean Rivers Program sites from Anthony, New Mexico, to the American Dam in El Paso, Texas.

While it is recommended that the mainstem Rio Grande sampling sites be retained for the monitoring program to capture changing hydrologic conditions in the watershed, the monitoring program should be updated to include more intensive monitoring in the hotspot areas that were identified. This includes East Drain, Mesquite Drain, and Montoya Drain. This will provide greater resolution to the *E. coli* loading within these areas. The objectives of this monitoring effort are outlined in Table 14.

Objective	Question	Outcome	Decision Criteria
Determine the primary sub-watersheds where *E. coli* loading is likely to originate (spatial).	Have the geographic sources of *E. coli* been adequately identified?	Identification of the sub-watersheds contributing to the *E. coli* impairment.	Are the data sufficient to support geographic identification of *E. coli* loading?
Determine the seasonal conditions when increased *E. coli* loading occurs (temporal).	Have the temporal trends for *E. coli* distribution been identified?	Comparison of *E. coli* loading between wet versus dry conditions (ie storm events).	Are the data sufficient to determine seasonal trends for *E. coli* loading?
Determine the percent contribution of *E. coli* loading from both spatial and temporal sources.	Have the percent contribution of *E. coli* loading from spatial and temporal trends been identified?	Estimates of *E. coli* loading from identified sub-watersheds under both wet and dry conditions.	Are the data sufficient to estimate *E. coli* loading from the identified sources?
Further characterize the spatial distribution of *E. coli* within the "hotspot" area.	Has the spatial distribution of *E. coli* within the "hotspot" area been identified?	Identification of the distribution of *E. coli* within the "hotspot" area.	Are the data sufficient to determine the distribution of *E. coli* within the "hotspot" area?

Table 14: Monitoring objectives for a modiifed routine monitoring program.

The current *E. coli* monitoring effort was initially conducted under the guidance of NMED and the NMED Quality Assurance Project Plan (QAPP). This was followed by the development of a project specific QAPP which describes the sampling stations and rationale, the monitoring frequency, sampling procedures and data management (Appendix II). A preliminary task would be to update the QAPP to address changes to the water quality objectives.

The routine monitoring should continue indefinately as long as funding is available. Once results have been through the QA process, all monitoring data should be shared with NMED and the Texas Clean Rivers Program annually.

Monitoring Targeted Management Measures

Monitoring the targeted management measures is critical to determining if mitigation efforts are reducing the *E. coli* pollutant loading as intended. This may involve two different types of assessments: first, to determine if the management measure is functioning as intended and producing the intended results; second, to determine the contribution the management measure is making to the overall reduction to *E. coli* loading to the Rio Grande. In conjunction with the routine sampling data, this information can then be used to determine if the prescribed amanagment measures are achieving the goal of reducing the bacteriological impairment of *E. coli* in the Rio Grande in southern New Mexico. Given the diversity of the targeted management measures an array of approaches is recommended to determine efficacy of a specific management measure. This will include, but not be limited to: monitoring for *E. coli* upstream and downstream of the implementation project, monitoring flow (where applicable) upstream and downstream of the project area, and evaluation of the load reduction produced by the mitigation measure. The following components of monitoring targeted management measures is recommended:

- Evaluate the DMRs of the WWTPs following facility replacement or upgrade.
- Monitor the river for *E. coli* below WWTP discharge points.
- Monitor the *E. coli* load above and below constructed wetlands to assess their efficacy.
- Follow the progress of the manure digestor project and the number of participating producers.
- Record the number of enforcement actions and assess the results of subsequent mitgation plans.
- Track distribution of stakeholder outreach materials addressing illegal waste disposal in agricultural drains.

Monitoring of targeted management measures should last no fewer than three years following implementation. Once results have been through the QA process targeted monitoring data should be shared with NMED and the USIBWC Texas Clean Rivers Program.

Higher Resolution *E. coli* Monitoring- Recommendations

It is clear there are still still data gaps concerning *E. coli* pollution in the drainage system, especially in the southern end of the watershed where elevated levels of *E. coli* seem more persistent. There is not currently funding to support recommended efforts to fill these data gaps. Several approaches are recommended by the stakeholder working group. should funding become available.

Level I

An initial strategy would be to conduct a thorough ground survey inspecting the drains for unauthorized discharge of waste, which may be in the form of actual dedicated discharge locations (pipes) and illegal waste disposal sites. Depending on the level of funding available, this should also include a survey of all the drains on both sides of the Rio Grande between Mesquite, New Mexico, and Corchesne Bridge in El Paso, Texas. Once potential sources have been identified, the locations should be mapped and a further mitigation strategy developed to include educational outreach, cleanup, and possibly enforcement of violators. To accompany this program, bimonthly *E. coli* sampling May through October is recommended to determine if mitigation measures are effective. Depending on the level of monitoring frequency, this preliminary approach would require little technical assistance and a relatively low level of funding.

Level II

A second, more expensive and technically challenging approach would be to develop a more intensive *E. coli* survey to include a refined source tracking analysis. Initial sites should be selected longitudinally along the East and Mesquite drains starting just above the confluence with the Rio Grande below Anthony, Texas, and sampled for *E. coli*. Identified “hotspots” would be sampled for further source tracking analysis to obtain a higher resolution than prior efforts. Additional sampling sites should also include select points along the river from above the New Mexico 225 Bridge in Anthony downstream to the Rio Grande at El Paso USGS gage at Courchesne Bridge. Depending on the level of funding available, sampling for *E. coli* is recommended in each of the drains in the southern end of the New Mexico portion of the Rio Grande just upstream of each drain confluence with the river.

Level III

A study should also be conducted on the sediments of the East Drain to determine if there is a viable population of *E. coli* present. If *E. coli* is surviving and reproducing in the sediments, as studies have suggested in other areas (Hardina and Fujioka 1991; Fujikoa 1999; Ishii et al. 2006; Byappanahalli et. al. 2012), then the potential for *E. coli* effluxing into the water column exists (Garzio-Hadzick et al. 2010). If this is occurring, it could have a profound impact on mitigation.

REFERENCES

Ackerly, Neal, 1992. *Irrigation systems in the Mesilla Valley : An Historical Overview*. Center for Anthropological Research New Mexico State University, Las Cruces, New Mexico.

Brzozowski, Carol, 2012. *Rain Garden Monitoring in Stormwater*. The Journal for Surface Water Quality Professionals. Vol. 13, No 5, Forester Media Inc, Santa Barbara, California.

Byappanahalli, Muruleedhara N; Yan, T; Matthew, J. H.; Ishii, S.; Fujioka, R.S.; Whitman, R.L.; and M.J. Sadowsky, 2012. *The population structure of Escherichia coli isolated from subtropical and temperate soils*. USGS Staff Published Research. Paper 505.

Canavan, Allie, 2012. Low Impact Development in the Southwest. Clearing the Waters Newsletter. Vol. 15 No. 2. Summer 2010. New Mexico Environment Department, ftp://ftp.nmenv.state.nm.us/www/swqb/WPS/CTW/ClearingTheWaters-Summer2010.pdf

Clary, Jane, Jones, J.; Urbonas, B; Quigley, M.; Strecker, E. and Todd Wagner, 2008. *Can Stormwater BMPs Remove Bacteria? New Findings from International Stormwater BMP Database.* Stormwater: The Journal for Surface Water Quality Professionals. Vol. 9, No 3, Forester Media Inc, Santa Barbara, California.

City of Las Cruces, 2011. One Valley, One Vision 2040: Doña Ana County, New Mexico Regional Plan. http://www.las-cruces.org/code/vision_2040/documents/plan.pdf

Cudia, Chris. 2012. "Best" Best Management Practices. Clearing the Waters Newsletter. Vol. 17 No. 1. Summer 2010. New Mexico Environment Department. ftp://ftp.nmenv.state.nm.us/www/swqb/WPS/CTW/ClearingTheWaters-Summer2012.pdf

Doyle, Michael, P. and Marilyn C. Erickson. 2005. *Closing the Door on the Fecal Coliform Assay*. Microbe/ Vol. 1, No. 4.

Ernst, A.E., S. Schrader, V. Lopez, J. Prior-Magee, K. Boykin, B. Thompson, D. Schrupp, L. O'Brien, W. Kepner, K. Thomas, and J. Lowry. 2007. *Land Stewardship. Chapter 4. In: J.S. Prior-Magee, K.G. Boykin, D.F. Bradford, W.G. Kepner, J.H. Lowry, D.L. Schrupp, K.A. Thomas, and Bruce C. Thompson (eds). Southwest Regional Gap Analysis Final Report. U.S. Geological Survey, Gap Analysis Program, Moscow, ID (2007).*

Fujioka R, Sian-Denton C, Borja M, Castro J, and K. Morphew. 1999. *Soil: the environmental source of Escherichia coli and enterococci in Guam's streams*. J Appl Microbiol Symp Suppl 1999;85:83S–9S.

Garzio-Hadzick, A., Shelton, D.R., Hill, R.L., Pachepsky, Y.A., Guber, A.K., and R. Rowland. 2010. *Survival of manure-borne E. coli in streambed sediment: Effects of temperature and sediment properties*. Water Research 44 (9), pp. 2753-2762.

Hardina CM, and R. S. Fujioka. *Soil: the environmental source of Escherichia coli and enterococci in Hawaii's streams*. Environ Toxicol Water Qual 1991;6:185–95.

Ishii S, Ksoll WB, Hicks RE, and Sadowsky. 2006. *Presence and growth of naturalized Escherichia coli in temperate soils from Lake Superior watersheds*. Appl Environ Microbiol 2006a;72:612–21.

Hawley, John. 2004. *Creation of a digital hydrogeologic framework model of the Mesilla Basin and southern Jornada del Muerto Basin*. New Mexico Water Resources Research Institute, New Mexico State University. Technical Completion Report #332.

Kasperson, Janice, 2013. *Too Much or Too Little*. Stormwater: The Journal for Surface Water Quality Professionals. Vol. 14, No 2, Forester Media Inc, Santa Barbara, California.

Kelly, Pat. 1986. *River of Lost Dreams* : *Navigation on the Rio Grande*. University of Nebraska Press, Lincoln Nebraska. 149 p.

King, J. Phillip and Julie Maitland. 2003. *Water for River Restoration: Potential for Collaboration between Agricultural and Environmental Water Users in the Rio Grande Project Area*. Report Prepared for the World Wildlife Fund. http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/470_water-for-river-restoration---rio-grande-project-area.pdf

Las Cruces, 2011. www.las-cruces.org/code/vision_2040/documents/plan.pdf 2011

Pérez de Luxán, Diego. 1929. *Expedition into New Mexico made by Antonio de Espejo, 1582-1583, as revealed in the journal of Diego Pérez de Luxán, a member of the party*. Translated, with introd. and notes, by George Peter Hammond and Agapito Rey. The Quivera Society, Las Angeles, California.

New Mexico Environment Department. 2007. *Total Maximum Daily Load (TMDL) for the Main Stem of the Lower Rio Grande (from The International Boundary with Mexico to Elephant Butte Dam).* ftp://ftp.nmenv.state.nm.us/www/swqb/LRG/TMDL/LowerRioGrandeTMDL.pdf

New Mexico Environment Department. 2012. *Standards for Interstate and Intrastate Surface Waters*, New Mexico Water Quality Control Commission, 20.6.4 NMAC, November 20, 2012).

Smith, Geoffrey B. Bacterial Source Tracking Study in the Cimarron New Mexico Watershed May, 2007. http://www.cimarronwatershed.org/info/AnnualReport2007_pp_1-24.pdf

Stotz, Nancy G., 2000. *Historic Reconstruction of the Ecology of the Rio Grande/Rio Bravo Channel Floodplain in the Chihuahuan Desert*. Chihuahuan Desert Program, World wildlife Fund. http://bva.colech.edu.mx/xmlui/bitstream/handle/123456789/HASH011881a4ea6f4251ce76a0ad/bio020.pdf?sequence=3

Tetra Tech, 2004. *A Manual of Conservation Practices to Reduce Pollution Loads Generated from Nonpoint Sources*. http://smiley.nmsu.edu/pdnwc/docs/BMPImplementationAppendix.pdf.

U.S. Census 2010. http://www.census.gov/2010census/data/

USEPA. 2001. *Protocol for Developing Pathogen TMDLs.* First Edition. United States Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch, Washington D.C. 20460. EPA 841-R-00-002. http://www.epa.gov/owow/tmdl/pathogen_all.pdf

USEPA. 2005. Microbial Source Tracking Guide Document. United States Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio. EPA/600-R-05-064. http://twri.tamu.edu/docs/bacteria-tmdl/epa%20mstguide%206-05.pdf

USEPA. 2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Water* United States Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch, Washington D.C. 20460. EPA 841-B-08-002. http://water.epa.gov/polwaste/nps/handbook_index.cfm

USEPA. 2012. Identifying and Protecting Healthy Watersheds: Concepts, Assessments and Management Approaches United States Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans and Watersheds, Washington D.C. 20460. EPA 841-B-11-002. http://water.epa.gov/polwaste/nps/watershed/upload/hwi-watersheds-complete.pdf

Varma, Jay K., Greene K.D., Reller M.E., DeLong S.E., Janine Trottier, J., Nowicki, S.F., DiOrio, M., Koch, E. M., Bannerman, T.L., York, S.T., Lambert-Fair, M, Wells, J.G. and P.S. Mead. 2003. *An Outbreak of Escherichia coli O157 Infection Following Exposure to a Contaminated Building*. The Journal of the American Medical Association.Vol. 290. N0 20. pp 2709-2712.

Wilson, S.C., Morrow-Tesch, J., Straus, D.C., Cooley, J.D., Wong, W. C., Mitlohner, F.M., and J.J. Mcglone. 2002. *Airborne Microbial Flora in an Cattle Feedlot.* Applied and Environmental Microbiology, Vol. 68, No. 7 p. 3238-3242.

APPENDIX I

ESTIMATING POLLUTANT LOADS

Pollutant loading estimates for *E. coli* were determined by several methods. Actual estimated daily loads for the Sunland Park, and South Central Regional WWTPs were calculated from direct measurements collected from the facility outfalls during the 2011 NMED survey. Pollutant load estimations allowed under the NPDES permit were calculated for Sunland Park, and South Central Regional WWTPs. Daily loads were estimated for cattle, sewage, pet and horse sources in the East Drain as well as horse sources in Montoya Drain. The estimated daily loads for the East Drain were calculated from data collected during the source tracking study. The estimated daily loads for Montoya Drain were calculated utilizing agricultural census statistics and ground truth surveying. Estimates were determined utilizing methods outlined in the *Protocol for Developing Pathogen TMDLs* (EPA, 2001).

Relevant Unit Conversions

1 gallon = 0.134 cubic feet 1 mL =0 .000264 gallons 100 mL = 0.0264 gallons

WWTP daily discharge flows

Sunland Park (2.0 MG/day)(3785mL/gal) **= 7.57 x 10^{9} mL/day**

South Central Regional (1.05 MG/day)(3785 mL/gal) = **3.97 x 10^{9} mL/day**

NPDES Permit Limits for each WWTP

Sunland Park (7.57 x 10^{9} mL/day)(126 cfu/100mL) **= 9.54 x 10^{9} cfu/day**

South Central Regional (3.97 x 10^{9} mL/day)(126 cfu/100mL) **= 5.00 x 10^{9} cfu/day**

Estimates of Actual Load for each WWTP

Sunland Park exceeded *E. coli* standard four out of six times (3 at 2,420, 1 at 1,203)

=avg 1,410 cfu/100mL

South Central Regional exceeded *E. coli* standard three out of six times at 2,420 cfu/100mL
=avg 1,210 cfu/100mL

Assuming a conservative number of half the observed discharge from the limited samples collected at each facility and the equation (discharge)(observed cfu/100mL)(0.5) = cfu/day

Sunland Park (7.57 x 10^{9} mL/day)(1,410 cfu/100mL)(0.5) = **5.34 x 10^{10} cfu/day**

South Central Regional (3.97 x 10^{7} mL/day)(1,210 cfu/100mL)(0.5) = **2.40 x 10^{10}cfu/day**

East Drain (actual load from BST study) = 2.81 x 10^{12} cfu/day

Cattle (14%)(2.81 x 10^{12} cfu/day) = **3.93 x 10^{11} cfu/day**

Sewage (13.3%)(2.81 x 10^{12} cfu/day) = **3.74 x 10^{11} cfu/day**

Pets (7.1%)(2.81 x 10^{12} cfu/day) = **2.00 x 10^{11} cfu/day**

Horse (12%)(2.81 x 10^{12} cfu/day) **= 3.37 x 10^{11} cfu/day**

Estimated *E. coli* Load from Dairies

Assumptions

One dairy cow produces 1 x 10^{11} cfu/day (fecal coliform)
There is ≈ 50% *E.coli* in fecal coliform/cow (EPA 2002, Doyle and Erickson, 2006).
There are ≈ 20,000 dairy cows along "dairy row"
Therefore (20,000)(1 x 10^{11})(0.5) = *E.coli*/day **= 1.00 x 10^{15} cfu/day**
Assume 0.01% of the *E. coli* is transmitted to drain (2 cows) **= 1.00 x 10^{11} cfu/day**

Estimated Horse *E. coli* l load (Montoya Drain)

There have been observed discharges of horse fecal material into Montoya Drain in the vicinity of the racetrack. There are two bridges leading from paddocks to the track over Montoya Drain w/o BMPs. Washing of blankets and other racing equipment discharged to street then to drain.

Assumptions

2,206 horses in Dona Ana County (NMDA Census, 2007)
Primary concentration (75%) of horses is in the vicinity of the racetrack (1,655).
Fecal material from 0.15% (2.5) horses/day discharged to Montoya Drain.
One horse produces 4.2 x 10^8 cfu/day (fecal coliform)
There is ≈ 50% *E. coli* in fecal coliform (EPA 2002, Doyle and Erickson, 2006).

Horse Fecal Load/day = (4.2 x 10^8)(2.5)(0.5) **= 5.25 x 10^8 cfu/day**

POTENTIAL LOAD REDUCTIONS FROM MANAGEMENT MEASURES

Load Reduction from WWTP Upgrades

(estimated load from sampling)-(permit limit)

Sunland Park **= 4.39 x 10^{10} cfu/day**

South Central Regional **= 1.90 x 10^{10} cfu/day**

\Constructed Wetland (East Drain) **(Assume 25% efficiency)**

Total Load (total load)(0.25) = (2.81 x 10^{12})(0.25) **= 7.0 x 10^{11} cfu/day**

Cattle Load (% cattle load)(0.25) = (3.93 x 10^{11})(0.25) **= 9.83 x 10^{10} cfu/day**

Sewage Load (% sewage load)(0.25) = (3.74 x 10^{11})(0.25) **= 9.35 x 10^{10} cfu/day**

Pets (% pets load)(.25) **= (**2.00 x 10^{11})(0.25) **= 5.00 x 10^{10} cfu/day**

Horse (% horse load)(0.25) = (3.37 x 10^{11})(0.25) **= 8.43 x 10^{10} cfu/day**

Constructed Wetland (Montoya Drain) **(Assume 25% efficiency)**

Horse Load (Equine load)(0.25) = (5.25 x 10^8 cfu/day)(0.25) **= 1.31 x 10^8 cfu/day**

Constructed Wetland (Sunland Park WWTP) (Assume 25% efficiency)

Sunland Park WWTP (5.34×10^{10} cfu/day)(0.25) **= 1.34×10^{10} cfu/day**

Enforcement and Stakeholder Outreach

To date all enforcement activities have involved horse manure. Any positive effects from this BMP would likely have a larger impact, but only *E. coli* from horses is considered. A conservative estimate on load reduction assumes decreasing the load by 2 horses/day utilizing the following equation:

(4.2×10^{8})(2)(0.5) **= 4.2×10^{8} cfu/day**

APPENDIX II

Project Quality Assurance Project Plan

Water Quality Monitoring to Determine Pollutant Loading Sources

for the

Paso del Norte Watershed Based Plan Project

Clean Water Act Section 319 Grant No. C9-996101-13

Submitted by

New Mexico Environment Department

Surface Water Quality Bureau

APPROVAL PAGE

______________________ Chris Canavan Project Officer, SWQB Watershed Protection Section	________ Date
______________________ Tim Michael Interim Quality Assurance Officer, SWQB	________ Date
______________________ Abe Franklin Program Manager, SWQB Watershed Protection Section	________ Date
______________________ Sharon Daugherty Environmental Protection Specialist, WQPD, EPA Region 6	________ Date
______________________ Curry Jones Chief, State and Tribal Programs Section, WQPD, EPA Region 6	________ Date

TABLE OF CONTENTS

ACRONYMS

EBID	Elephant Butte Irrigation District
E. coli	Escherichia coli
EPA	Untied States Environmental Protection Agency
MST	Microbial Source Tracking
NMED	New Mexico Environment Department
PQAPP	Project Quality Assurance Project Plan
QA	Quality Assurance
QAO	Quality Assurance Officer
SWQB	Surface Water Quality Bureau
TMDL	Total Maximum Daily Load
WQPD	Water Quality Protection Division

1.0 PROJECT MANAGEMENT

1.1 Distribution List

Table 1

Distribution List and Project Roles and Responsibilities

Name	Organization	Title/Role	Responsibility	Contact Information
Abe Franklin	SWQB	WPS Program Manager	Reviewing and approving PQAPP, managing project personnel and resources	(505) 827-2793 abraham.franklin@state.nm.us
Bessie	SWQB	Office and Admin Supervisor	Maintaining project files	(505) 827-0584 bessie.muzumdar@state.nm.us
Tim Michael	SWQB	Interim QA Officer	Reviewing and approving PQAPP	(505) 476-3799 tim.michael@state.nm.us
Chris Canavan	SWQB	Project Officer	Preparing PQAPP, project reporting, coordinating with contractors.	(575) 647-7926 chris.canavan@state.nm.us
Hilary Brinegar*	NMDA	Water and Natural Resource Policy Specialist	Project oversight, project reporting, coordinating with contractors and report writing.	(575) 646-2642 hbrinegar@nmda.nmsu.edu
James Narvaez*	EBID	Hydrology Director	Oversee water quality sampling team in data collection and record keeping, submitting reports.	(575) 526-6671 (ext 430) jnarvaez@ebid-nm.org
Patrick Lopez*	EBID	SCADA Supervisor, Hydrology Dept	Supervise water quality sampling team	(575) 526-6671 (ext 431) patlopez@ebid-nm.org
Sharon Daugherty	EPA	Environmental Protection Specialist WQPD, Region 6	Reviewing and approving PQAPP	(214) 665-2259 daugherty.sharon@epa.gov
Curry Jones	EPA	Chief, State and Tribal Programs Section WQPD, Region 6	Reviewing and approving PQAPP	(214) 665-6793 jones.curry@epa.gov

*The Project Officer will require those marked with and asterisk to sign the PQAPP Acknowledgement Statement.

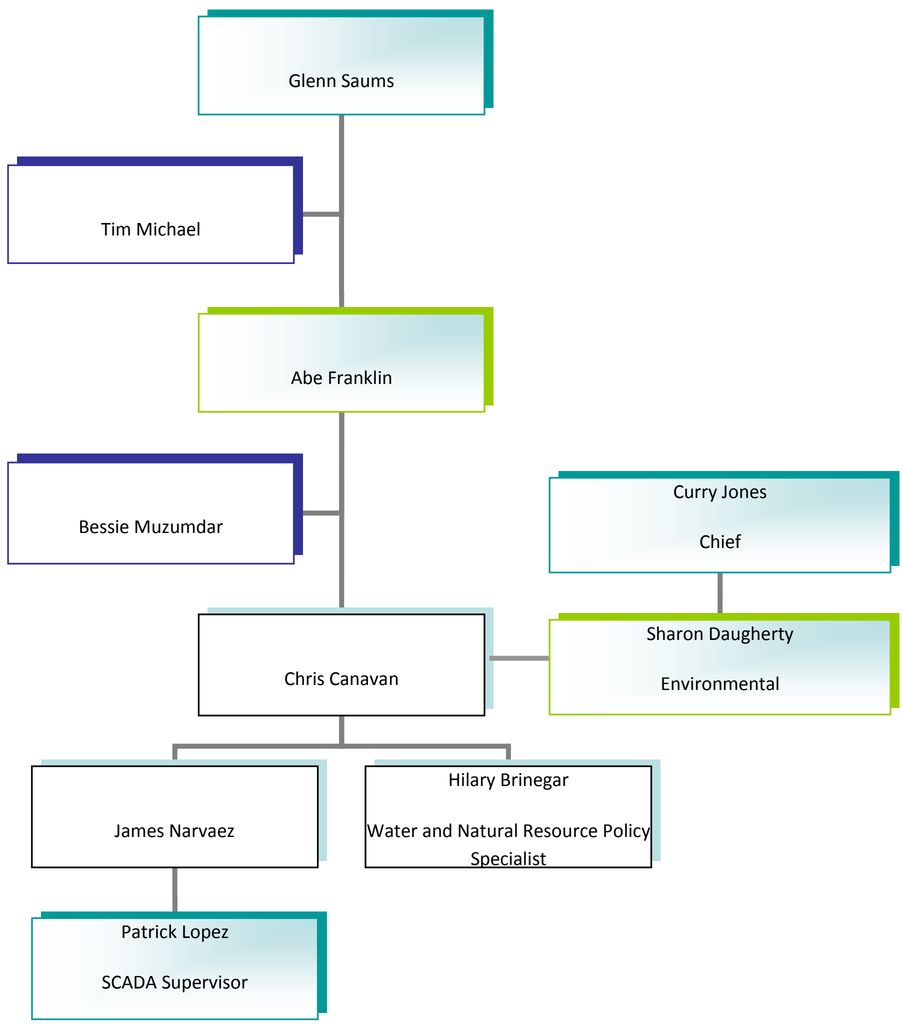
1.2 Project Organization

The Bureau QMP (NMED/SWQB 2009) documents the independence of the QAO from this project. The QAO is responsible for maintaining the official approved PQAPP.

Figure 1

Organization Chart

Paso del Norte Watershed Based Plan Monitoring Project



1.3 Problem Definition/Background

This PQAPP documents the quality requirements for *Water Quality Monitoring to Determine Pollutant Loading Sources for the Paso del Norte Watershed Based Plan Project.*

When changes affect the scope, implementation or assessment of the outcome, this PQAPP will be revised to keep project information current. The Project Officer, with the assistance of the QA Officer, will determine the impact of any changes on the technical and quality objectives of the project. This Project Plan will be reviewed annually by the Project Officer to determine the need for revision.

Objective

The objectives of the environmental monitoring are to identify the primary spatial and temporal locations of *Escherichia coli* (*E. coli*) impairment in the El Paso-Las Cruces Watershed (USGS HUC 13030102), to estimate the associated pollutant loading from those locations and to identify the host organisms.

Background

The El Paso-Las Cruces Watershed was surveyed by the SWQB Monitoring and Assessment Section in 2004 as part of an intensive water quality survey of the lower Rio Grande in New Mexico. As a result of this survey, a Total Maximum Daily Load (TMDL) for *E. coli* was developed for the main stem of the Rio Grande from the New Mexico-Texas state line at the international boundary with Mexico, upstream to one mile below Caballo Reservoir. While this survey resulted in a TMDL, the scope of the assessment was not sufficient to specifically identify the sources of *E coli* on either a spatial or temporal scale, or from which hosts the *E. coli* emanated.

In 2005, the Paso del Norte Watershed Council applied for a grant to develop a watershed plan to address the *E. coli* impairment. This portion (Phase I) of the Paso del Norte Watershed Based Plan was completed in December 2007. This effort, which included an extensive review of existing data, identified data gaps that indicated a need for a water quality survey designed to further delineate the *E. coli* sources.

In 2008, the New Mexico Department of Agriculture on behalf of the Paso del Norte Watershed Council submitted the Work Plan for Phase II of the Paso del Norte Watershed Based Plan (Phase II WBP). The objective of this phase, as stated under Section 7, Project Description, Addressing Water Quality Data Gaps, is as follows:

> The objective of the Phase II WBP process is to identify more specifically the subbasins or areas within the watershed that may be contributing to the water quality exceedance.

As a result, a water quality survey was initiated to examine the potential inputs of *E. coli* into the main stem of the Rio Grande in south central New Mexico below Caballo dam. The sampling outlined in the FSP is part of that effort.

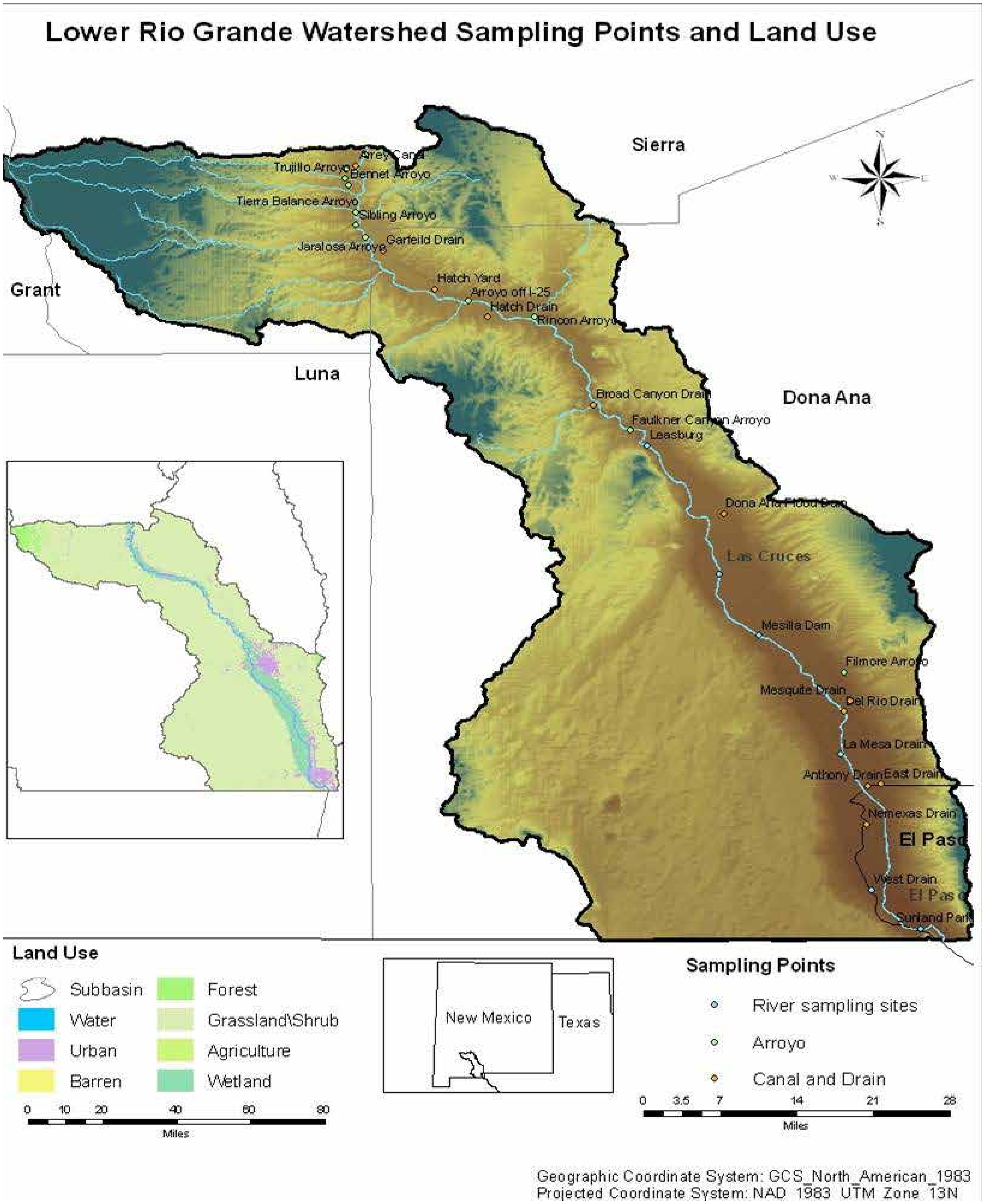
1.4 Project/Task Description

Description

Sites will be sampled monthly or quarterly for the purpose of determining spatial and seasonal variability in *E. coli* due to events such as storms, drought, manure application, etc. During the monsoon months of July through October, when runoff is expected to be greatest, additional sampling will occur as the opportunity arises. Data collected in the first year will be used to adjust the sampling program in the second year to focus on hotspots. Samples will also be collected to estimate pollutant loadings and to identify the host organisms.

Location

Figure 2



Schedule

Table 2

Sampling Schedule

Activity	Spring 2010	Summer 2010	Fall 2010	Winter 2010-2011	Spring 2011	Summer 2011	Fall 2011	Winter 2011-2012	Spring 2012
Data collection & submittal of samples for analysis.			============================						
Data Verification & Validation, Assessment of data				============================					

Sampling will continue through October 2011 with monthly samples collected from seven stations in the Rio Grande from Caballo Dam to Sunland Park, and quarterly from seven stations in agricultural drains along the same reach. Drain samples will be collected quarterly (July, October, January, and April) from 12 stations. The stream gauge data will provide accurate flow measurements that will be utilized to calculate the pollutant load at a given station. Additional opportunistic sampling may occur during the summer monsoon season in major ephemeral drainages, or within the river downstream of the point at which the flow enters the river.

The above sampling scheme will be utilized for the duration of the project. However, following the first year of sampling and an initial analysis of the data, four stations will be identified for analysis with microbial source tracking (MST) techniques. Sampling of these stations will be more rigorous and increased sampling events will take place during the monsoon season of 2011. For each sampling event at each of these stations, five samples will be taken five minutes apart to give five replicate analyses for each event.

Sampling Stations and Rationale

Sampling stations were chosen to target potential inflows of *E. coli* into the main stem of the Rio Grande. All river stations are located at a stream gauging station and were chosen to provide good spatial distribution. The drain sampling stations were chosen to provide data on the primary perennial inflows into the river. The sampling points in the drains will be located upstream of the confluence with the Rio Grande and most all the drain sampling stations are also co-located with a stream gauge. Opportunistic samples will also be collected following intense thunderstorms during the summer monsoon season in an attempt to capture storm flow in ephemeral drainages. Four locations will be chosen for sampling during the summer of 2011 for MST analysis.

Table 3

Station Locations and Rationale

Station Name	Type	Location	Station Rationale
Caballo Dam Cable	River	N 32.884608 W 107.292800	Located at the top of the watershed.
Garfield Drain	Drain	N 32.750100 W 107.269000	Perennial tributary
Hatch Drain	Drain	N 32.657008 W 107.130710	Perennial tributary
Rincon Drain	Drain	N 32.656833 W 107.068942	Perennial tributary
Haynor Bridge	River	N 32.613417 W 107.020450	Downstream of three major drain inflows.
Leasburg Cable	River	N 32.476992 W 106.919769	Located at the break between the NMED assessment units.
Seldon Drain	Drain	N 32.471530 W 106.893160	Perennial tributary
Picacho Bridge	River	N 32.296258 W 106.824186	Above the Las Cruces WWTP
Mesilla Dam	River	N 32.210194 W 106.771786	Below Las Cruces and Mesilla
Picacho Drain	Drain	N 32.248700 W106.822200	Perennial tributary
Del Rio Drain	Drain	N 32.104017 W 106.893160	Perennial tributary
La Mesa Drain	Drain	N 32. 043311 W 106.662878	Perennial tributary
Anthony Bridge	River	N 32.999500 W 106.636222	Below Anthony WWTP, and two major drain discharges
East Drain	Drain	N 32.002131 W 106.609131	Perennial tributary
Anthony Drain	Drain	N 31.999620 W106.627033	Perennial tributary
Newmexas Drain	Drain	N 31.945836 W 106.628535	Perennial tributary
West Drain	Drain	N 31.853297 W 106.622119	Perennial tributary
Montoya Drain	Drain	N 31.806150 W106.552011	Perennial tributary
Sunland Park	River	N 32.799119, W 106.556.397	Bottom station on the reach, and below the Sunland Park WWTP

1.5 Quality Objectives and Criteria for Measurement Data

Question/Decision

The questions to be answered by the sampling are: For *E. coli*, what are the spatial and temporal locations of high concentrations, what is the loading from the major source locations, and what are the host organisms?

The decision is whether or not the subbasins or areas within the watershed that may be contributing to the water quality exceedance have been adequately identified. More specifically:

- Have the locations been identified adequately to determine spatial distribution on a large scale (urban, rural, rangeland) and to a smaller scale or “hotspots” (subwatersheds, drains, 12 digit HUC, etc.)?
- Have temporal trends of *E. coli* distribution been identified?
- Has sufficient information been collected to estimate the loading of *E. coli* from the identified “hotspots”?
- Have the sources within specific” hotspots” been identified adequately to determine the activity or host organism that is generating the *E. coli*?

Data Quality Objectives

1. The data quality of the *E. coli* sampling will be sufficient to answer the study question; that is, the data quality will be sufficient to identify the spatial and temporal locations of high concentrations of *E. coli*, the locations of major *E. coli* loadings, and the *E. coli* host organisms.

2. The data quality of both the *E. coli* sampling and the turbidimeter and sonde measurements will be sufficient to meet the requirements of the NMED Surface Water Quality Bureau for data to be used for water quality assessment purposes.

Measurement Quality Objectives

The measurement quality objectives will be sufficient to achieve the Data Quality Objective and will be in conformance with those listed in the Surface Water Quality Bureau QAPP.

1.6 Special Training/Certification

No special training or certification is required. Sampling will be conducted by the Elephant Butte Irrigation District (EBID) hydrology department personnel who conduct routine water quality sampling and have received prior training.

1.7 Documents and Records

The Project Officer will make copies of this PQAPP and any subsequent revisions available to all individuals on the distribution list.

Documents and records will include the PQAPP, field notebooks, project specific data collection sheets, spreadsheets generated for analysis, validation and verification records, the final monitoring report, and the project final report.

2.0 DATA GENERATION AND ACQUISITION

2.1 Sampling Design

The sampling stations were chosen to target potential inflows of *E. coli* into the main stem of the Rio Grande. All river stations are located at a stream gauging station and were chosen to provide good spatial distribution. The drain sampling stations were chosen to provide data on the primary perennial inflows into the river. The sampling point in the drains will be located just upstream of the confluence with the Rio Grande and most of the drain sampling stations are also co-located with a stream gauge. The stream gauge data will provide flow measurements that will be utilized to calculate the pollutant load at a given station. Additional opportunistic sampling may occur during the summer monsoon season in major ephemeral drainages, or within the river downstream of the point at which the flow enters the river.

Following the first year of sampling and an initial analysis of the data, four stations will be selected for collection of samples for analysis with microbial source tracking (MST) techniques, in order to identify the *E. coli* host organisms. Samples will be collected at these stations during the monsoon season of 2011.

2.2 Sampling Methods

Sampling will be in accordance with "Microbial Methods for Monitoring the Environment" (Bordner and Winter, 1978) with the following modifications: *E. coli* samples will be collected in certified sterile containers that do not contain sodium thiosulfate. The sodium thiosulfate dechlorination agent is not used because the water samples are not expected to contain residual chlorine. Samples will be collected utilizing a swing sampler mounted on an extension pole. This sampler is designed with a quick release clamp to hold the sample container, and facilitates sampling from a bridge and allows the technician to collect a sample from further out in the stream away from the bank.

Samplers will wear clean powder free, disposable, gloves while collecting and processing samples. Samples will be labeled, cooled to 4°C and transported to the laboratory for analysis within 6 hours of sample collection, per the analytical method requirements (Hach Method 10029).

A second sample will be collected in a separate container for the field measurement of turbidity using a Hach 2100 portable turbidimeter.

Separate samples (using separate containers) will be collected for MST analysis. For each MST sampling event five samples will be collected five minutes apart to give five replicate analyses for each event.

Site water parameters will be measured for temperature, pH, conductivity, and dissolved oxygen with a submersible sonde.

2.3 Sample Handling and Chain of Custody

As a component of collecting field notes, a sample chain of custody is filled out by the field technician prior to leaving the sampling station. The chain of custody is submitted with the sample upon delivery to the laboratory, and following relinquishment and receipt of the sample, the form is photocopied and a copy is provided to the field technician for the project records.

2.4 Analytical Methods

E. coli samples will be analyzed by EPA-approved Hach Method 10029 (m-ColiBlue24®) that incorporates specific non-coliform growth inhibitors and a selective enzymatic indicator to allow for simultaneous detection and quantitation of both *E. coli* and total coliforms. This procedure involves filtering the water sample (or the serial dilution) through a 0.45µm membrane filter, placing the filter in a Petri dish containing a filter pad and m-ColiBlue24® nutrient broth and incubating at 35 ± 0.5°C for 24 hours. Immediately following incubation, all blue colonies are enumerated as *E. coli* and red colonies are enumerated as total coliforms. Positive and negative bacterial controls are routinely run in parallel with the m-ColiBlue24® analyses.

E. coli samples analyzed for MST will require separate water samples. Once the *E. coli* samples have been processed as described above, the membrane filters will be stored at 4˚C for up to five days and then sent in insulated Styrofoam mailers overnight express to the Institute of Environmental Health (IEH) lab. At the IEH labs, the presumptive *E. coli* will be transferred and tested for *E. coli* confirmation, and then chromosomal DNA will be extracted and analyzed by Pulsed Field Gel Electrophoresis to identify the probable *E. coli* host organism.

2.5 Quality Control

Field Quality Control

Each sampling run will include a field blank, which will consist of a sample bottle filled with distilled water and then placed on ice for transport to the analytical lab where it will be analyzed the same as any other sample. The *E. coli* blank count will be recorded as are other sample results. If the blank shows a detection of *E. coli*, then all of the samples for that sampling run will be flagged. Decisions regarding retention or rejection of flagged data will be made based on the use of the data.

Laboratory Quality Control

Samples that are not analyzed within the period allowed by the method (6 hours) will be flagged.

Incubation temperature and time should be within the method requirements (35°C ± 0.5°C for 24 ± 4 hours) and should be recorded. The incubator temperature should be recorded at the beginning and at the end of the incubation period.

Quality control for *E. coli* samples analyzed for MST is the responsibility of the IEH laboratory.

2.6 Instrument/Equipment Testing, Inspection and Maintenance

The instruments used to collect the data that may require testing and maintenance are the turbidimeter and the sonde. All instruments will be tested, inspected and maintained in accordance with the manufacturer's specifications as included in the user's manual.

2.7 Instrument Calibration and Frequency

The Hatch turbidimeter will be calibrated each sampling day. Sondes will be calibrated according to a standard procedure.

2.8 Data Management

The data will be maintained in the project file.

3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessment and Response Actions

The SWQB Project Officer will provide project oversight by periodically assisting with and/or reviewing data collection efforts. A review of the sampling efforts will take place monthly. Quarterly reports will describe the progress of the project tasks and any potential problems with task implementation or schedule. This process includes justification for adjusting the task, or the task schedule, and making adjustments to the timeline if applicable. The SWQB Project Officer will be responsible for approving any changes and ensuring changes are implemented by the designated party. All problems and adjustments to the project plan will be documented in the project file and included in the final report.

3.2 Reports to Management

Quarterly reports are submitted by the contractor to the SWQB Project Officer and include progress of project implementation and any available data. Printouts, status reports or special reports for SWQB or EPA will be prepared upon request. Separate annual monitoring reports will also be provided and included in the final report. The SWQB Project Officer will be responsible for maintaining project progress in the EPA Grants Reporting and Tracking System and the final report, and all other required project deliverables to be submitted to the EPA under this grant.

4.0 DATA VALIDATION AND USABILITY

4.1 Data Review, Validation and Verification

Data will be considered usable if there is reasonable evidence that the requirements of this PQAPP were followed.

4.2 Validation and Verification Methods

The SWQB Project Officer will ensure that valid and representative data are acquired. Verification of field sampling and analytical results will occur in the review of data performed by the SWQB Project Officer. In the event questionable data are found, the SWQB Project Officer will consult with project personnel to determine the validity of the data. Results of the verification process will be included in the final reports.

4.3 Reconciliation with User Requirements

The user requirement is a restatement of the data quality objective: the data will be sufficient to identify the spatial and temporal locations of high concentrations of *E. coli*, the locations of major *E. coli* loadings and the *E. coli* host organisms in the El Paso-Las Cruces watershed.

If the data do not meet this requirement, then steps will be taken to determine if it is possible to adjust the sampling plan, or if more data or if data of higher quality will be needed to obtain the data quality objective.

5.0 REFERENCES

Bordner, Robert and John Winter. (1978). Microbiological Methods for Monitoring The Environment. Environmental Monitoring and Support Laboratory, Office of Research and Development, U. S. Environmental Protection Agency, Cincinnati, Ohio 45268

Hach Method 10029

https://www.nemi.gov/apex/f?p=237:38:5158424281211745::::P38_METHOD_ID:5577

Descriptive Name: *E. coli* by m-ColiBlue24 Broth Procedure for Membrane Filtration
Official Name: Coliforms: Membrane Filtration (simultaneous detection) In: Hach Analytical Procedures. m-ColiBlue24 Broth Procedure for Membrane Filtration. Hach Product Literature #8433. Hach: Loveland, CO.

NMED/SWQB 2009. *Quality Management Plan for New Mexico Environment Department Surface Water Quality Bureau Environmental Data Operations 2010*. New Mexico Environment Department/Surface Water Quality Bureau, October 2009.

APPENDIX III

List of Acronyms

BECC	Border Environmental Cooperation Commission
BEIF	Border Environmental Infrastructure Fund
BLM	United States Bureau of Land Management
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BST	Bacterial Source Tracking
CAFO	Confined Animal Feeding Operation
cfs	Cubic Feet per Second
cfu	Coliform Forming Units
CRRUA	Camino Real Regional Utility Authority
CWA	Clean Water Act
DMR	Discharge Monitoring Report
DOD	Department of Defense
E. coli	*Escherichia coli*
EBID	Elephant Butte Irrigation District
EQIP	Environmental Quality Incentives Program
GLO	Government Land Office
HB	House Bill
LID	Low Impact Development
MDL	Method Detection Limit
MGD	Million Gallons per Day
NADB	North American Development Bank
NMAC	New Mexico Administrative Code
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
QAPP	Quality Assurance Project Plan
RGDIC	Rio Grande Dam and Irrigation Company
SRF	State Revolving Fund
SWQB	Surface Water Quality Bureau
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USIBWC	United States International Boundary and Water Commission
UV	Ultra Violet